상기 측정한 허락 횟수로써 상기 초기 지속 값(P_{mbms})을 갱신하고, 상기 갱신한 지속 값(P_{mbms})을 적어도 포함하는 엑세스 컨트롤 메시지가 MBMS 제어채널을 통해 상기 이동단말들로 전송하는 과정을 포함함을 특징으로 하는 상기 방법.

청구항 19.

제18항에 있어서, 상기 MBMS 제어채널은 제2공통제어물리채널을 통해 전송함을 특징으로 하는 상기 방법.

청구항 20.

미리 결정된 복수의 시그네쳐들 중 임의로 선택되어진 하나의 시그네쳐를 사용하여 억세스 프리앰블을 생성하고 상기 억세스 프리앰블을 통해 응답 메시지를 전송하기 위한 랜덤접근채널의 할당을 요구하는 단말기들과, 적어도 하나 이상의 셀을 포함하고 상기 단말기들로부터의 억세스 프리앰블을 수신하여 해당 랜덤접근채널의 사용을 허락하는 기지국과, 상기 기지국을 통해 상기 단말기들로 순방향 제어 메시지를 전송하는 기지국 제어기를 가지며, 상기 기지국 제어기가 상기 기지국들을 통해 상기 단말기들로 MBMS서비스를 제공하는 이동통신시스템에서 상기 단말기들이 상기 기지국 제어기에 의해 제공되는 지속 값(P_{mbms})에 의해 상기 억세스 프리앰블을 전송하는 방법에 있어서,

상기 기지국 제어기로부터 요청된 상기 MBMS 서비스가 제공될 것임을 통지하는 호출이 이루어질 시 상기 통지와 함께 상기 기지국 제어기로부터 제공되는 초기 지속 값(P_{mbms})에 의해 상기 호출에 대응하여 상기 랜덤접근채널의 할당을 요청하는 상기 억세스 프리앰블을 전송하는 과정과,

상기 초기 지속 값(P_{mbms})에 의해 상기 억세스 프리앰블을 전송하는 중 상기 기지국 제어기에 의해 갱신된 지속 값(P_{mbms})을 수신할 시 상기 초기 지속 값(P_{mbms}) 또는 이전 지속 값(P_{mbms})을 상기 수신한 지속 값(P_{mbms})으로 변경하는 과정과,

0에서 1사이의 실수 값(R)을 임의로 결정하고, 상기 실수 값(R)이 상기 변경한 지속 값(P_{mbms})보다 작으면 상기 억세스 프리앰블을 상기 기지국으로 전송하는 과정을 포함함을 특징으로 하는 상기 방법.

청구항 21.

미리 결정된 복수의 시그네쳐들 중 임의로 선택되어진 하나의 시그네쳐를 사용하여 억세스 프리앰블을 생성하고 상기 억세스 프리앰블을 통해 응답 메시지를 전송하기 위한 랜덤접근채널의 할당을 요구하는 단말기들과, 적어도 하나 이상의 셀을 포함하고 상기 단말기들로부터의 억세스 프리앰블을 수신하여 해당 랜덤접근채널의 사용을 허락하는 기지국과, 상기 기지국을 통해 상기 단말기들로 순방향 제어 메시지를 전송하는 기지국 제어기를 가지며, 상기 기지국 제어기가 상기 기지국들을 통해 상기 단말기들로 MBMS서비스를 제공하는 이동통신시스템에서 상기 기지국 제어기가 상기 단말기들에게 상기 억세스 프리앰블을 전송할 구간을 제공하는 방법에 있어서,

상기 이동단말들에 의해 요청된 상기 MBMS 서비스가 제공될 것임을 통지하기 위해 상기 이동단말들을 호출할 시 초기 지속 값(P_{mbms})을 상기 이동단말들로 전송하는 과정과,

상기 기지국 제어기로부터 상기 MBMS 서비스가 제공될 것임을 통지하는 호출 과 함께 수신한 초기 지속 값(P_{mbms})에 의해 상기 호출에 대응한 응답 메시지를 전송하기 위해 상기 랜덤접근채널의 할당을 요청하는 상기 억세스 프리앰블을 전송하는 과정과,

소정 주기동안 상기 이동단말들로부터의 상기 억세스 프리앰블들에 대응하여 상기 기지국이 사용을 허락한 허락 횟수를 측정하는 과정과,

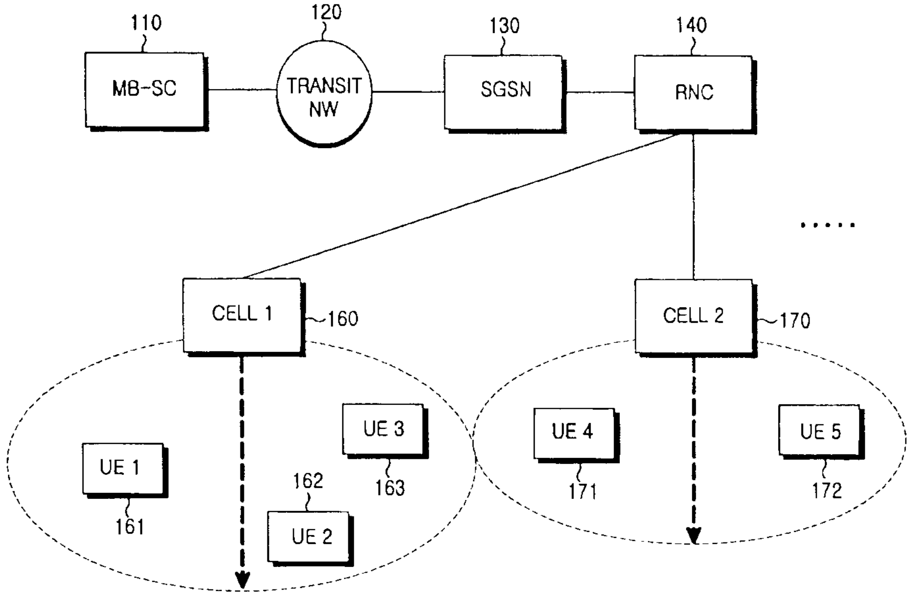
상기 측정한 허락 횟수로써 상기 초기 지속 값(P_{mbms})을 갱신하고, 상기 갱신한 지속 값(P_{mbms})을 포함하는 MBMS 제어채널을 제2공통제어물리채널을 통해 상기 이동단말들로 전송하는 과정과,

상기 초기 지속 값(P_{mbms})에 의해 상기 억세스 프리앰블을 전송하는 중 상기 기지국 제어기에 의해 갱신된 지속 값(P_{mbms})을 수신할 시 상기 초기 지속 값(P_{mbms}) 또는 이전 지속 값(P_{mbms})을 상기 수신한 지속 값(P_{mbms})으로 변경하는 과정과,

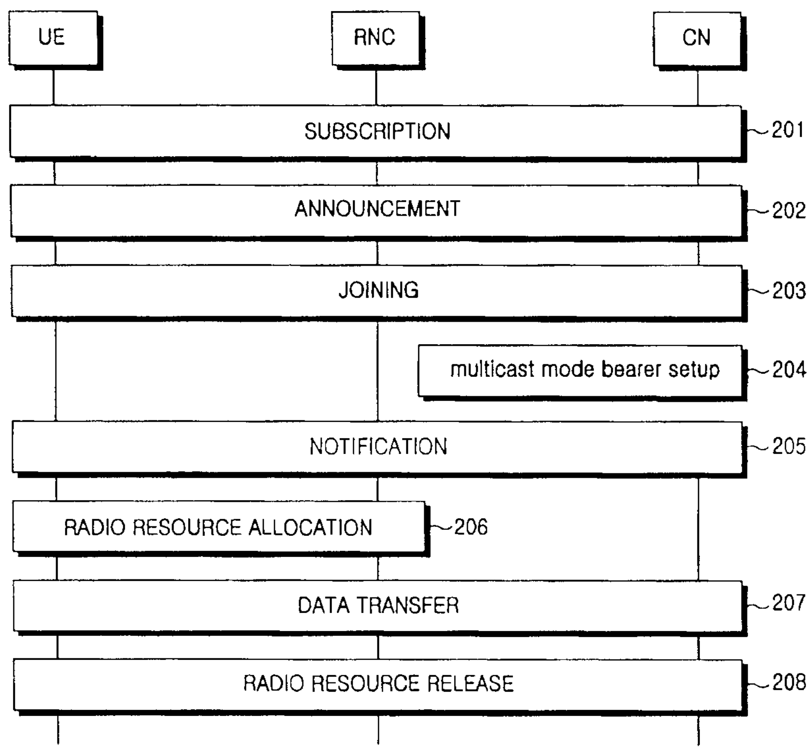
상기 변경된 지속 값(P_{mbms})에 의해 상기 호출에 대응한 응답 메시지를 전송하기 위해 상기 랜덤접근채널의 할당을 요청하는 상기 억세스 프리앰블을 전송하는 과정을 포함함을 특징으로 하는 상기 방법.

도면

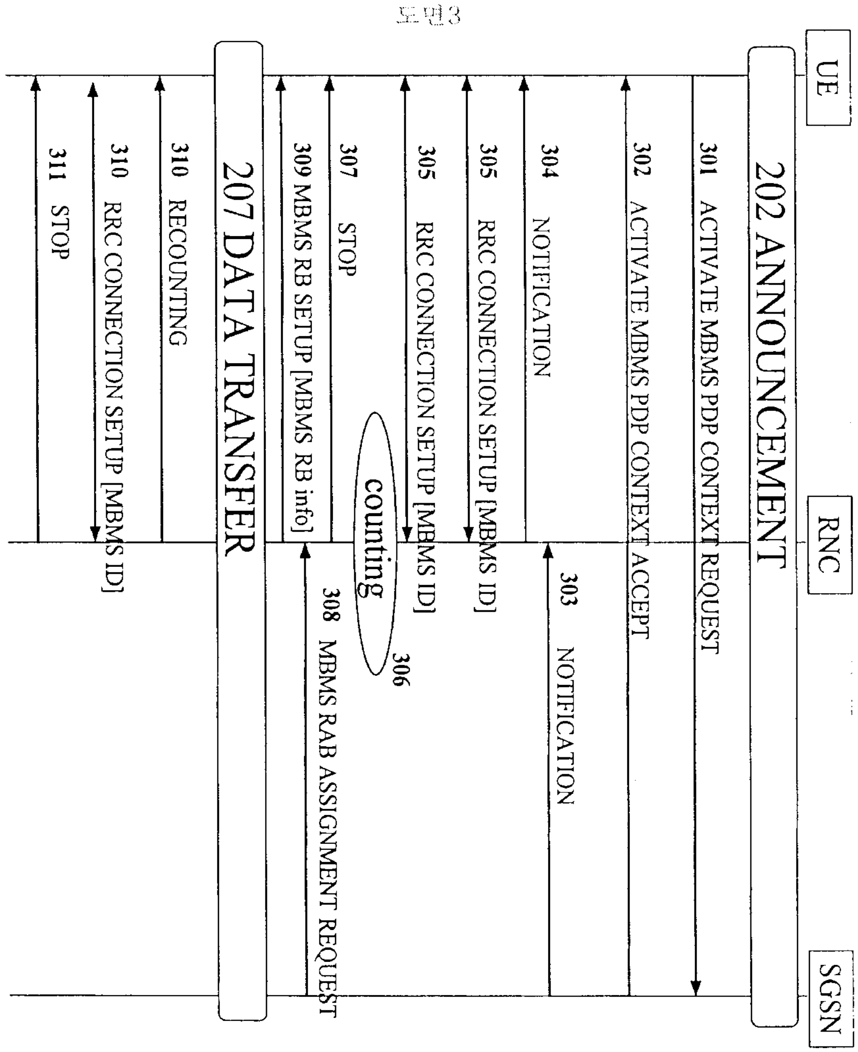
도면1


110
MB-SC
120
TRANSIT
NW
130
SGSN
140
RNC
.....
CELL 1
160
CELL 2
170
UE 1
161
UE 2
162
UE 3
163
UE 4
171
UE 5
172

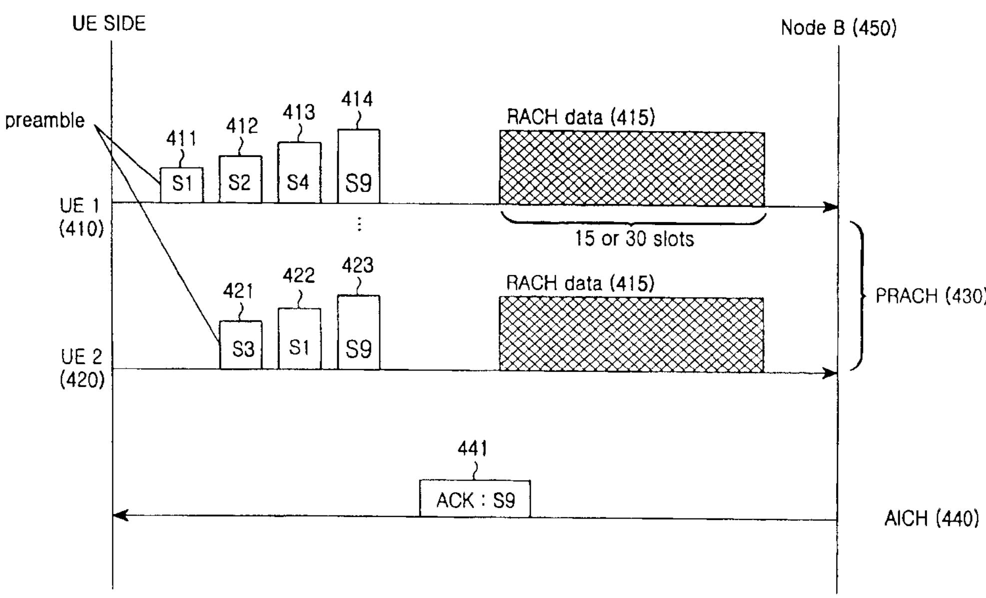
도면2


UE
RNC
CN
SUBSCRIPTION
201
ANNOUNCEMENT
202
JOINING
203
multicast mode bearer setup
204
NOTIFICATION
205
RADIO RESOURCE ALLOCATION
206
DATA TRANSFER
207
RADIO RESOURCE RELEASE
208

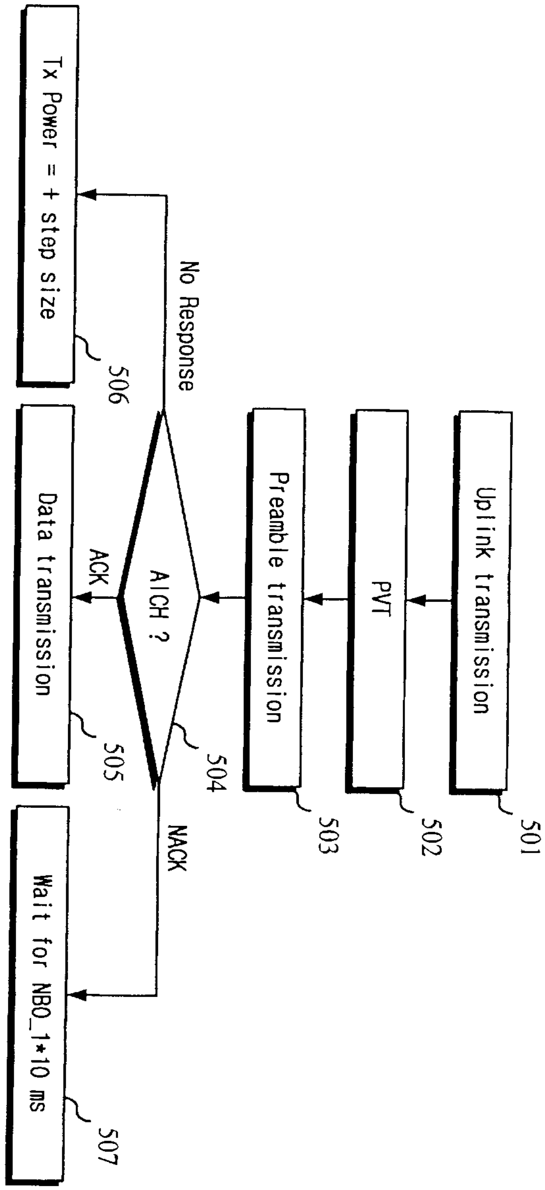
도면3


UE
RNC
SGSN
202 ANNOUNCEMENT
301 ACTIVATE MBMS PDP CONTEXT REQUEST
302 ACTIVATE MBMS PDP CONTEXT ACCEPT
303 NOTIFICATION
304 NOTIFICATION
305 RRC CONNECTION SETUP [MBMS ID]
305 RRC CONNECTION SETUP [MBMS ID]
counting
306
307 STOP
308 MBMS RAB ASSIGNMENT REQUEST
309 MBMS RB SETUP [MBMS RB info]
207 DATA TRANSFER
310 RECOUNTING
310 RRC CONNECTION SETUP [MBMS ID]
311 STOP

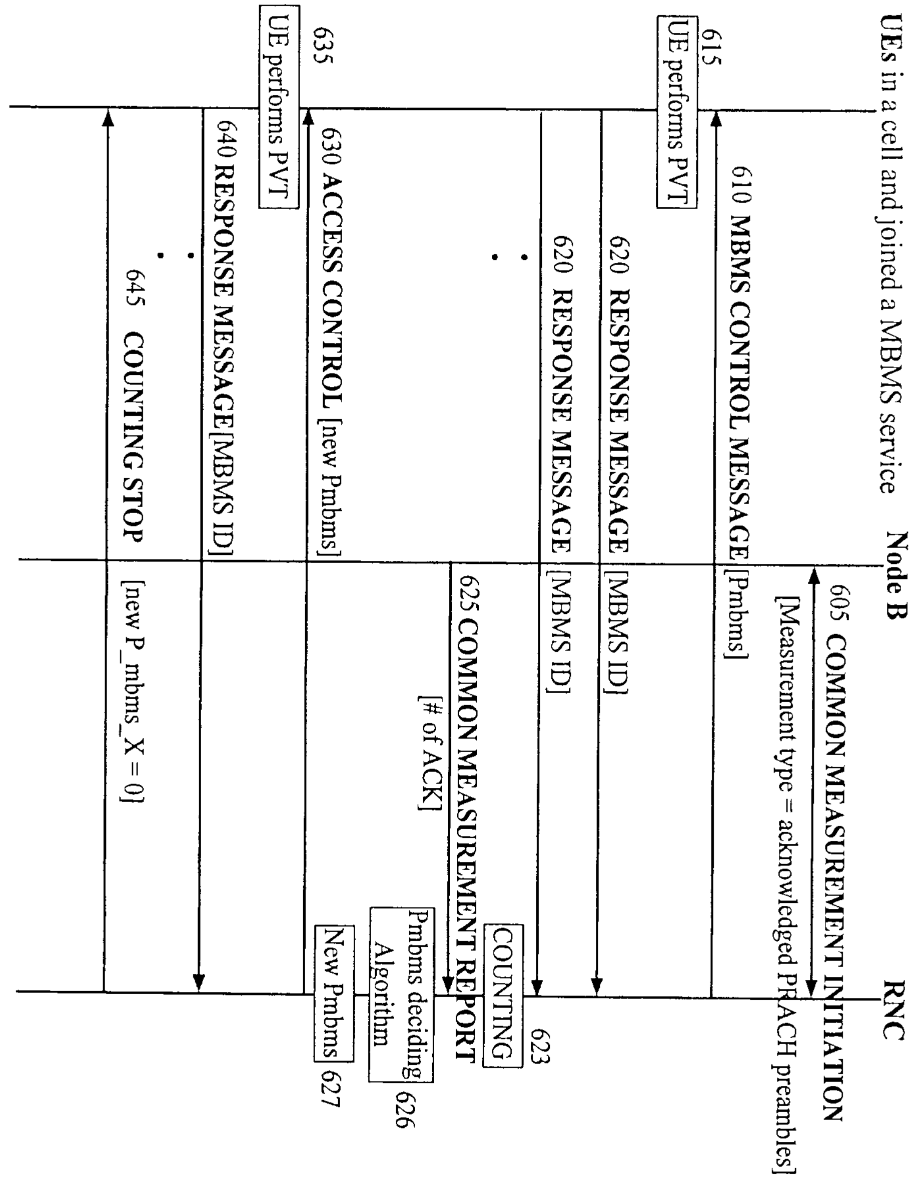
도면4


UE SIDE
Node B (450)
preamble
411
412
413
414
S1
S2
S4
S9
RACH data (415)
UE 1
(410)
15 or 30 slots
421
422
423
S3
S1
S9
RACH data (415)
PRACH (430)
UE 2
(420)
441
ACK : S9
AICH (440)

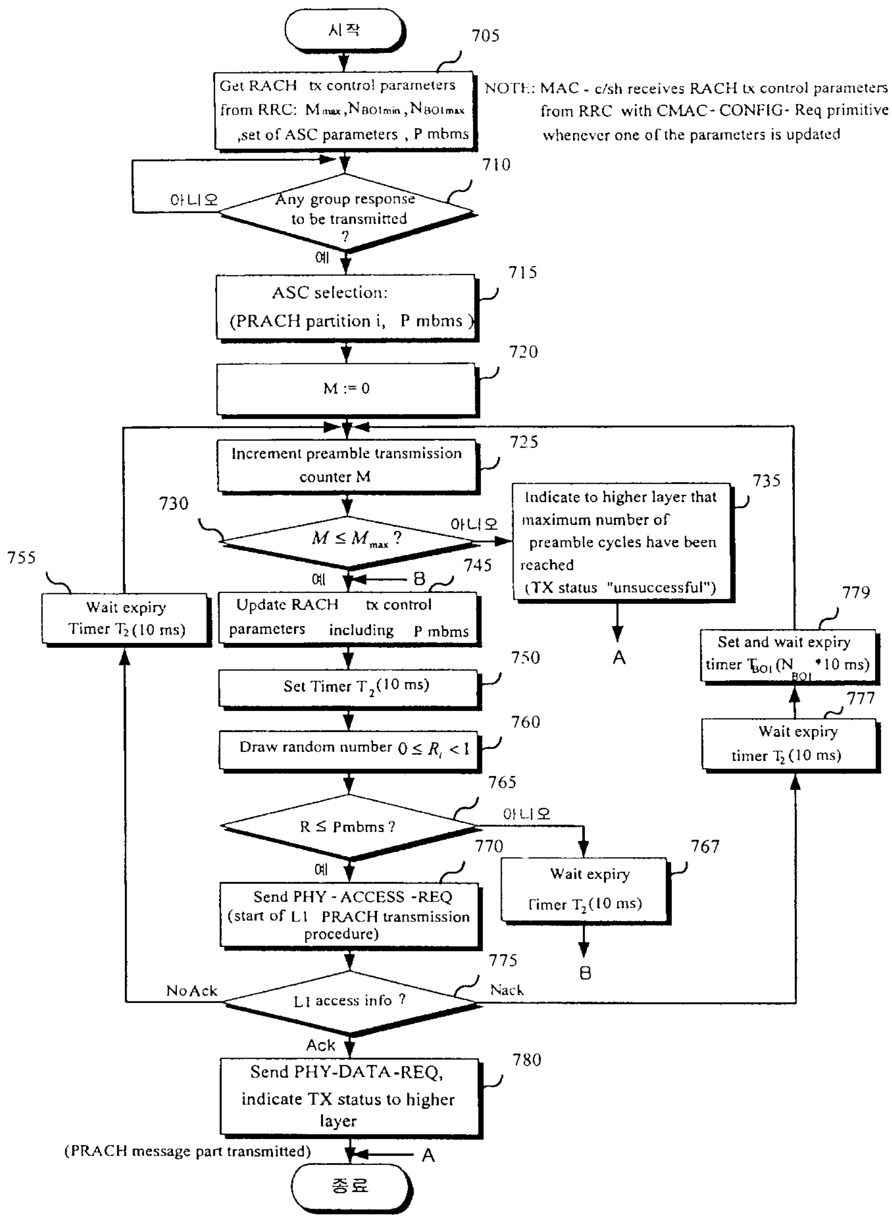
도면5


Uplink transmission
501
PVT
502
Preamble transmission
503
AICH ?
504
ACK
Data transmission
505
No Response
Tx Power = + step size
506
NACK
Wait for NBO_1*10 ms
507

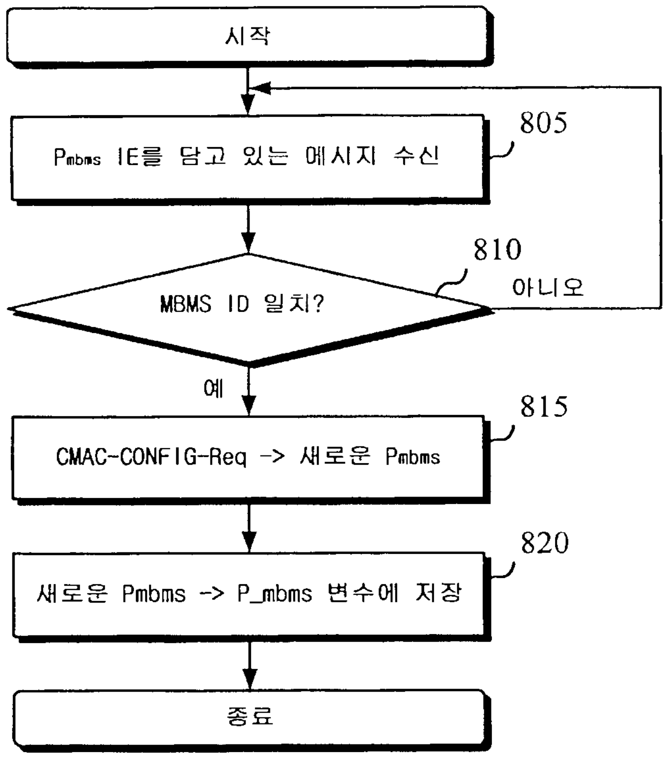
도면6


UEs in a cell and joined a MBMS service
Node B
RNC
605 COMMON MEASUREMENT INITIATION
[Measurement type = acknowledged PRACH preambles]
610 MBMS CONTROL MESSAGE [Pmbms]
615
UE performs PVT
620 RESPONSE MESSAGE [MBMS ID]
620 RESPONSE MESSAGE [MBMS ID]
623
COUNTING
625 COMMON MEASUREMENT REPORT
[# of ACK]
Pmbms deciding Algorithm
626
New Pmbms
627
630 ACCESS CONTROL [new Pmbms]
635
UE performs PVT
640 RESPONSE MESSAGE[MBMS ID]
645 COUNTING STOP
[new P_mbms_X = 0]

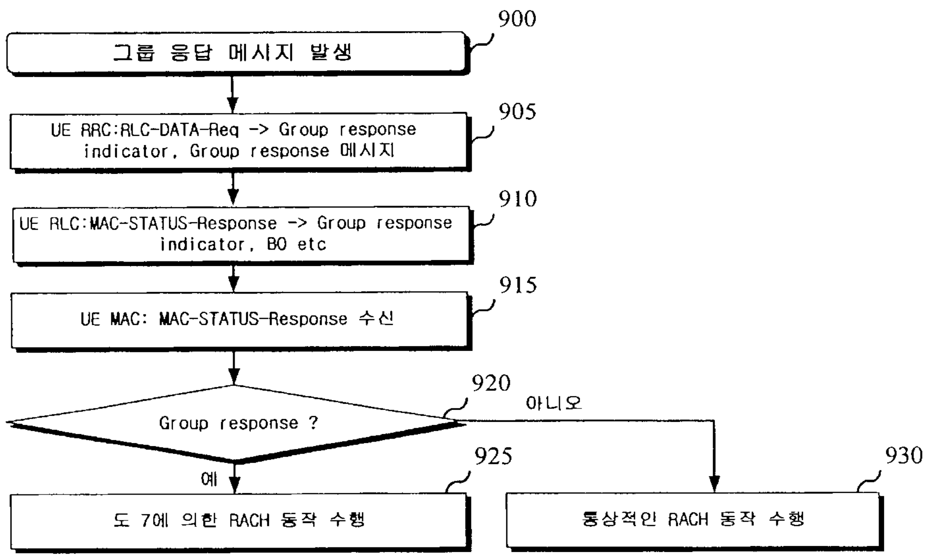
도면7


시작
705
Get RACH tx control parameters from RRC: Mmax, NBO1min, NBO1max, set of ASC parameters, P mbms
NOTE: MAC - c/sh receives RACH tx control parameters from RRC with CMAC-CONFIG-Req primitive whenever one of the parameters is updated
710
아니오
Any group response to be transmitted ?
예
715
ASC selection: (PRACH partition i, P mbms)
720
M := 0
725
Increment preamble transmission counter M
730
M ≤ Mmax ?
아니오
735
Indicate to higher layer that maximum number of preamble cycles have been reached (TX status "unsuccessful")
A
755
Wait expiry Timer T2 (10 ms)
예
B
745
Update RACH tx control parameters including P mbms
750
Set Timer T2 (10 ms)
760
Draw random number 0 ≤ Ri < 1
765
R ≤ Pmbms ?
아니오
767
Wait expiry Timer T2 (10 ms)
B
770
예
Send PHY-ACCESS-REQ (start of L1 PRACH transmission procedure)
775
L1 access info ?
NoAck
Nack
779
Set and wait expiry timer TBO1 (NBO1 * 10 ms)
777
Wait expiry timer T2 (10 ms)
Ack
780
Send PHY-DATA-REQ, indicate TX status to higher layer
(PRACH message part transmitted)
A
종료

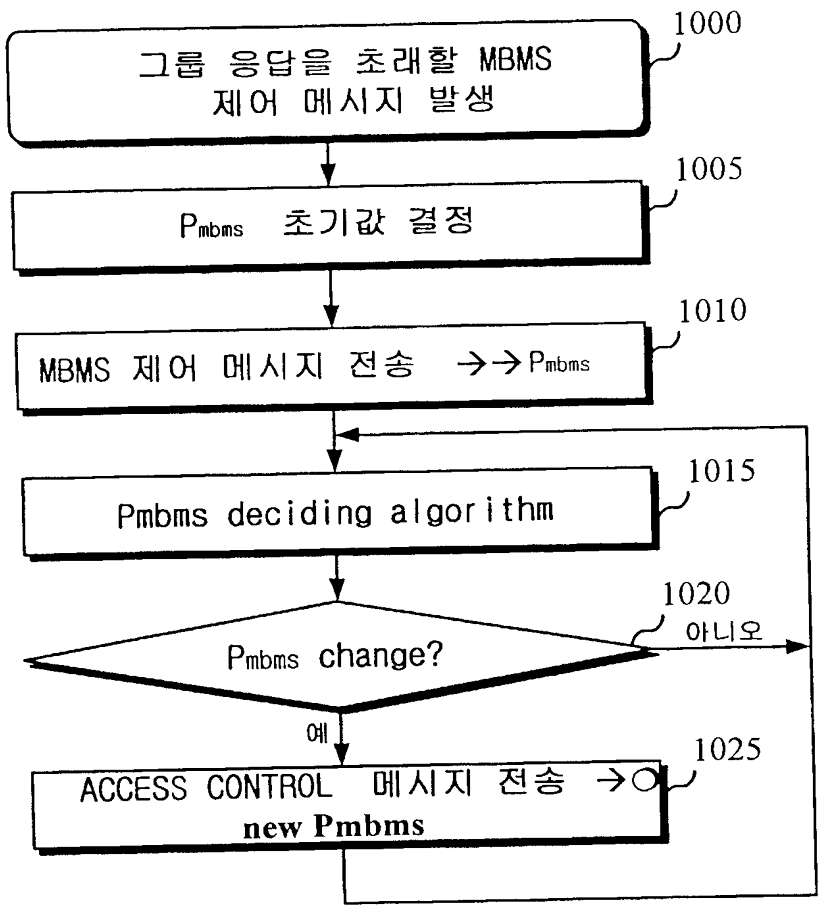
도면8


시작
805
Pmbms IE를 담고 있는 메시지 수신
810
MBMS ID 일치?
아니오
예
815
CMAC-CONFIG-Req -> 새로운 Pmbms
820
새로운 Pmbms -> P_mbms 변수에 저장
종료

도면9


900
그룹 응답 메시지 발생
905
UE RRC:RLC-DATA-Req -> Group response indicator, Group response 메시지
910
UE RLC:MAC-STATUS-Response -> Group response indicator, BO etc
915
UE MAC: MAC-STATUS-Response 수신
920
Group response ?
아니오
예
925
도 7에 의한 RACH 동작 수행
930
통상적인 RACH 동작 수행

도면10


1000
그룹 응답을 초래할 MBMS 제어 메시지 발생
1005
Pmbms 초기값 결정
1010
MBMS 제어 메시지 전송 →→Pmbms
1015
Pmbms deciding algorithm
1020
Pmbms change?
아니오
예
1025
ACCESS CONTROL 메시지 전송 →○
new Pmbms

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(54) **Hybrid automatic repeat request combining method and system in orthogonal frequency division multiplexing system**

(57) The present invention provides a HARQ (Hybrid Automatic Repeat Request) combining method in an OFDM (Orthogonal Frequency Division Multiplexing) system, which adopts improved Chase combining method weighted by SNR and variance of SNR to realize HARQ combining. The method can improve system performance in processing power and time delay, particularly in low SNR environment, and will not make the system more complex.

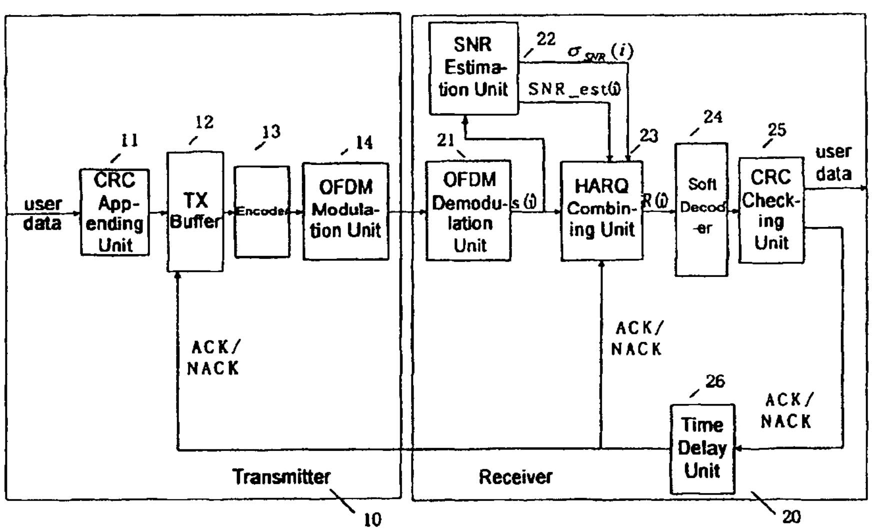


Fig.1

EP 1 496 639 A2

Description

FIELD OF THE INVENTION

[0001] The present invention generally relates to a mobile communication system and particularly to a HARQ (Hybrid Automatic Repeat Request) combining method in an OFDM (Orthogonal Frequency Division Multiplexing) system.

BACKGROUND OF THE INVENTION

[0002] Existing simple combining techniques use Chase combining weighted by SNR (signal-to-noise ratio) to realize HARQ combining. Here, SNR is an average value over a period of time (for example, a data frame).

[0003] There are two cases in relatively low SNR environment: 1) variance of SNR may be relatively high over the same period of time; 2) variance of SNR may be relatively low over the same period of time. The first case indicates that time selective fading of the signal is very serious. The effect of fast fading in time domain may be neglected and the performance of HARQ combining at the receiver side may be reduced if only Chase combining weighted by SNR is simply adopted to realize HARQ combing.

SUMMARY OF THE INVENTION

[0004] The object of the present invention is to provide a HARQ combining method in an OFDM system, which can solve problems existing in the prior art, improve system performance in throughput and time delay, and reduce the system retransmission times at the same time.

[0005] The HARQ combining method in an OFDM system according to the present invention comprises the following steps:

a. A transmitter transmitting data to a receiver in a unit of frame, then the receiver weighting the received data based on its SNR and variance of SNR and storing the weighted data as final data in a buffer of a HARQ combining unit, and later, the receiver processing the stored final data to determine whether the received data frames are correct;

b. If the data frames are correct, the receiver outputting the final data and feeding back an ACK indicator respectively to the HARQ combining unit of the receiver and the transmitter, and if the data frames are not correct, the receiver feeding back a NACK indicator respectively to the HARQ combining unit of the receiver and the transmitter;

c. When the HARQ combining unit of the receiver and the transmitter receives an ACK indicator, the process returning to step a, until all data has been transmitted;

d. When the HARQ combining unit of the receiver and the transmitter receives a NACK indicator, the transmitter retransmitting original data to the receiver, then the HARQ combining unit of the receiver weighting the received retransmission data based on its SNR and variance of SNR, and combining the weighted retransmission data with the data stored in the buffer of the HARQ combining unit, and at the same time, storing the combined data as final data in the buffer of the HARQ combining unit, then the receiver processing the combined final data to determine whether the combined data frames are correct, and returning to step b.

[0006] In step a, before the transmitter transmits data to the receiver in a unit of frame, the data needs to undergo some processes including CRC appending, encoding and OFDM modulating in turn, and at the same time storing the data after CRC appending and before encoding in a TX buffer as final data in order to facilitate possible retransmission. In step a, before the receiver weights the received data based on its SNR and variance of SNR, the receiver has to OFDM-demodulate the received data. In step a, the receiver processes the stored final data, including in turn soft decoding and CRC checking, and then obtaining an ACK or NACK indicator based on the determining whether the received data is correct by CRC checking.

[0007] In step b, the ACK or NACK indicator fed back to the transmitter is inputted to the TX buffer. When said TX buffer receives an ACK indicator, it will store new data as final data in itself, whereas when said TX buffer receives a NACK indicator, it will hold original final data unchanged.

[0008] In step d, before the HARQ combining unit of the receiver weights the received retransmission data based on its SNR and variance of SNR, the receiver has to OFDM-demodulate the received retransmission data. In step d, the receiver SNR-estimates the OFDM-demodulated retransmission data to obtain its SNR and variance of SNR. In Step d, the receiver processes the combined final data, including in turn soft decoding and CRC checking, and then obtaining an ACK or NACK indicator based on the determining whether the combined data frames are correct by CRC checking.

[0009] Here, in the receiver of the present invention, the processes for weighting the received data and weighted combining the retransmission data can be realized according to the following formula:

$$\begin{cases} R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}{\sum_{i=0}^{N_{retrans}} \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}, & SNR\_est(i) < SNR_{threshold} \text{ and } \sigma_{SNR}(i) > \sigma_{threshold} \\ R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * SNR\_est(i)}{\sum_{i=0}^{N_{retrans}} SNR\_est(i)}, & SNR\_est(i) \geq SNR_{threshold} \text{ or } \sigma_{SNR}(i) \leq \sigma_{threshold} \end{cases},$$

where i indicates the i-th retransmission, and $i \geq 0$;
$N_{retrans}$ indicates the retransmission times of a transmission block, and $1 \leq N_{retrans} \leq N_{\max}$;
$N_{\max}$ indicates the maximum retransmission times of a transmission block;
$R(i)$ indicates the data after the i-th combining;
$S(i)$ indicates the data before the i-th combining;
$SNR\_est(i)$ indicates SNR of the i-th estimation;
$SNR_{threshold}$ indicates the threshold of SNR;
$\sigma_{SNR}(i)$ indicates variance of SNR of the i-th estimation;
$\sigma_{threshold}$ indicates the threshold of variance of SNR.

[0010] The receiver in the OFDM system of the present invention comprises:

a SNR estimation unit for SNR-estimating the demodulated data to obtain estimated SNR and variance of SNR and outputting them;

a HARQ combining unit for receiving the output from the SNR estimation unit, weighting inputted demodulated data based on inputted SNR and variance of SNR, and storing the weighted data as final data in a buffer of said HARQ combining unit, then determining whether to execute the combining based on determining whether the received data frames are correct: if the received data frames are correct, not executing the combining; if the received data frames are not correct, weighting the inputted demodulated retransmission data based on its SNR and variance of SNR, and combining the weighted retransmission data with the data stored in the buffer of said HARQ combining unit and storing the combined data as final data in the buffer of said HARQ combining unit.

[0011] The present invention implements a hybrid automatic repeat request combining method in an OFDM system by means of improved Chase combining weighted by SNR and variance of SNR. The method improves system performance in throughput and time delay, particularly in low SNR environment, and will not make the system more complex.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The present invention will now be further described in combination with the attached drawings and exemplary embodiments of the present invention.

Fig. 1 is a schematic illustrating relevant structure of the receiver and transmitter for performing the HARQ combining method of the present invention in an OFDM system;

Fig. 2 is a simulation curve chart of SNR - Bit Error Ratio (BER) in which the HARQ combining method of the present invention is compared with normal Chase combining method and non-weighted data combining method;

Fig. 3 is a simulation curve chart of SNR - System Throughput in which the HARQ combining method of the present invention is compared with normal Chase combining method and non-weighted data combining method; and

Fig. 4 is a simulation curve chart of SNR - Time Delay in which the HARQ combining method of the present invention is compared with normal Chase combining method and non-weighted data combining method.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] With reference to the attached drawings and preferred embodiments, the present invention will now be further described.

[0014] Fig. 1 is a schematic illustrating related structure of the receiver and transmitter for performing the HARQ combining method of the present invention in an OFDM system. As shown in Fig. 1, at the side of Transmitter 10, firstly, CRC Appending Unit 11 of Transmitter 10 appends CRC to inputted user data in unit of frame and stores the appended user data with CRC bit as final user data in TX Buffer (transmitter buffer) 12. Then, TX Buffer 12 transmits the stored user data to Encoder 13, which encodes the user data inputted from TX Buffer 12 and outputs the result to OFDM Modulation Unit 14. And later, OFDM Modulation Unit 14 transmits the OFDM-modulated user data to a transmission unit of Transmitter 10 (not shown in Fig. 1), which transmits the user data to radio channels (not shown in Fig. 1).

[0015] At the side of Receiver 20, firstly, after a receiving unit of Receiver 20 (not shown in Fig. 1) receives the user data transmitted from Transmitter 10 from radio channels, OFDM Demodulation Unit 21 OFDM-demodulates the received user data and inputs the result, i.e., user data ***S*(0)** to HARQ Combining Unit 23 and SNR Estimation Unit 22, respectively. SNR Estimation Unit 22 SNR-estimates the user data ***S*(0)** to get estimation values of SNR and variance of SNR, i.e., ***SNR_est*(0)** and $\sigma_{SNR}(0)$, of the user data ***S*(0)**. Then ***SNR_est*(0)** and $\sigma_{SNR}(0)$ are inputted together into HARQ Combining Unit 23. HARQ Combining Unit 23 weights the user data ***S*(0)** based on estimated SNR and Variance of SNR, i.e., ***SNR_est*(0)** and $\sigma_{SNR}(0)$ to get weighted user data ***R*(0)**, and stores the result, i.e., weighted user data ***R*(0)** as final user data in the buffer of HARQ Combining Unit 23. And later, HARQ Combining Unit 23 inputs the user data ***R*(0)** to Soft Decoder 24, in which the inputted user data ***R*(0)** is soft decoded and outputted to CRC Checking Unit 25. CRC Checking Unit 25 determines whether the user data frames received by Receive 20 are correct and then gets an ACK or NACK indicator accordingly.

[0016] If CRC Checking Unit 25 determines the user data received by receiver 20 are correct, CRC Checking Unit 25 will output the user data after CRC checking and issue an ACK indicator, which is fed back respectively to HARQ Combining Unit 23 of Receiver 20 and TX Buffer 12 of Transmitter 10. There should be a certain time delay before HARQ Combining Unit 23 of Receiver 20 and TX Buffer 12 of Transmitter 10 receive the ACK indicator, respectively, so the ACK indicator issued from CRC Checking Unit 25 of Receiver 20 is delayed by Time Delay Unit 26 of Receiver 20 before fed back to HARQ Combining Unit 23 of Receiver 20 and TX Buffer 12 of Transmitter 10, respectively.

[0017] When TX Buffer 12 of Transmitter 10 and HARQ Combining Unit 23 of Receiver 20 receive an ACK indicator, the operating procedures for transmitting user data at the side of the transmitter and for receiving user data at the side of the receiver are repeated. That is, TX Buffer 12 of Transmitter 10 gets new user data after CRC appending (in unit of frame), and stores it as final user data. Then the stored user data is transmitted to radio channels (not shown in Fig. 1) via a transmission unit (not shown in Fig. 1) after encoded and OFDM modulated by Transmitter 10. Receiver 20 receives the new user data transmitted by Transmitter 10 from radio channels (not shown in Fig. 1) and processes the received new user data, including OFDM demodulating, SNR estimating and weighting in turn, and at the same time storing weighted new user data as final user data in the buffer of HARQ Combining Unit 23. And later, the stored user data is soft decoded and CRC checked to determine whether the received new user data frames are correct. If the received new user data frames are correct, Receiver 20 outputs the user data after CRC checking and feeds back an ACK indicator to HARQ Combining Unit 23 of Receiver 20 and TX Buffer 12 of Transmitter 10 simultaneously. Thus, all these processes form a loop.

[0018] If CRC Checking Unit 25 determines the received user data frames are not correct, CRC Checking Unit 25 of Receiver 20 will issue a NACK indicator. In the same way, the NACK indicator is also delayed by Time Delay Unit 26 and fed back to HARQ Combining Unit 23 of Receiver 20 and TX Buffer 12 of Transmitter 10, respectively.

[0019] When HARQ Combining Unit 23 of Receiver 20 and TX Buffer 12 of Transmitter 10 receive a NACK indicator, TX Buffer 12 of Transmitter 10 does not get new user data, and retransmits the stored final user data to Encoder 13 and OFDM Modulation Unit 14 to encode and modulate it. After that, the user data is transmitted to radio channels (not shown in Fig. 1) via the transmission unit (not shown in Fig. 1). After receiving the user data retransmitted by Transmitter 10 from radio channels (not shown in Fig.1), Receiver 20 OFDM-demodulates the retransmission user data to get retransmission data ***S*(1)** and inputs the retransmission data ***S*(1)** into SNR Estimation Unit 22 and HARQ Combining Unit 23, respectively. SNR Estimation Unit 22 SNR-estimates the retransmission data ***S*(1)** to get its estimation values of SNR and Variance of SNR, i.e., ***SNR_est*(1)** and $\sigma_{SNR}(1)$, and inputs the estimated ***SNR_est*(1)** and $\sigma_{SNR}(1)$ together into HARQ Combining Unit 23. HARQ Combining Unit 23 weights the inputted retransmission data ***S*(1)** based on its ***SNR_est*(1)** and $\sigma_{SNR}(1)$, then gets user data ***R*(1)** by combining the weighted retransmission data and final user data ***S*(0)** stored in the buffer of HARQ Combining Unit 23, and at the same time stores the combined user data ***R*(1)** as final user data in the buffer of HARQ Combining Unit 23.

[0020] Then, HARQ Combining Unit 23 inputs the combined user data $R(1)$ into Soft Decoder 24 to decode it. Soft Decoder 24 outputs soft-decoded data to CRC Checking Unit 25 to determine whether the received retransmission user data is correct. If the received retransmission user data is not correct, Receiver 20 feeds back a NACK indicator to HARQ Combining Unit 23 of Receiver 20 and TX Buffer Unit 12 of Transmitter 10, respectively. When HARQ Combining Unit 23 of Receiver 20 and TX Buffer Unit 12 of Transmitter 10 receive the NACK indicator, the operating procedures for retransmitting user data at the side of the transmitter and for receiving retransmitted user data at the side of the receiver are repeated. That is, after encoded and OFDM modulated by Transmitter 10, the final user data in TX Buffer 12 is retransmitted to radio channels (not shown in Fig. 1) via the transmission unit (not shown in Fig. 1). After receiving the user data retransmitted by Transmitter 10 from radio channels (not shown in Fig. 1), Receiver 20 gets retransmission data $S(2)$ by OFDM demodulation, and then gets $SNR\_est(2)$ and $\sigma_{SNR}(2)$ by SNR-estimating the retransmission data $S(2)$. HARQ Combining Unit 23 weights the inputted retransmission data $S(2)$ based on inputted $SNR\_est(2)$ and $\sigma_{SNR}(2)$, and then combines the weighted retransmission data with the final user data $S(1)$ in the buffer of HARQ Combining Unit 23 to get user data $R(2)$, which is stored as final user data in the buffer of HARQ Combining Unit 23. And later, $R(2)$ is soft decoded and CRC-checked by Receiver 20 to determine whether the received new retransmission user data is correct. If the received retransmission user data is not correct, Receiver 20 feeds back a NACK indicator respectively to HARQ Combining Unit 23 of Receiver 20 and TX Buffer 12 of Transmitter 10, thus constituting a loop. The loop will go on until the received new retransmission user data is correct. Then Receiver 20 outputs the retransmission user data and feeds back an ACK indicator respectively to HARQ Combining Unit 23 of Receiver 20 and TX Buffer 12 of Transmitter 10 simultaneously.

[0021] The above weighted combining process can be realized according to the following formula:

$$\begin{cases} R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}{\sum_{i=0}^{N_{retrans}} \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}, & SNR\_est(i) < SNR_{threshold} \text{ and } \sigma_{SNR}(i) > \sigma_{threshold} \\ R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * SNR\_est(i)}{\sum_{i=0}^{N_{retrans}} SNR\_est(i)}, & SNR\_est(i) \geq SNR_{threshold} \text{ or } \sigma_{SNR}(i) \leq \sigma_{threshold} \end{cases},$$

Where i indicates the i-th retransmission and $i \geq 0$;
$N_{retrans}$ indicates the retransmission times of a transmission block, and $1 \leq N_{retrans} \leq N_{max}$;
N_{max} indicates the maximum retransmission times of a transmission block;
$R(i)$ indicates the data after the i-th combining;
$S(i)$ indicates the data before the i-th combining;
$SNR\_est(i)$ indicates the SNR of the i-th estimation;
$SNR_{threshold}$ indicates the threshold of SNR;
$\sigma_{SNR}(i)$ indicates variance of SNR of the i-th estimation;
$\sigma_{threshold}$ indicates the threshold of variance of SNR.

[0022] According to above detailed description of the embodiment, the HARQ (Hybrid Automatic Repeat Requests) combining method in an OFDM (Orthogonal Frequency Division Multiplexing) System of the present invention can be summarized as the following steps:

a. A transmitter transmits data to a receiver in a unit of frame, then the receiver weights the received data based on its SNR and variance of SNR and stores the weighted data as final data in a buffer of a HARQ combining unit, and later, the receiver processes the stored final data to determine whether the received data frames are correct;

b. If the data frames are correct, the receiver will output the final data and feed back an ACK indicator respectively to the HARQ combining unit of the receiver and the transmitter, and if the data frames are not correct, the receiver will feed back a NACK indicator respectively to the HARQ combining unit of the receiver and the transmitter;

c. When the HARQ combining unit of the receiver and the transmitter receive an ACK indicator, the process returns to step a, until all data has been transmitted;

d. When the HARQ combining unit of the receiver and the transmitter receive a NACK indicator, the transmitter retransmits original data to the receiver, then the HARQ combining unit of the receiver weights the received retransmission data based on its SNR and variance of SNR, and combines the weighted retransmission data with the data stored in the buffer of the HARQ combining unit, and at the same time, stores the combined data as final data in the buffer of the HARQ combining unit, then the receiver processes the combined final data to determine whether the combined data frames are correct, after that, the process returns to Step b.

[0023] At the same time, from the above embodiment the receiver in the OFDM system of the present invention will be achieved, which includes:

a SNR estimation unit for SNR-estimating the demodulated data to obtain estimated SNR and variance of SNR and outputting them;

a HARQ combining unit for receiving the output from the SNR estimation unit, weighting inputted demodulated data based on its SNR and variance of SNR, and storing the weighted data as final data in a buffer of said HARQ combining unit, then determining whether to execute the combining based on the determination whether the received data frames are correct: if the received data frames are correct, not executing the combining; if the received data frames are not correct, weighting the inputted demodulated retransmission data based on its SNR and variance of SNR and combining the weighted retransmission data with the data in the buffer of said HARQ combining unit, and at the same time, storing the combined data as final data in the buffer of said HARQ combining unit.

[0024] The transmitter and other function modules of the receiver in the OFDM system can be realized by existing technologies. Thus, their description are omitted here.

[0025] Herein, in the receiver of the present invention, the process of the HARQ combining unit for weighting the received data and weighted combining the retransmission data based on its SNR and variance of SNR respectively can be realized according to the following formula:

$$\begin{cases} R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}{\sum_{i=0}^{N_{retrans}} \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}, & SNR\_est(i) < SNR_{threshold} \quad and \quad \sigma_{SNR}(i) > \sigma_{threshold} \\ R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * SNR\_est(i)}{\sum_{i=0}^{N_{retrans}} SNR\_est(i)}, & SNR\_est(i) \geq SNR_{threshold} \quad or \quad \sigma_{SNR}(i) \leq \sigma_{threshold} \end{cases},$$

Where i indicates the i-th retransmission and $i \geq 0$;
$N_{retrans}$ indicates the retransmission times of a transmission block, and $1 \leq N_{retrans} \leq N_{max}$;
N_{max} indicates the maximum retransmission times of a transmission block;
R(i) indicates the data after the i-th combining;
$S(i)$ indicates the data before the i-th combining;
$SNR\_est(i)$ indicates the SNR of the i-th estimation;
$SNR_{threshold}$ indicates the threshold of SNR;
$\sigma_{SNR}(i)$ indicates variance of SNR of the i-th estimation;
$\sigma_{threshold}$ indicates the threshold of variance of SNR.

[0026] Figures 2, 3, and 4 show the simulation curve chart of SNR-BER (Bit Error Ratio), SNR-Throughput and SNR-Time Delay according to comparing examples of the present invention, respectively. As show in Figures 2-4, curves a1, a2, and a3 indicate the simulation curves when employing non-weighted combining method, curves b1, b2, and b3 indicate the simulation curves when employing normal Chase combining method weighted by SNR, and curves c1, c2, and c3 indicate the simulation curves when employing improved Chase combining method weighted by SNR and variance of SNR of the present invention.

[0027] The simulation curves shown in Figures 2-4 are obtained in the following simulation environments: in an OFDM system; the carrier frequency is 3.2GHz; the channel is an outdoor multipath channel A with AWGN+UMTS; the mobile speed is 120km/h; coding mode is 1/3 Turbo coding; modulation mode is 16QAM; CRC is 24-bit; channel estimation and SNR estimation are ideal; the simulation point is 10240*150; and the maximum retransmission times are set to 5. According to Figures 2, 3, and 4, the improved Chase combining method weighted by SNR and variance of SNR of the present invention improves not only the performance of BER, but also system performance in throughput and time delay. And in relatively low SNR (less than 11dB) environment, the improvement of system performance in throughput and time delay of the method is remarkable. Thus, the improved Chase combining method weighted by SNR and variance of SNR of the present invention has more advantages, particularly in low SNR environment, which is the common condition in mobile communication systems.

[0028] As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof except as defined in the appended claims.

Claims

1. A Hybrid Automatic Repeat Request (HARQ) combining method in an Orthogonal Frequency Division Multiplexing (OFDM) system, comprising steps of:

   a. a transmitter transmitting data to a receiver in a unit of frame, then the receiver weighting the received data based on its SNR and variance of SNR and storing the weighted data as final data in a buffer of a HARQ combining unit, and later, the receiver processing the stored final data to determine whether the received data frames are correct;

   b. if the data frames are correct, the receiver outputting the final data and feeding back an ACK indicator respectively to the HARQ combining unit of the receiver and the transmitter, and if the data frames are not correct, the receiver feeding back a NACK indicator respectively to the HARQ combining unit of the receiver and the transmitter;

   c. when the HARQ combining unit of the receiver and the transmitter receiving an ACK indicator, the process returning to step a, until all data has been transmitted;

   d. when the HARQ combining unit of the receiver and the transmitter receiving a NACK indicator, the transmitter retransmitting original data to the receiver, then the HARQ combining unit of the receiver weighting the received retransmission data based on its SNR and variance of SNR, and combining the weighted retransmission data with the data stored in the buffer of the HARQ combining unit, and at the same time, storing the combined data as final data in the buffer of the HARQ combining unit, then the receiver processing the combined final data to determine whether the combined data frames are correct, after that, the process returning to step b.

2. The HARQ combining method according to Claim 1, wherein in said step a, before the transmitter transmits data to the receiver in unit of frame, the data needs to undergo processes of CRC appending, coding and OFDM modulating in turn, and at the same time storing the data after CRC appending and before coding as final data in a TX buffer in order to facilitate possible retransmission.

3. The HARQ combining method according to Claim 2, wherein in said step a, before the receiver weights the received data based on its SNR and variance of SNR, the receiver has to OFDM-demodulate the received data.

4. The HARQ combining method according to Claim 3, wherein in said step a, the receiver processes stored final data including soft decoding and CRC checking in turn, and then obtaining an ACK or NACK indicator based on the determination whether the received data is correct by CRC checking.

5. The HARQ combining method according to Claim 1, wherein in said step b, the ACK or NACK indicator fed back to the transmitter is inputted to the TX buffer, and if said TX buffer receives an ACK indicator, it will store new data as final data in itself, and if said TX buffer receives a NACK indicator, it will hold the final data unchanged.

6. The HARQ combining method according to Claim 4, wherein in said step d, before the HARQ combining unit of the receiver weights the received retransmission data based on its SNR and variance of SNR, the receiver has to OFDM-demodulate the received retransmission data.

7. The HARQ combining method according to Claim 6, wherein in said step d, the SNR and variance of SNR of the retransmission data are obtained by the receiver by SNR-estimating the received OFDM-demodulated retrans-

mission data.

8. The HARQ combining method according to Claim 7, wherein in said step d, the receiver processes the combined final data including soft decoding and CRC checking in turn, and then obtaining an ACK or NACK indicator based on the determination whether the combined data frames are correct by CRC checking.

9. The HARQ combining method according to Claim 1, wherein the process of said Receiver for weighting the received data and weighted combining said retransmission data is implemented according to the following formula:

$$\begin{cases} R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}{\sum_{i=0}^{N_{retrans}} \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}, & SNR\_est(i) < SNR_{threshold} \text{ and } \sigma_{SNR}(i) > \sigma_{threshold} \\ R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * SNR\_est(i)}{\sum_{i=0}^{N_{retrans}} SNR\_est(i)}, & SNR\_est(i) \geq SNR_{threshold} \text{ or } \sigma_{SNR}(i) \leq \sigma_{threshold} \end{cases},$$

where i indicates the i-th retransmission, and $i \geq 0$; $N_{retrans}$ indicates the retransmission times of a transmission block, and $1 \leq N_{retrans} \leq N_{max}$;
N_{max} indicates the maximum retransmission times of a transmission block;
$R(i)$ indicates the data after the i-th combining;
$S(i)$ indicates the data before the i-th combing;
$SNR\_est(i)$ indicates the SNR of the i-th estimation;
$SNR_{threshold}$ indicates the threshold of SNR;
$\sigma_{SNR}(i)$ indicates variance of SNR of the i-th estimation;
$\sigma_{threshold}$ indicates the threshold of variance of SNR.

10. A receiver in an OFDM system, comprising:

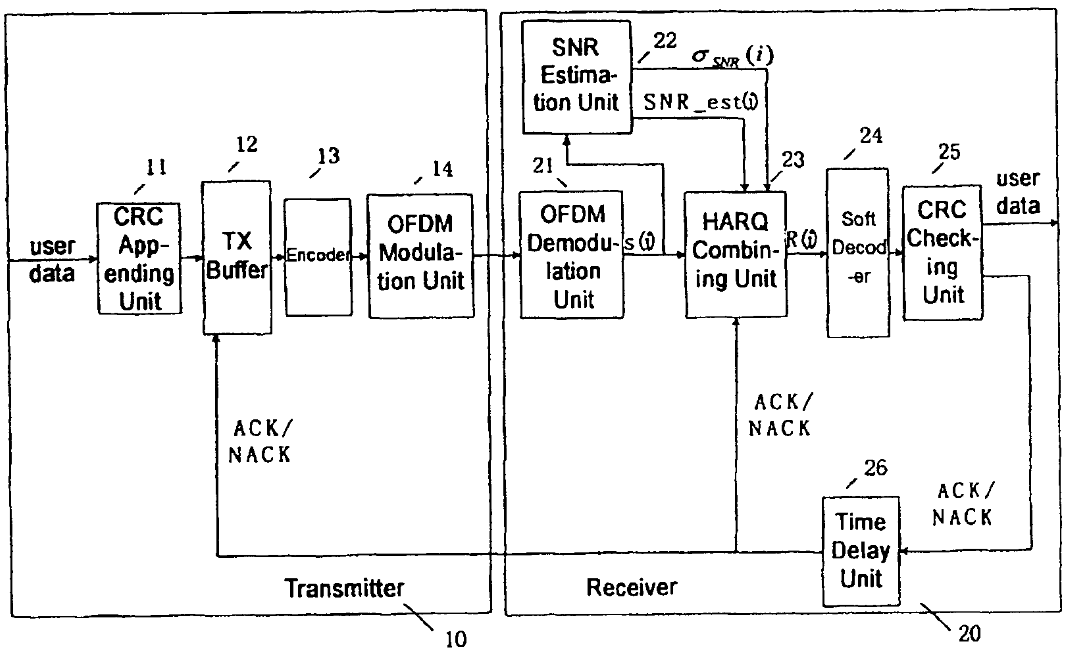
a SNR estimation unit for SNR-estimating demodulated data to obtain estimated SNR and variance of SNR and outputting them;

a HARQ combining unit for receiving the output from the SNR estimation unit, weighting inputted demodulated data based on inputted SNR and variance of SNR, and storing the weighted data as final data in a buffer of said HARQ combining unit, then determining whether to execute the combining based on the determination whether the received data frames are correct: if the received data frames are correct, not executing the combination; if the received data frames are not correct, weighting the inputted demodulated retransmission data based on its SNR and variance of SNR , combining the weighted retransmission data with the data in the buffer of said HARQ combining unit, and storing the combined data as final data in the buffer of said HARQ combining unit.

11. The receiver according to Claim 10, wherein the processes for weighting the demodulated data and weighted combining said inputted demodulated retransmission data is implemented according to the following formula:

$$\begin{cases} R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}{\sum_{i=0}^{N_{retrans}} \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}, & SNR\_est(i) < SNR_{threshold} \quad and \quad \sigma_{SNR}(i) > \sigma_{threshold} \\ R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * SNR\_est(i)}{\sum_{i=0}^{N_{retrans}} SNR\_est(i)}, & SNR\_est(i) \geq SNR_{threshold} \quad or \quad \sigma_{SNR}(i) \leq \sigma_{threshold} \end{cases},$$

where i indicates the i-th retransmission, and $i \geq 0$; $N_{retrans}$ indicates the retransmission times of a transmission block, and $1 \leq N_{retrans} \leq N_{\max}$;
N_{max} indicates the maximum retransmission times of a transmission block;
$R(i)$ indicates the data after the i-th combining;
$S(i)$ indicates the data before the i-th combining;
$SNR\_est(i)$ indicates the SNR of the i-th estimation;
$SNR_{threshold}$ indicates the threshold of SNR;
$\sigma_{SNR}(i)$ indicates the variance of SNR of the i-th estimation;
$\sigma_{threshold}$ indicates the threshold of Variance of SNR.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R(i)
Soft Decod-er
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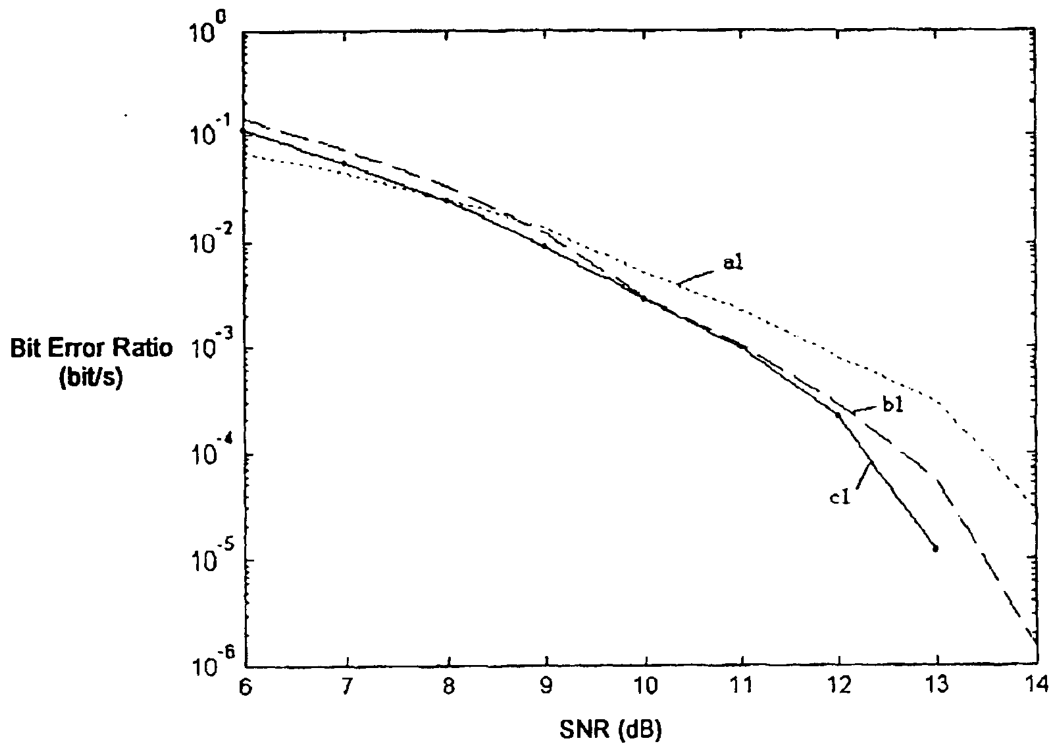
Transmitter
Receiver
10
20

Fig.1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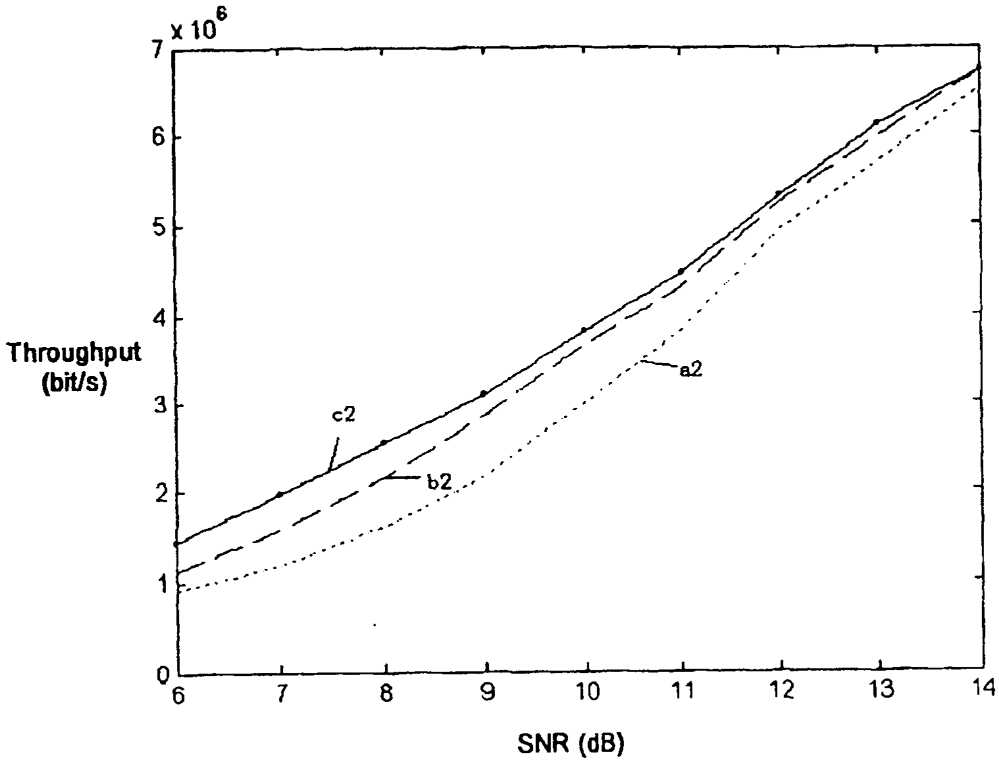
b1
c1

Fig.2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6
5
4
3
2
1
0
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b2
a2
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7
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10
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12
13
14
SNR (dB)

Fig.3

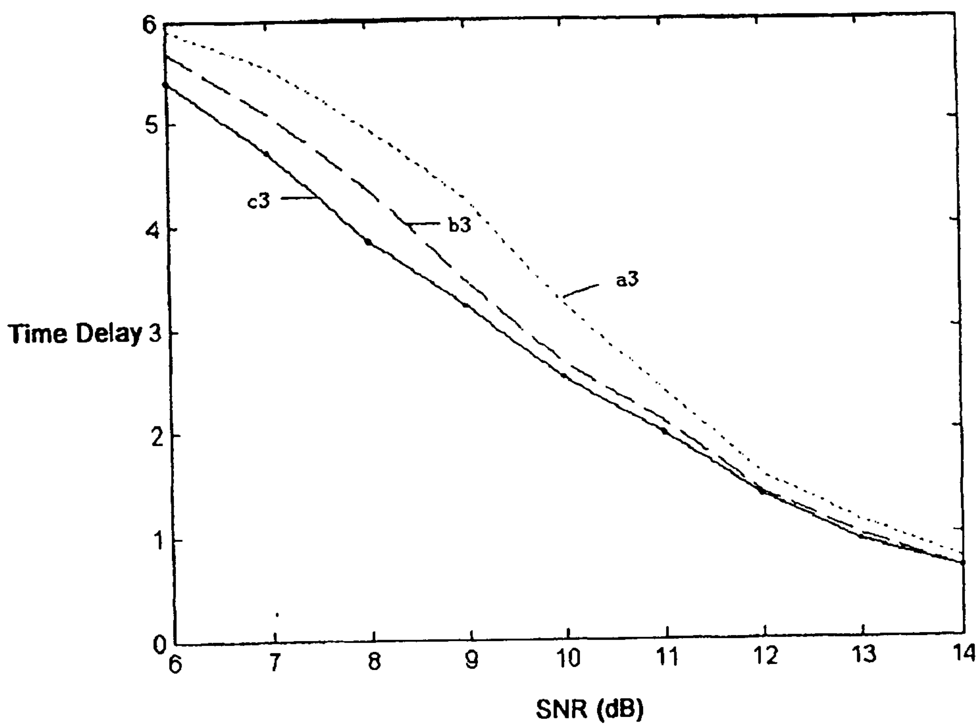

Fig.4

Electronic Acknowledgement Receipt

EFS ID:	5653967
Application Number:	12159841
International Application Number:	
Confirmation Number:	3203
Title of Invention:	METHOD OF TRANSMITTING/RECEIVING A PAGING MESSAGE IN A WIRELESS COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Young Dae Lee
Customer Number:	35884
Filer:	Rolando Gonzalez
Filer Authorized By:	
Attorney Docket Number:	2101-3515
Receipt Date:	07-JUL-2009
Filing Date:	22-OCT-2008
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Application Type:	U.S. National Stage under 35 USC 371

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1	Information Disclosure Statement (IDS) Filed (SB/08)	2101-3515_052509_IDS1449.pdf	611704 5dfcac4cfffbcf5c64498e35764df6a5f20b66ab	no	6

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☒ Basic National Fee *(or authorization to charge)*
☒ Description ☒ Claims ☒ Abstract
☒ Drawing Figure(s) - (# of drwgs. 8)
☐ Translation of Article 19 Amendments
☐ entered ☐ not entered :
☐ not a page for page substitution
☐ replaced by Article 34 Amendment
☐ Annexes to 409
☐ entered ☐ not entered :
☐ not a page for page substitution
☐ no translation ☐ other : ________
☐ Application Data Sheet
☐ Power of Attorney
☐ Change of Address

Preliminary Amendment(s) Filed on :
1. ☐ same as 371 request date 2. ________ 3. ________
☒ Information Disclosure Statement(s) Filed on :
1. ☐ same as 371 request date 2. 12-19-08 3. ________
☐ Assignment Document (forwarded to Assignment Branch)
☐ Assignee Statement Under 37 CFR 3.73(b)
☐ Assignee PG Publication Notice
☐ Substitute Specification Filed on :
1. ☐ same as 371 request date 2. ________ 3. ________
☐ Verified Small Status Statement
☒ Oath/ Declaration (executed)
☐ Oath/ Declaration ☐ unsigned ☐ no citizenship ☐ other
☐ DNA Diskette ☐ Sequence Listing
☐ Other : ________

NOTES : ☐ I.A. used as Specification ☐ Other :

35 U.S.C. 371 - Receipt of Request (PTO-1390)	mo. 7 / day / / yr. 2008
Date Acceptable Oath/ Declaration Received	☐ Same as 371 Req. Date; ☐ mo. 10 / day 22 / yr. 2008
Date of Completion of requirements under 35 U.S.C. 371	☐ Same as 371 Req. Date; ☐ Same as OATH Date; ☐ mo. / day / yr. 200
Date of Completion of DO/ EO 903 - Notification of Acceptance	
Date of Completion of DO/ EO 905 - Notification of Missing Requirements	
Date of Completion of DO/ EO 909 - Notification of Abandonment	
Date of Completion of DO/ EO 916 - Notification of Defective Response	
Date of Completion of DO/ EO 922 - Notification to Comply w/ Requirements for Patent Applications Containing Nucleotide and/or Amino Acid Sequence Disclosures	
Date of Completion of DO/ EO 923	

4

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	12159841
	Filing Date	
	First Named Inventor	Young Dae Lee
	Art Unit	2617
	Examiner Name	Not assigned
	Attorney Docket Number	2101-3515

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20050185608	A1	2005-08-25	Lee et al.	

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		12159841
	Filing Date		
	First Named Inventor	Young Dae Lee	
	Art Unit		2617
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	Attorney Docket Number		2101-3515

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	First Named Inventor	Young Dae Lee
	Art Unit	2617
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CERTIFICATION STATEMENT

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☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Harry S. Lee/	Date (YYYY-MM-DD)	2009-05-09
Name/Print	Harry S. Lee	Registration Number	56,814

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

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Electronic Acknowledgement Receipt

EFS ID:	5306375
Application Number:	12159841
International Application Number:	
Confirmation Number:	3203
Title of Invention:	METHOD OF TRANSMITTING/RECEIVING A PAGING MESSAGE IN A WIRELESS COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Young Dae Lee
Customer Number:	35884
Filer:	Harry Sung Lee
Filer Authorized By:	
Attorney Docket Number:	2101-3515
Receipt Date:	09-MAY-2009
Filing Date:	
Time Stamp:	22:56:26
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Filed (SB/08)	2101-3515_IDS_1449.pdf	608313 884a82f02e69adb59acd43a7c403c6c14254f018	no	4

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	12159841
	Filing Date	
	First Named Inventor	Young Lee
	Art Unit	2617
	Examiner Name	
	Attorney Docket Number	2101-3515

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Application Number		12159841
	Filing Date		
	First Named Inventor	Young Lee	
	Art Unit		2617
	Examiner Name		
	Attorney Docket Number		2101-3515

	1	NTT DOCOMO et al. "Multiplexing method of shared control channeil in uplink single-carrier FDMA radio access" TSG-RAN WG1 #42bis, R1-051143, October 14, 2005.	☐

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Examiner Signature		Date Considered	

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	Application Number	12159841
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	First Named Inventor	Young Lee
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	Attorney Docket Number	2101-3515

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☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/PUYA PARTOW-NAVID/	Date (YYYY-MM-DD)	2009-03-26
Name/Print	PUYA PARTOW-NAVID	Registration Number	59,657

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Electronic Acknowledgement Receipt

EFS ID:	5044523
Application Number:	12159841
International Application Number:	
Confirmation Number:	3203
Title of Invention:	METHOD OF TRANSMITTING/RECEIVING A PAGING MESSAGE IN A WIRELESS COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Young Dae Lee
Customer Number:	35884
Filer:	Puya Partow-Navid
Filer Authorized By:	
Attorney Docket Number:	2101-3515
Receipt Date:	26-MAR-2009
Filing Date:	
Time Stamp:	18:43:58
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Filed (SB/08)	IDS.pdf	607867 cc2d3f71d97637825b1892eadd23fd70977a6779	no	4

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	Filing Date	
	First Named Inventor	Young Lee
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Examiner Initial*	Cite No	Patent Number	Kind Code1	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6317430		2001-11-13	Knisely, et al.	

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Examiner Initial*	Cite No	Foreign Document Number3	Country Code2 i	Kind Code4	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T5
	1	2003/056723	WO		2003-07-10	NOKIA		☐
	2	2003/007636	WO		2003-01-23	QUALCOMM		☐
	3	2002/047417	WO		2002-06-13	NOKIA		☐

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	Filing Date		
	First Named Inventor	Young Lee	
	Art Unit		2617
	Examiner Name		
	Attorney Docket Number		2101-3515

	4	2003043259	WO		2003-05-22	NOKIA		☐
	5	2003017691	WO		2003-02-27	QUALCOMM		☐
	6	2005088886	WO		2005-09-22	SAMSUNG		☐
	7	2005074312	WO		2005-08-12	SAMSUNG		☐

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	1	MOTOROLA: "Paging Channel Design for E-UTRA", 3GPP TSG-RAN WG1,R1-061712 [online] June 27, 2006	☐
	2	SARKA, S. et al.: Common-Channel Soft Handoff in cdma2000-The Paging Channel. IEEE Transactions on Microwave Theory and Techniques. June 2000	☐
	3	NTT DOCOMO, et al.: "Paging Channel Structure for E-UTRA Downlink", 3GPP TSG-RAN WG1, R1-060034 [online], January 23, 2006	☐
	4	PHILLIPS: "Envolved Paging Indicators for LTE"; 3GPP TSG-RAN WG2 Meeting #49, Seoul, Korea, November 7-11, 2005	☐
	5	LG ELECTRONICS INC.: "Framing in the MAC entity", 3GPP TSG-RAN WG2 #52 R2-061012, March 27-31, 2006, Athens, Greece	☐

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	Application Number	12159841
	Filing Date	
	First Named Inventor	Young Lee
	Art Unit	2617
	Examiner Name	
	Attorney Docket Number	2101-3515

	6	LG ELECTRONICS INC.: "HARQ and ARQ Operation"; 3GPP TSG-RAN WG2 #50, R2-060106, January 9-13, 2006, Sophia Antipolis, France.	☐
	7	HUAWEL: "Further considerations on multiplexing method of shared Control Channel in Uplink Single-Carrier FDMA", TSG-RAN WG1#43, R1-051430; Seoul Korea, November 7-11, 2005.	☐

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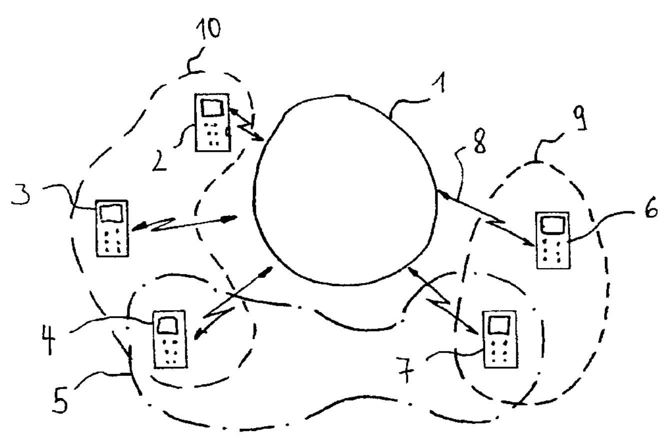
(54) **Title:** COMMUNICATION SYSTEM HAVING IMPLEMENTED POINT-TO-MULTIPOINT-MULTICAST FUNCTION



(57) **Abstract:** The present invention refers to a communication system having a network (1) and a plurality of user terminals (2,3,4) that are coupled to the network via a communication channel using wireless radio frequency transmission and having a downlink channel for transmitting messages in the direction from the network to the user terminals wherein the downlink channel comprises a paging channel for transmission of paging messages in paging frames for initiating communication with a user terminal allocated to a paging group of a plurality of user terminals, and a paging indicator channel for transmission of a paging indicator belonging to the paging group when there is a paging message for the user terminal belonging to the paging group, wherein the user terminal processes the next paging frame transmitted on the paging channel to see whether there is a paging message intended for it when the paging indicator has been transmitted on the paging indicator channel, and wherein the paging message on the paging channel comprises a point-to-multipoint-multicast (PTM-M) group identifier to identify a PTM-M group.

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COMMUNICATION SYSTEM HAVING IMPLEMENTED POINT- TO-MULTIPOINT- MULTICAST FUNCTION

The present invention refers to a communication system comprising a network and a plurality of user terminals that are coupled to the network via a communication channel using wireless radio frequency transmission and having a downlink channel for transmitting messages in the direction from the network to the user terminals. Further, the invention relates to a network and a user terminal, both for use in said communication system.

Recently, mobile telephone communication networks and systems have become very popular, for example, the telephone network corresponding to the Global Mobile Satellite (GMS) standards. The GMS systems supports the usual mobile telephone communication and, in addition, a number of further services, e.g. the short message service (SMS) cell broadcast and the point to multipoint multicast (= PTM-M) service in the general packet radio system.

The PTM-M service is a service in which the message is transmitted to all subscribers currently located within a geographical area. The message contains a group identifier indicating whether the message is of interest to all subscribers or to only a subset of subscribers or user terminals, e.g. certain mobile telephones also called mobile stations belonging to a specific PTM group. The PTM-M service is a connectless unidirectional service, i.e. in the downlink direction from the network to the user terminal, and is a variable bit rate service.

The object of the present invention is the implementation of the PTM-M service in communication systems, e.g. the Universal Mobile Telecommunication System (UMTS), of the latest generation.

This object is solved by a communication system according to claim 1 and by a method for its operation according to claim 14. Accordingly, the communication system of the invention comprises a network and a plurality of user terminals that are coupled to the network via a communication channel using wireless radio frequency transmission and having a downlink channel for transmitting messages in the direction from the network to the user terminals, wherein the downlink channel comprises:

a paging channel for transmission of paging messages in paging frames for initiating communication with a user terminal allocated to a paging group of a plurality of user terminals, and a paging indicator channel for transmission of a paging indicator belonging to the paging group when there is a paging message for the user terminal belonging to the paging group, wherein the user terminal processes the next paging frame transmitted on the paging channel to determine whether there is a paging message intended for it when the paging indicator has been transmitted on the paging indicator channel, and

wherein the paging message on the paging channel comprises a point-to-multipoint-multicast (PTM-M) group identifier to identify a PTM-M group.

A considerable advantage of the present invention is the implementation of the PTM-M service in the communication system, for instance, the UMTS without the requirement of additional channels or downlink transport channels. This is achieved by using a paging channel, a paging indicator channel and a downlink transport channel already provided by the communication system. These channels are destinated to implement the PTM-M service in the communication system. Thereby a substantial increase of the system complexity in the e.g. UMTS is avoided when the PTM-M service is getting implemented.

Preferably, the paging channel itself is used to transport the PTM-M messages, wherein the paging message on the paging channel comprises one or a plurality of PTM-M messages being intended for the PTM-M group identified by means of the PTM-M group identifier. The paging channel may be the secondary common control physical channel (S-CCPCH) of the UMTS.

In an alternative embodiment, the downlink channel may comprise in addition a downlink transport channel shared by several user terminals and allocated for transporting PTM-M messages, wherein the user terminal accesses the PTM-M messages of the downlink transport channel when, in the paging channel, the user terminal has detected a PTM-M identifier of a PTM-M group to which the user terminal is allocated to.

In an preferred embodiment, the communication system is the UMTS and the downlink transport channel for PTM-M messages is the known forward access channel (FACH) or the downlink shared channel (DSCH) of the UMTS.

The PTM-M identifiers or the plurality of PTM-M identifiers allocated to a user terminal may be stored in a data memory of the user terminal. This allows a quick decision in the user terminal or the mobile telephone whether a detected PTM-M identifier on the paging channel is of interest to the user terminal or not. This helps to save battery power of the mobile phone as the phone is enabled to re-enter quickly into sleep mode or idle mode in which a low power consumption is attained.

In an preferred embodiment, the PTM-M group identifier is the international mobile group identifier used in the general packet radio system (GPRS).

The method of the invention comprises the following steps:
in a paging channel of the downlink channel, transmitting of paging messages in paging frames for initiating communication with a user terminal allocated to a paging group of a plurality of user terminals,
in a paging indicator channel of the downlink channel, transmitting of a paging indicator allocated to the paging group when there is a paging message for the user terminal belonging to the paging group,
processing the next paging frame transmitted on the paging channel by the user terminal to see whether there is a paging message intended for it when the paging indicator has been transmitted on the paging indicator channel, and,
in the paging message of the paging channel, transmitting at least one point-to-multipoint-multicast (PTM-M) group identifier to identify a PTM-M group by the network.

Preferably the method of the invention comprises allocating an area to a cell or to a plurality of cells by the network wherein the user terminal is in the area, and providing the paging indicator channel and the paging channel comprising the PTM-M identifier or plurality of PTM-M identifiers to the cell or to the plurality of cells of the area.

The method may comprise, in an area serviced by the network and divided into a plurality of cells, entering one of said cells by the mobile user terminal and registering of the user terminal to be in said cell by the network of the communication system, providing of PTM-M identifiers on a downlink transport channel of the downlink channel, the information indicating the PTM-M groups being supported in said cell by the network, reading the PTM-M identifiers on the downlink transport channel by the user terminal, and
comparing the PTM-M identifiers being read from the downlink transport channel with PTM-M identifiers being stored in a memory of the user terminal and indicating the PTM-M groups to which the user terminal is subscribed in order to determine the PTM-M groups being serviced in the cell for said user terminal. These steps effectively support sleep-mode operation of the user terminal or mobile phone in connection with the implementation of the PTM-M service, i.e. an effective way for saving power of the mobile phone.

The invention according to yet another aspect also relates to a network according to claim 12, especially for use in a communication system according to claim 1. The above preferred embodiments of the communication system also apply to the network.

Further, the invention relates to a user terminal, e.g. a mobile station, according to claim 13, especially for use in a communication system according to claim 1. The above preferred embodiments of the communication system also apply to the user terminal.

Further advantageous embodiments of the invention are mentioned in the dependent claims.

Further advantages, advantageous embodiments and additional applications of the invention are provided in the following description of a preferred embodiment of the invention in connection with the figures being enclosed which show:

Fig. 1 a schematic view of a communication system according to a preferred embodiment of the invention;

Fig. 2 a schematic timing diagram showing three different downlink transport channels of the communication system of Fig. 1 in order to explain the method of the invention in connection with Fig. 3; and

Fig. 3 a schematic flow chart showing the substantial steps of the invention if a user terminal starts from sleep-mode.

Fig. 1 shows schematically the basic structure of a communication system according to a preferred embodiment of the invention. The communication system is a UMTS system of the latest generation which is called a 3GPP WCDMA system and which comprises a UMTS terrestrial radio access network (UTRAN) 1 as network and a plurality of terminal users 2, 3, 4, 6, 7 or mobile stations, e.g. mobile phones according to the UMTS standard, which are coupled to the UTRAN 1 via a communication channel using wireless radio frequency transmission of payload and control information or messages and having a downlink channel 8 being directed from the UTRAN 1 to the plurality of terminal users 1, 2, 3, 4, 6 to 7. A detailed explanation of the downlink channel 8 used in the shown UMTS is described, for instance, in the technical specification 3GPP TS 25.211 V3.4.0 (2000-09) "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Physical channels and mapping of transport channels onto physical channels (FDD) (Release 1999)" issued by the 3GPP Organizational Partners, which specification is incorporated herein by reference.

As shown in Fig. 1, the user terminals 2, 3 and 4 are in the same cell 10, whereas the user terminals 6 and 7 are in a further cell 9, each of the cells 9, 10 covering a different area or are located within the same geographical area. The user terminals 4 and 7 belong to the same PTM-M-group 5 to which a special PTM-M group identifier or corresponding control data are allocated. The PTM-M group identifier may be the known international mobile group identifier (IMGI) of the known general packet radio system (GPRS). PTM-M identifiers and corresponding IMGIs are used to implement the PTM-M service in the UMTS.

The downlink channel 8 of the UMTS comprises, inter alia, a paging indicator channel (PICH) 20, a paging channel 21, e.g. the secondary common control paging channel (S-CCPCH), and a further downlink transport channel 22, e.g. the downlink shared channel (DSCH) or the forward access channel (FACH).

In general, the paging channel 21 is a downlink transport channel that carries data relevant to the paging procedure, that is, when the network or UTRAN 1 wants to initiate communication with one of the plurality of user terminals. The simplest example is a speech call to the user terminal. The UTRAN 1 transmits a paging message to the user terminal on the paging channel of those cells belonging to the location area that the user terminal is expected to be in. The identical paging message can be transmitted in a single cell or in up to a few hundreds of cells depending on the configuration of the UTMS.

The paging channel 21 is operated together with the paging indicator channel 20 to provide the user terminals with effective sleep mode operation. The paging indicator channel 20 transfers paging indicators 23 which appear periodically on the paging indicator channel 20 when there are paging messages for any of the user terminals belonging to a paging group which may comprise all user terminals of the cells 9 and 10 or only either the user terminals of the cell 9 or the user terminals of the cell 10.

As shown in Fig. 1, for instance, the user terminal 7 within cell 9 is a member of the paging group related to cell 9 and in addition also a member of a PTM-M group 5 corresponding to a PTM-M service and a special PTM-M group identifier 24 (see. Fig. 2). Further, the user terminal 4 in the cell 10 is a member of a further paging group related to cell 10 and in addition also a member of the PTM-M group 5 corresponding to the PTM-M service and the PTM-M group identifier 24 (see Fig. 2).

The preferred embodiment of the method of the invention is described and explained in the following in relation to the Fig. 2 and 3.

For instance, the user terminal 7 has just recently entered the cell 9 (see step S1 in Fig. 3) and registration of the user terminal 7 has been accomplished by the user terminal 7 and the UTRAN 1 (see step S2). The user terminal 7 subsequently reads the PTM-M group identifier information comprising also the PTM-M group identifier 24 on a BCH downlink channel which contains the information which PTM-M groups are supported in the cell 9 (see step S3). The user terminal 7 compares (see step S4) the PTM-M group identifiers read from the BCH downlink channel with the PTM-M group identifiers being stored, for instance, in a SIM card as a memory of the user terminal 7. In the present example, the user terminal 7 or its owner is only subscribed to the PTM-M group 5 identified by the PTM-M group identifier 24 and, therefore, only the PTM-M group identifier 24 is stored in its SIM card. The user terminal 7 in the next step S5, therefore, only selects the PTM-M group identified by the PTM-M identifier 24, when it should detect the PTM-M group identifier as paging message on the paging channel 21.

The user terminal 7, in the following, scans the paging indicator channel 20 in order to detect a paging indicator 23. If the paging indicator channel 20 does not transport a paging indicator 23, the user terminal 7 enters the sleep mode, this step not being shown in Fig. 3.

Hereinafter, the illustrated embodiment relates to the case when the UTRAN 1 wants to send a PTM-M message 25 of the PTM-M service to the user terminal 7. At first, the UTRAN 1 determines on the basis of the information stored during the registration step S2 the cell and/or the cells in which the user terminal 7 is expected to be in. In the present example, shown in Fig. 1, the UTRAN 1 finds the user terminal 7 to be in the cell 9. The UTRAN 1, then, issues periodically the paging indicator 23 on the paging indicator channel 20 and further issues a paging frame 26 comprising the PTM-M group identifier 24 as paging message on the paging channel 21, wherein the paging frame 26 has an offset value in time ta with regard to the paging indicator 23 on the paging indicator channel 20. In addition, the UTRAN 1 outputs a PTM-M message 25 on the additional downlink transporting channel 22, the PTM-M message belonging to the PTM-M service being active.

Starting from the idle mode or sleep mode S9, the user terminal 7 scans periodically the paging channel 20 in order to detect a paging indicator. The user terminal detects the paging indicator 23 issued from the UTRAN 1 (step S6). In the following, the user terminal 7 scans a next paging frame 26 on the paging channel 21 after the duration ta and detects the PTM-M group identifier 24 issued by the UTRAN 1 on the paging channel 21. The time ta between the end of the paging indicator 23 and the beginning of the next paging frame is typically 7680 chips.

Subsequently, the user terminal 7 compares the detected PTM-M group identifier 24 with the PTM-M group identifier stored in its SIM card (see step S7 of Fig. 3). Provided the detected PTM-M group identifier 24 is identical to the stored PTM-M group identifier, the user terminal determines that a PTM-M message or PTM-M user data is issued belonging to the PTM-M group 5 in which it is subscribed, (see Yes after step S7 in Fig. 3). If a "No" should result after step S7, there is no PTM-M message of a PTM-M group the user terminal 7 is subscribed to and the user terminal 7 returns into its sleep mode.

In the case of a "Yes" after step S7 the user terminal 7 scans the downlink transporting channel 22 (see step S8) in order to detect and to read the PTM-M message 25 issued by the UTRAN 1. After processing of the PTM-M message 25, the user terminal 7 returns into its sleep mode in step S9. The user terminal S9 repeats the steps S6, S7, S8, S9 and S10 periodically.

As shown in Fig. 1, also the user terminal 4 is a member of the PTM-M group 5 and, therefore, it is subscribed to the corresponding PTM-M service. In order to provide the PTM-M service to the user terminal 4, the UTRAN 1 issues the paging indicator 23 on the paging indicator channel 20, the PTM-M group identifier 24 on the paging channel 21 and the PTM-M message 25 as described above with reference to the user terminal 7 and simultaneously transmits them to the user terminal 7 in the cell 10 in which the user terminal 4 is expected to be. The user terminal 4 carries out the same steps as described above with regard to the user terminal 7 in order to detect and read the PTM-M message 25.

In case of further user terminals (not shown in the figures) or a large number of user terminals belonging to the same PTM-M group, the paging indicators 23, the PTM-M group identifier 24 and the PTM-M message 25 are output simultaneously to all user terminals belonging to the same PTM-M group regardless of whether the user terminals are within one cell or within a large number of different cells.

Claims

1. Communication system comprising a network and a plurality of user terminals that are coupled to the network via a communication channel using wireless radio frequency transmission and having a downlink channel for transmitting messages in the direction from the network to the user terminals, wherein the downlink channel comprises:
   a paging channel for transmission of paging messages in paging frames for initiating communication with a user terminal allocated to a paging group of a plurality of user terminals, and
   a paging indicator channel for transmission of a paging indicator belonging to said paging group,in case there is a paging message for the user terminal belonging to said paging group, wherein the user terminal processes the next paging frame transmitted on the paging channel to determine whether there is a paging message intended for the user when the paging indicator has been transmitted on the paging indicator channel, and
   wherein the paging message on the paging channel comprises a point-to-multipoint-multicast (PTM-M) group identifier to identify a PTM-M group.

2. Communication system according to claim 1, wherein the paging message on the paging channel comprises one or a plurality of PTM-M messages being intended for the PTM-M group and identified by means of the PTM-M group identifier.

3. Communication system according to claim 1, wherein the downlink channel comprises in addition a downlink transport channel shared by several user terminals and intended to transport PTM-M messages, wherein the user terminal accesses the PTM-M messages of the downlink transport channel when, in the paging channel, the user terminal has detected a PTM-M identifier of a PTM-M group to which the user terminal is allocated to.

4. Communication system according to claim 3, wherein the communication system is the UMTS and the downlink transport channel is the forward access channel (FACH) of the UMTS.

5. Communication system according to claim 3, wherein the communication system is the UMTS and the downlink transport channel is the downlink shared channel (DSCH) of the UMTS.

6. Communication system according to one of the preceding claims, wherein an area is allocated to a cell or to a plurality of cells, wherein the user terminal is located in that area, the network transmitting the paging indicator channel and the paging channel comprising the PTM-M identifier or a plurality of PTM-M identifiers to the cell or to the plurality of cells of the area.

7. Communication system according to one of the preceding claims, wherein the PTM-M identifier or the plurality of PTM-M identifiers allocated to the user terminal are stored in a data memory of the user terminal.

8. Communication system according to claim 7, wherein the data memory is a memory in a SIM card of the user terminal.

9. Communication system according to one of the preceding claims, wherein the communication system is the Universal Mobile Telecommunication System (UMTS), wherein the network is the UMTS Terrestrial Radio Access network and wherein the user terminal is an UMTS terminal or an UMTS mobile phone.

10. Communication system according to one of the preceding claims, wherein the communication system is the UMTS and the paging channel is the secondary common control physical channel (S-CCPCH) of the UMTS.

11. Communication system according to one of the preceding claims, wherein the PTM-M group identifier is the international mobile group identifier used in the general packet radio system (GPRS).

12. Network, adapted to communicate with a plurality of user terminals that are coupled to the network via a communication channel using wireless radio frequency transmission and having a downlink channel for transmitting

messages in the direction from the network to the user terminals, wherein the downlink channel comprises:
a paging channel for transmission of paging messages in paging frames for initiating communication with a user terminal allocated to a paging group of a plurality of user terminals, and
a paging indicator channel for transmission of a paging indicator belonging to said paging group,in case there is a paging message for the user terminal belonging to the paging group, and wherein the paging message on the paging channel comprises a point-to-multipoint-multicast (PTM-M) group identifier to identify a PTM-M group.

13. User terminal, adapted to communicate with a network, comprising a mobile station including reception means adapted for receiving messages from the network in a downlink channel; wherein said downlink channel comprises :
a paging channel for reception of paging messages in paging frames for initiating communication with said network, the user terminal being adapted to be allocated to a paging group comprising a plurality of user terminals, and
a paging indicator channel for reception of a paging indicator belonging to said paging group,in case there is a paging message for the user terminal belonging to said paging group, wherein the user terminal processes the next paging frame received on the paging channel to determine whether there is a paging message intended for the user when the paging indicator has been transmitted on the paging indicator channel, and
wherein the paging message on the paging channel comprises a point-to-multipoint-multicast (PTM-M) group identifier to identify a PTM-M group.

14. Method for operation of a communication system comprising a network and a plurality of user terminals that are coupled to the network via a communication channel using wireless radio frequency transmission and having a downlink channel for transmitting messages in the direction from the network to the user terminals, wherein the method comprises:
in a paging channel of the downlink channel, transmitting of paging messages in paging frames for initiating communication with a user terminal allocated to a paging group of a plurality of user terminals,

in a paging indicator channel of the downlink channel, transmitting of a paging indicator allocated to the paging group, in case there is a paging message for the user terminal belonging to the paging group,
processing of the next paging frame transmitted on the paging channel by the user terminal to determine whether there is a paging message intended for the user when the paging indicator has been transmitted on the paging indicator channel, and,
in the paging message of the paging channel, transmitting at least one point-to-multipoint-multicast (PTM-M) group identifier to identify a PTM-M group by the network.

15. Method according to claim 14, wherein the paging message on the paging channel comprises a PTM-M message being intended for the PTM-M group which is identified by means of the PTM-M group identifier.

16. Method according to claim 15, the method comprising:
in the downlink channel, providing in addition a downlink transport channel shared by several user terminals and intended for transporting PTM-M messages, the user terminal accessing the PTM-M messages of the downlink transport channel when, in the paging channel, the user terminal has detected a PTM-M identifier of a PTM-M group to which the user terminal is allocated to.

17. Method according to one of the claims 14 to 16, the method comprising: allocating an area to a cell or to a plurality of cells by the network, wherein the user terminal is in that area, and providing the paging indicator channel and the paging channel comprising the PTM-M identifier or plurality of PTM-M identifiers to the cell or to the plurality of cells of the area.

18. Method according to one of the claims 14 to 17, the method comprising:
storing of the PTM-M identifier or the plurality of PTM-M identifiers allocated to the user terminal in a data memory of the user terminal.

19. Method according to one of the claims 14 to 18, the method comprising:

in an area serviced by the network and divided into a plurality of cells, entering one of said cells by the mobile user terminal and
registering of the user terminal to be in said cell by the network of the communication system,
providing of PTM-M identifiers on a downlink transport channel of the downlink channel, the information indicating the PTM-M groups being supported in said cell by the network,
reading the PTM-M identifiers on the downlink transport channel by the user terminal, and
comparing the PTM-M identifiers being read from the downlink transport channel with PTM-M identifiers being stored in a memory of the user terminal and indicating the PTM-M groups to which the user terminal is subscribed in order to determine the PTM-M groups being serviced in the cell for said user terminal.

20. Method according to one of the claims 14 to 19, the method comprising:
periodically detecting and reading of the paging indicators on the paging indicator channel by the user terminal.

21. Method according to claim 20, the method comprising:
next, in case a paging indicator is detected on the paging channel, reading of the paging message on the paging channel which is allocated to the paging indicator.

22. Method according to claim 20, the method comprising:
next, in case a PTM-M identifier is detected by the user terminal in the paging message on the paging channel, comparing the detected PTM-M identifier to the PTM-M identifier or the PTM-M-identifiers stored in the user terminal.

23. Method according to claim 22, the method comprising:
next, in case the detected PTM-M identifier corresponds to one of the PTM-M identifiers being stored in user terminal, reading of PTM-M messages belonging to a PTM-M-group identified by the PTM-M-identifier on a downlink transport channel of the downlink channel.

24. Method according to claim 20, wherein the user terminal is in a sleep-mode between the steps of periodically detecting and reading of the paging indicators.

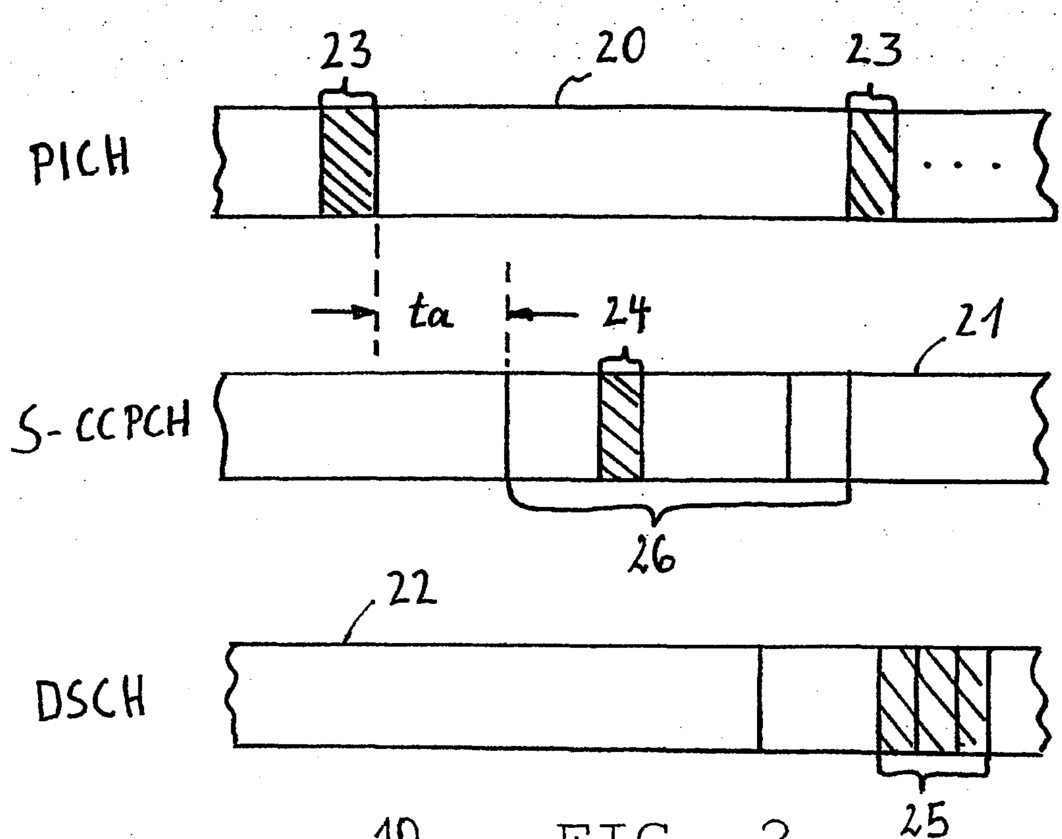

FIG. 2

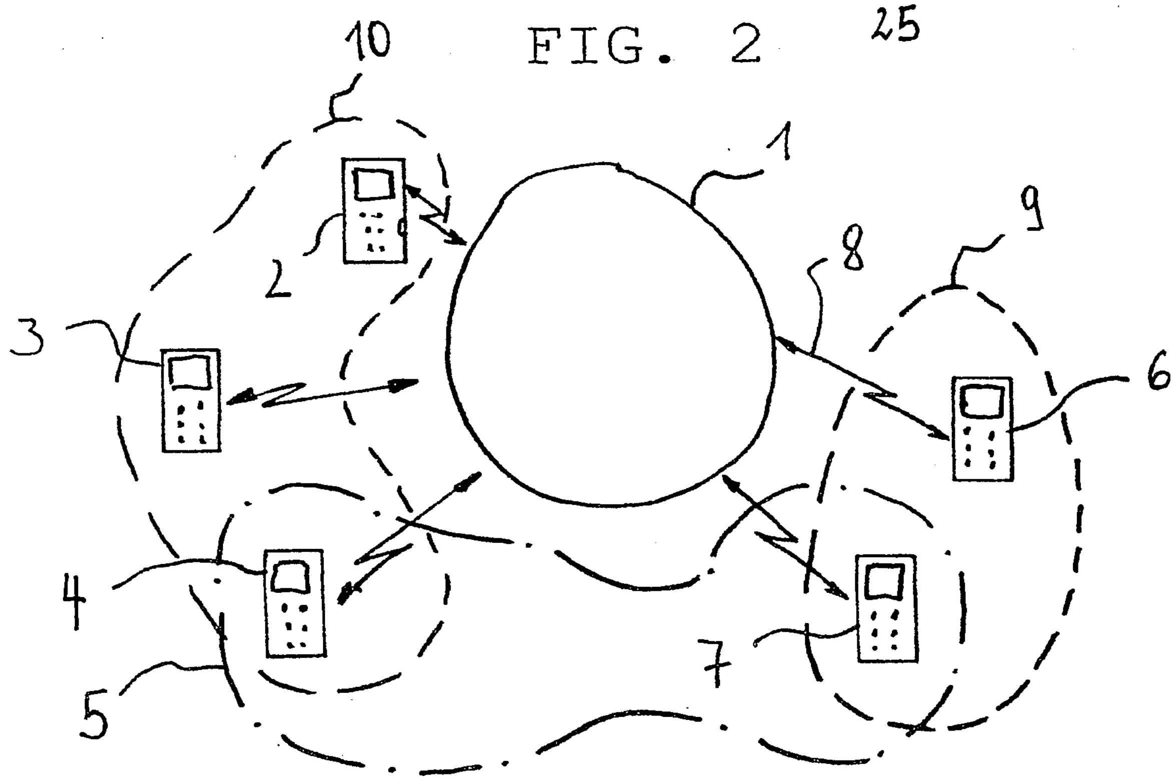

FIG. 1

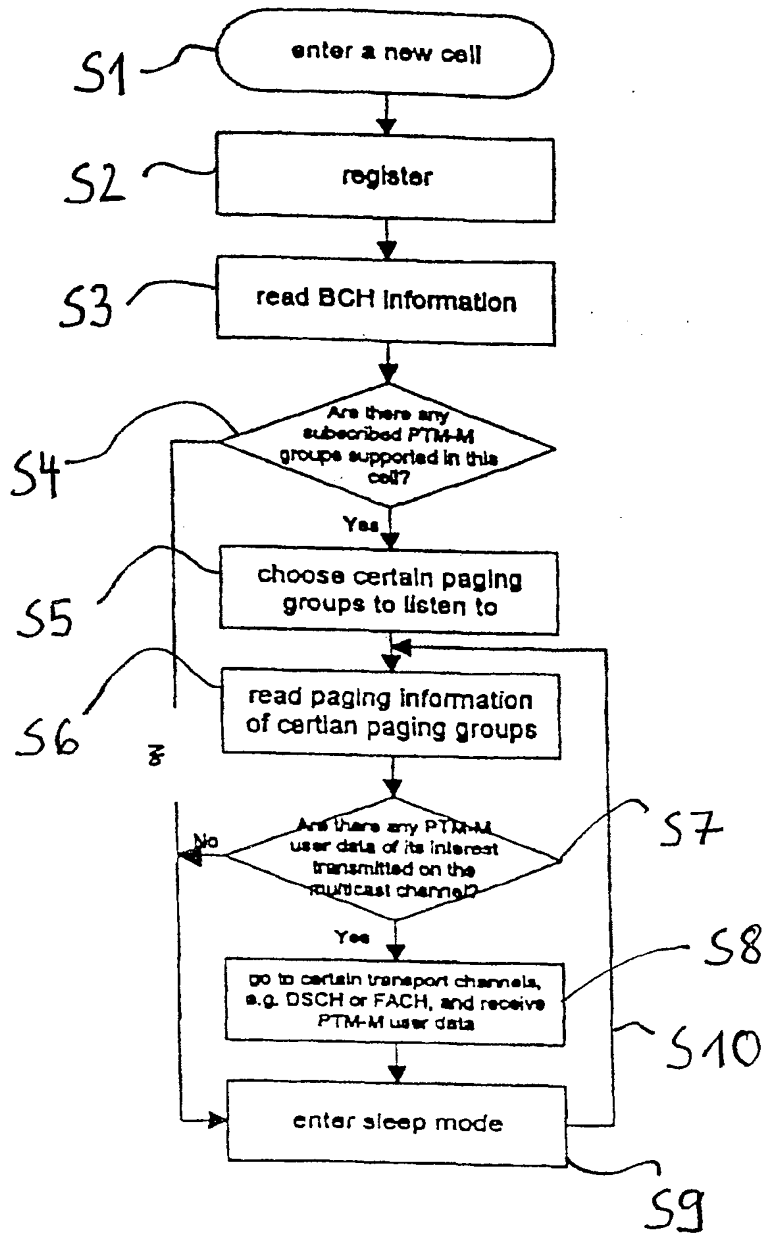
S1
enter a new cell
S2
register
S3
read BCH information
S4
Are there any subscribed PTM-M groups supported in this cell?
Yes
S5
choose certain paging groups to listen to
S6
read paging information of certian paging groups
S7
Are there any PTM-M user data of its interest transmitted on the multicast channel?
No
Yes
S8
go to certain transport channels, e.g. DSCH or FACH, and receive PTM-M user data
S10
enter sleep mode
S9

FIG. 3

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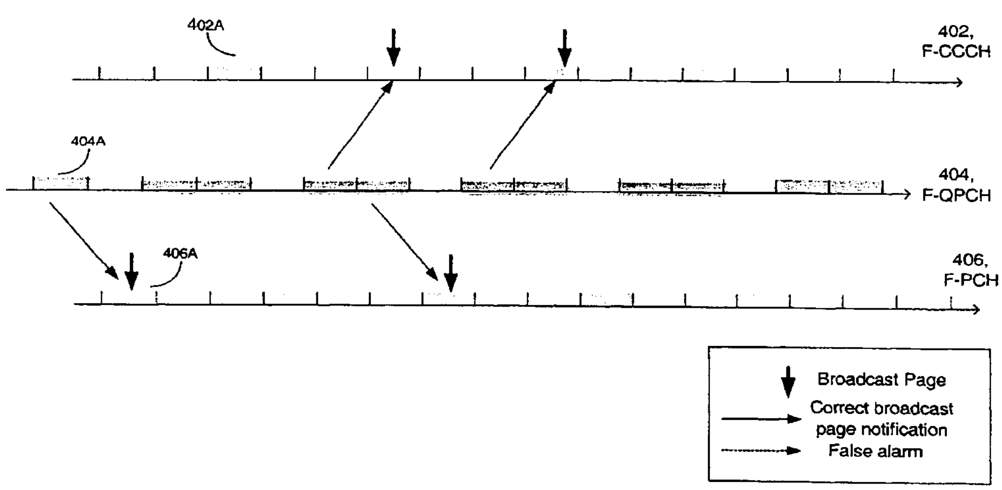
(54) **Title:** METHOD AND SYSTEM FOR IMPROVING BATTERY PERFORMANCE IN BROADCAST PAGING



(57) **Abstract:** A method and system are provided that allow a mobile communications service provider to broadcast messages using more than one broadcast channel protocol, such that only the mobile stations designed to receive broadcast messages transmitted under each protocol are woken up to monitor their respective broadcast channel slots, thus saving battery life in mobile stations designed to receive broadcast messages transmitted using other broadcast channel protocols.

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METHOD AND SYSTEM FOR IMPROVING BATTERY PERFORMANCE IN BROADCAST PAGING

BACKGROUND

Field

[1001] The present invention relates generally to telecommunications systems, and more specifically to a method and system for improving battery life in mobile stations designed to receive broadcast messages.

Background

[1002] In cellular telephone systems such as the IS-95 family of code division multiple access (CDMA) systems defined in the IS-95, IS-95A, and IS-95B standards and earlier versions of cdma2000, a base station uses a paging channel (F-PCH) to transmit broadcast pages and broadcast messages to target mobile stations. The base station may also send broadcast indicators on quick paging channel (F-QPCH) slots to inform the target mobile stations to monitor the F-PCH channel slots for the upcoming broadcast pages and/or broadcast messages.

[1003] In the newer versions of cdma2000, the base station uses a common control channel (F-CCCH) to transmit broadcast pages, a broadcast control channel (F-BCCH) to transmit broadcast messages. The base station may also send broadcast indicators on the F-QPCH channel slots to inform the target mobile stations to monitor the F-CCCH slots for the broadcast pages, which may point to the assigned F-BCCH channel slots that carry broadcast messages.

[1004] A service provider may choose to adopt either of the above broadcasting channel protocols to broadcast messages to target mobile stations, but only the mobile stations that are designed for a chosen broadcasting channel protocol would be able to receive the broadcast messages. It is highly desirable to transmit broadcast messages using both broadcasting channel protocols such that the mobile stations that are designed to receive broadcast messages transmitted in either broadcasting channel protocol would be able to receive the broadcast messages.

[1005] Currently, if a service provider transmits a broadcast message using both broadcasting channel protocols, the broadcast indicators on the F-QPCH channel slots, which may be used to signal a group of mobile stations to monitor the broadcast pages on either the F-PCH or F-CCCH channel, may cause false signaling to other mobile stations. For example, a broadcast indicator on a F-QPCH channel slot that correctly points to a broadcast page slot on the F-PCH channel may also erroneously point to a broadcast page slot on the F-CCCH channel. Consequently, the mobile stations that are designed to monitor the F-CCCH channel slots may be unnecessarily awakened to monitor the F-CCCH channel slots. Therefore, these mobile stations may suffer from unnecessary battery consumption.

[1006] There is a need in the art for providing broadcast messages using more than one broadcasting channel protocol such that the mobile stations designed to receive broadcast messages using one broadcasting channel protocol produce no false signaling to the mobile stations designed to receive broadcast messages using other broadcast channel protocols.

SUMMARY

[1007] One aspect of the present invention is directed to a method and system for providing broadcast messages using more than one broadcast channel protocol. The method and system may include transmitting a plurality of first broadcast page slots on a first channel, transmitting a plurality of second broadcast page slots on a second channel, and transmitting a plurality of broadcast indicators on a third channel, such that each one of the plurality of broadcast indicators may point to only one of the first or second broadcast page slots.

[1008] In one embodiment of the present invention, the first broadcast page slots on the first channel may be shifted with respect to the second broadcast page slots on the second channel.

[1009] In another embodiment of the present invention, the first broadcast page slots on the first channel and the second broadcast page slots on the second channel may be transmitted at different broadcast page cycles.

[1010] Another embodiment of the present invention is directed to a base station for providing broadcast messages, which may include a transmitter and a processor. The transmitter may be adapted to transmit a plurality of first broadcast page slots on a first channel, transmit a plurality of second broadcast page slots on a second channel, and transmit a plurality of broadcast indicators on a third channel. The processor may be adapted to control the transmitter such that each one of the plurality of broadcast indicators points to only one of the first or second broadcast page slots.

[1011] In one embodiment of the present invention, the processor may be further adapted to shift the plurality of first broadcast page slots on the first channel with respect to the plurality of second broadcast page slots on the second channel.

[1012] In one embodiment of the present invention, the processor may be further adapted to control the transmitter to transmit the plurality of first broadcast page slots on the first channel and the plurality of second broadcast page slots on the second channel at different broadcast page cycles.

BRIEF DESCRIPTION OF THE DRAWINGS

[1013] FIG. 1 is a representation of an exemplary arrangement for forward channels used in message broadcasting;

[1014] FIG. 2 is a representation of an exemplary base station and mobile station that may be used in message broadcasting;

[1015] FIG. 3 is a representation of exemplary broadcast paging cycles for forward broadcast channels according to a first embodiment;

[1016] FIG. 4 is a representation of exemplary broadcast paging cycles for the forward broadcast channels according to a second embodiment; and

[1017] FIG. 5 is a representation of exemplary broadcast paging cycles for the forward broadcast channels according to a third embodiment.

DETAILED DESCRIPTION

[1018] The paging channel may be divided into 80 ms slots called paging channel slots. Paging and control messages for a mobile station operating in the non-slotted mode may be received in any one of the paging channel slots. Therefore, the non-slotted mode of operation requires the mobile station to monitor all slots. The forward common control channel also may be divided into 80 ms slots called forward common control channel slots. Paging and mobile-directed messages for a mobile station operating in the non-slotted mode may be received in any one of the forward common control channel slots. Therefore, the non-slotted mode of operation requires the mobile station to continuously monitor the forward common control channel.

[1019] The paging channel protocol or the forward common control channel protocol may provide for scheduling the transmission of messages for a specific mobile station in certain assigned slots. A mobile station that monitors the paging channel or the forward common control channel only during the assigned slots is referred to as operating in the slotted mode. During the slots in which the paging channel or the forward common control channel is not being monitored, the mobile station may stop or reduce its processing for power conservation.

[1020] A mobile station operating in the slotted mode generally monitors the paging channel or the forward common control channel for one or two slots per slot cycle. The mobile station may specify its preferred slot cycle, e.g., by using the SLOT_CYCLE_INDEX field provided in the registration message, origination message, or page response message. The mobile station may also specify its preferred slot cycle using the SLOT_CYCLE_INDEX field of the terminal information record of the status response message or the extended status response message. Those of skill in the art would recognize that the messages referred to herein are defined in the cdma2000 standards.

[1021] The base station may transmit broadcast messages, e.g., data burst messages with broadcast addresses, to target mobile stations. In order to notify the mobile stations operating in slotted mode that a broadcast message is being transmitted to them, the base station may send a broadcast page, such as the general page message (GPM) or the universal page message (UPM) with a broadcast address type, to the target mobile stations. The physical channel or channels on which the broadcast pages and the corresponding broadcast messages may be transmitted to the mobile stations may depend on the common channel configuration. Two exemplary channel configurations are considered here.

[1022] The first configuration corresponds to the broadcasting channel protocol used in the IS-95 family of CDMA systems as well as the prior releases of cdma2000. In this configuration, the forward channels may include the paging channel (F-PCH), and the quick paging channel (F-QPCH). Both a broadcast page, which may point to a companion broadcast message slot that contains a broadcast message, and the broadcast message may be sent on the F-PCH.

[1023] The second configuration corresponds to the broadcasting channel protocol used in the newer release of cdma2000, e.g., Release A. In this configuration, the forward channels may include the common control channel (F-CCCH), broadcast control channel (F-BCCH), and the quick paging channel (F-QPCH). The broadcast page may be sent on the F-CCCH, and the broadcast message may be sent on the F-BCCH.

[1024] The broadcast pages may be distributed either on the F-PCH or the F-CCCH at specially defined channel slot cycles. On the F-PCH, a broadcast paging cycle (BPC) may have a duration of ($B_1 + X_1$) F-PCH slots, in which:

$$\mathbf{B_1 = 2^i \times 16,\ 1 \leq i \leq 7}$$

where i = BCAST_INDEX may be transmitted by the base station in the extended system parameters message or set by default when the extended system parameters message is not sent.

[1025] In order to reduce overhead, not to interfere with regular pages, and be efficient, the broadcast pages may be sent in the first slot of a broadcast paging cycle. The first slot of each broadcast paging cycle on the F-PCH is a paging channel slot in which:

$$\lfloor t/4 \rfloor \bmod (B_1 + X_1) = 0,$$

where t represents system time in frames.

[1026] Distribution of broadcast pages may also be on specially defined F-CCCH slot cycles. On the F-CCCH, the BPC may have a duration of (B_2 + X_2) F-CCCH channel slots, in which:

$$B_2 = 2^{1+i} \times 16, 1 \leq i \leq 7$$

where i = BCAST_INDEX may be transmitted by the base station in the system parameters message. The first slot of each broadcast paging cycle on the F-CCCH is a F-CCCH slot in which:

$$\lfloor t/4 \rfloor \bmod (B_2 + X_2) = 0,$$

where t represents system time in frames.

[1027] The F-QPCH may be divided into slots, e.g., 80 ms, called F-QPCH slots. The F-QPCH protocol may provide for scheduling the transmission of the paging indicators, the configuration change indicators, and the broadcast indicators in an F-QPCH slot. In order to reduce battery drainage in mobile stations due to unnecessary monitoring of every broadcast paging cycle slot, the F-QPCH slots may contain broadcast indicator (BI) bits that may be used to inform target mobile stations when to monitor the F-PCH/F-CCCH slot for a broadcast page. That is, if there is a broadcast page on the F-CCCH, for example, the BI bits of the corresponding F-QPCH slot are turned on to signal the target mobile stations to monitor the F-CCCH slots.

[1028] In one embodiment, a service provider may support broadcast messaging using both F-PCH and F-CCCH/F-BCCH broadcasting channel protocols. Therefore, if both channel protocols operate in slotted mode with the quick paging channel, the same F-QPCH may be used to signal a mobile unit that is configured to monitor either the F-PCH or the F-CCCH/F-BCCH for a broadcast page. In this embodiment, the BIs corresponding to the F-PCH may signal a group of mobile units to monitor the paging channel slots on the F-PCH, and the BIs corresponding to the F-CCCH may signal another group of mobile units to monitor the forward common control channel slots on the F-CCCH.

[1029] FIG. 1 shows a representation of an exemplary arrangement for forward channels used in message broadcasting. The F-PCH/F-CCCH 102 may be divided into 80 ms slots 104 called paging channel slots. The quick paging channel 106 may be also divided into 80 ms slots 108 called F-QPCH slots. According to one embodiment, if a mobile station operates in the slotted mode, is configured to receive the broadcast messages, and supports the quick paging channel scheme, the mobile station may monitor broadcast indicators on an assigned F-QPCH channel slot that is offset from the mobile station's assigned broadcast page slots by a predetermined time interval 110, e.g., 100 ms, as shown in FIG. 1.

[1030] FIG. 2 is a simplified block diagram of an embodiment of base station 204 and remote terminal 206, which are capable of implementing various aspects of the invention. For a particular communication, voice data, packet data, and/or messages may be exchanged between base station 204 and remote terminal 206, via an air interface 208. Various types of messages may be transmitted, such as messages used to establish a communication session between the base station and remote terminal and messages used to control a data transmission (e.g., power control, data rate information, acknowledgment, and so on).

[1031] For the reverse link, at remote terminal 206, voice and/or packet data (e.g., from a data source 210) and messages (e.g., from a controller 230) are provided to a transmit (TX) data processor 212, which formats and encodes the data and messages with one or more coding schemes to generate coded data. Each coding scheme may include any combination of cyclic redundancy check

(CRC), convolutional, turbo, block, and other coding, or no coding at all. The voice data, packet data, and messages may be coded using different schemes, and different types of messages may be coded differently.

[1032] The coded data is then provided to a modulator (MOD) 214 and further processed (e.g., covered, spread with short PN sequences, and scrambled with a long PN sequence assigned to the user terminal). The modulated data is then provided to a transmitter unit (TMTR) 216 and conditioned (e.g., converted to one or more analog signals, amplified, filtered, and quadrature modulated) to generate a reverse link signal. The reverse link signal is routed through a duplexer (D) 218 and transmitted via an antenna 220 to base station 204.

[1033] At base station 204, the reverse link signal is received by an antenna 250, routed through a duplexer (D) 252, and provided to a receiver unit (RCVR) 254. Receiver unit 254 conditions (e.g., filters, amplifies, down converts, and digitizes) the received signal and provides samples. A demodulator (DEMOD) 256 receives and processes (e.g., despreads, decovers, and pilot demodulates) the samples to provide recovered symbols. Demodulator (DEMOD) 256 may implement a rake receiver that processes multiple instances of the received signal and generates combined symbols. A receiving (RX) data processor 258 then decodes the symbols to recover the data and messages transmitted on the reverse link. The recovered voice/packet data is provided to a data sink 260, and the recovered messages may be provided to a controller 270. The processing by demodulator (DEMOD) 256 and RX data processor 258 are complementary to that performed at remote terminal 206. Demodulator (DEMOD) 256 and RX data processor 258 may further be operated to process multiple transmissions received via multiple channels, e.g., a reverse fundamental channel (R-FCH) and a reverse supplemental channel (R-SCH). Also, transmissions may be simultaneously from multiple remote terminals, each of which may be transmitting on a reverse fundamental channel, a reverse supplemental channel, or both.

[1034] On the forward link, at base station 204, voice and/or packet data (e.g., from a data source 262) and messages (e.g., from controller 270) are processed (e.g., formatted and encoded) by a transmit (TX) data processor 264, further processed (e.g., covered and spread) by a modulator (MOD) 266, and conditioned (e.g., converted to analog signals, amplified, filtered, and quadrature modulated) by a transmitter unit (TMTR) 268 to generate a forward link signal. The forward link signal is routed through duplexer (D) 252 and transmitted via antenna 250 to remote terminal 206.

[1035] At remote terminal 206, the forward link signal is received by antenna 220, routed through duplexer (D) 218, and provided to a receiver unit (RCVR) 222. Receiver unit (RCVR) 222 conditions (e.g., down converts, filters, amplifies, quadrature modulates, and digitizes) the received signal and provides samples. The samples are processed (e.g., despreaded, decovered, and pilot demodulated) by a demodulator (DEMOD) 224 to provide symbols, and the symbols are further processed (e.g., decoded and checked) by a receiving data processor 226 to recover the data and messages transmitted on the forward link. The recovered data is provided to a data sink 228, and the recovered messages may be provided to controller 230.

[1036] FIG. 3 shows a representation of an exemplary arrangement for the F-CCCH 302, F-QPCH 304, and F-PCH 306. In the arrangement shown in FIG. 3, the broadcast paging cycles on the F-CCCH and the broadcast paging cycles on the F-PCH have identical durations and start at identical slot numbers. Therefore, the respective broadcast page slots overlap. For example, the broadcast page slot 302A on the F-CCCH 302 overlaps with the broadcast page slot 306A on the F-PCH 306. Consequently, the BI bits on the F-QPCH slots point to the broadcast page slots on both the F-CCCH and the F-PCH. Specifically, if a BI bit on an F-QPCH slot were actually directed only to the F-PCH channel 306, the same BI bits would also erroneously point to the F-CCCH channel 302. This false signaling causes a mobile station designed to receive broadcast page on F-CCCH to unnecessarily wake up and monitor the F-CCCH. For example, the BI bits in the F-QPCH slot 304A that points to the broadcast page slot 306A on the F-PCH correctly wakes up a mobile designed to monitor F-PCH slot 306A, as shown by the solid-line arrow. However, because of the overlapping BPCs, the same BI bit also points to the broadcast page slot 302A on the F-CCCH 302, as shown by the broken-line arrow, which erroneously wakes up a mobile designed to monitor the F-CCCH.

[1037] According to one embodiment of the invention, the BPCs on the F-PCH and the F-CCCH may be shifted with respect to each other such that the broadcast slots on the F-CCCH and F-PCH do not overlap, as shown in FIG. 4. In FIG. 4, the broadcast page slots on the F-CCCH 402 do not overlap with the broadcast page slots on the F-PCH 406. Consequently, the BI bits on the quick paging channel slots on the F-QPCH channel do not point to both the F-CCCH slots and the F-PCH slots. Specifically, if a BI bit is directed to only one of the F-PCH or F-CCCH, the same BI bit does not point to the other of the F-PCH and the F-CCCH, which advantageously prevents a mobile station from unnecessarily waking up and monitoring the respective channel for broadcast messages. For example, the BI bit in the F-QPCH slot 404A that points to the broadcast page slot 406A on the F-PCH 406 correctly wakes up a mobile station designed to monitor the F-PCH, as shown by the solid-line arrow. Advantageously, the same BI bit does not point to the broadcast page slot 402A on the F-CCCH 402 because the F-QPCH slot 404A is positioned more than the allowed time interval, e.g., 100 ms, before the broadcast page slot 402A on the F-CCCH 402. Therefore, the two BPCs do not overlap, and only the intended target mobile stations wake up to monitor their respective broadcast page slots. This embodiment may have the following advantages: (1) the duration of one BPC need not be increased to avoid the overlap, which increases the average delay to deliver a broadcast message, and (2) the two BPCs may not overlap at any slot, thus eliminating false alarm due to broadcast paging and hence improving battery performance of the mobile station.

[1038] According to this embodiment, the base station may configure a predetermined shift into one of the equations that provide for the BPCs, such that the first slots of the BPCs are shifted by the predetermined shift. In one embodiment, the base station may introduce a shift of "N" slots in either the BPC on the F-CCCH or in the BPC on the F-PCH, as illustrated in the following equation:

$$(\lfloor t/4 \rfloor + N) \bmod (B + X) = 0$$

[1039] For example, when B+X=65, the base station may introduce a shift of two slots in the BPC on the F-CCCH compared to the BPC of the F-PCH. FIG.

4 shows the corresponding BPCs, and the first slots of the corresponding BPCs are shown in the following table:

	1	2	3	4	5	6	7	8	9	10	...
F-PCH	65	130	195	260	325	390	455	520	585	650	...
F-CCCH	63	128	193	258	323	388	453	518	583	648	...

[1040] According to another embodiment of the invention the base station may specify different values for X_1 and X_2 in the equations that provide for the BPCs of the F-PCH and F-CCCH, respectively, and thereby cause the BPCs of the F-PCH and the F-CCCH to have different periods. FIG. 5 shows an exemplary scenario where different values of X_1 and X_2 result in BPC=4 on the F-CCCH and BPC=3 on the F-PCH. Therefore, the broadcast page slots on the F-CCCH 502 do not overlap with the broadcast page slots on the F-PCH 506. Consequently, the same BI bit on the F-QPCH slots does not point to both the F-CCCH slots and the F-PCH slots. Specifically, if a BI bit were directed to only one of the F-PCH and F-CCCH channels, the same BI bit would not point to the other of the F-PCH and the F-CCCH, which advantageously prevents a mobile station's unnecessary wake up. For example, the BI bit in the F-QPCH slot 504A that points to the broadcast page slot 506A on the F-PCH 506 correctly wakes up a mobile designed to monitor the F-PCH. Advantageously, the same BI bit does not point to the broadcast page slot 502A on the F-CCCH 502 because the F-QPCH slot 504A is positioned more than the allowed time interval, e.g., 100 ms, before the broadcast paging slot 502A on the F-CCCH 502. For example, when B=64 and the base station sets X_1=1 on the F-PCH and X_2=2 on the F-CCCH, the following table shows the first slots of the resulting BPCs:

	1	2	3	4	5	6	7	8	9	10	...
F-PCH	65	130	195	260	325	390	455	520	585	650	...
F-CCCH	66	132	198	264	330	396	462	528	594	660	...

[1041] According to another embodiment of the invention, the base station may directly specify the values for BPCs of the F-PCH and the F-CCCH. The base station may specify different values for B_1 and B_2 in the equations that provide for the BPCs of the F-PCH and the F-CCCH , respectively, and thereby cause the BPCs of the F-PCH and F-CCCH to have different periods. The base station may specify the parameter "B" (rather than the BCAST_INDEX parameter) in the extended system parameters message for the F-PCH and in the system parameters message for the F-CCCH.

[1042] For example, the base station may set BPC=4 on the F-CCCH channel and BPC=3 on the F-PCH, as shown in FIG. 5. Therefore, the broadcast page slots on the F-CCCH 502 do not overlap with the broadcast page slots on the F-PCH 506, except possibly at the first slot at the first BPCs. Consequently, the same BI bit on the F-QPCH slots does not point to both the F-CCCH slots and the F-PCH slots. Specifically, if a BI bit were directed to only one of the F-PCH and the F-CCCH, the same BI bit would not point to the other of the F-PCH and the F-CCCH channel, which advantageously prevents a mobile station's unnecessary wake up. For example, the BI bit in the F-QPCH slot 504A that points to the broadcast page slot 506A on the F-PCH 506 correctly wakes up a mobile station designed to monitor the F-PCH. Advantageously, the same BI bit does not point to the broadcast page slot 502A on the F-CCCH 502 because the F-QPCH slot 504A is positioned more than the allowed time interval, e.g., 100 ms, before the broadcast paging slot 502A on the F-CCCH 502.

[1043] For example, for B_1=60 for the F-PCH and B_2=62 for the F-CCCH, the first slots of the corresponding BPCs are shown in the following table.

	1	2	3	4	5	6	7	8	9	10	..
F-PCH	60	120	180	240	300	360	420	480	540	600	..
F-CCCH	62	124	186	248	310	372	434	496	558	620	..

[1044] Those of skill in the art would understand that information and signals may be represented using any of a variety of different technologies and protocols. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[1045] Those of skill in the art would further appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present invention.

[1046] The various illustrative logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[1047] The steps of a method or algorithm described in connection with the embodiments disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be integral to the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in a user terminal. In the alternative, the processor and the storage medium may reside as discrete components in a user terminal.

[1048] The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein. The word "exemplary" is used exclusively herein to mean "serving as an example, instance, or illustration." Any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments.

[1049] WHAT IS CLAIMED IS:

CLAIMS

1. A method for providing broadcast messages, comprising:

transmitting a plurality of first broadcast page slots on a first channel;

transmitting a plurality of second broadcast page slots on a second channel; and

transmitting a plurality of broadcast indicators on a third channel, such that each one of the plurality of broadcast indicators points to only one of the first or second broadcast page slots.

2. The method of claim 1 wherein the plurality of first broadcast page slots on the first channel are shifted with respect to the plurality of second broadcast page slots on the second channel.

3. The method of claim 1 wherein the plurality of first broadcast page slots on the first channel and the plurality of second broadcast page slots on the second channel are transmitted at different broadcast page cycles.

4. The method of claim 3 wherein the different broadcast page cycles are set by assigning different values to the "B" parameter in $\lfloor t/4 \rfloor \bmod (B + X) = 0$, where "t" stands for a system time and "X" stands for another parameter.

5. The method of claim 3 wherein the different broadcast page cycles are set by assigning different values to the "X" parameter in $\lfloor t/4 \rfloor \bmod (B + X) = 0$, where "t" stands for a system time and "X" stands for another parameter.

6. A base station for providing broadcast messages, comprising:

means for transmitting a plurality of first broadcast page slots on a first channel;

means for transmitting a plurality of second broadcast page slots on a second channel; and

means for transmitting a plurality of broadcast indicators on a third channel, wherein each one of plurality of the broadcast indicators points to only one of the first or second broadcast page slots.

7. The base station of claim 6 further including means for shifting the plurality of first broadcast page slots on the first channel with respect to the plurality of second broadcast page slots on the second channel.

8. The base station of claim 6 wherein the plurality of first broadcast page slots on the first channel and the plurality of second broadcast page slots on the second channel are transmitted at different broadcast page cycles.

9. The base station of claim 8 wherein the different broadcast page cycles are set by assigning different values to the "B" parameter in $\lfloor t/4 \rfloor \bmod (B + X) = 0$, where "t" stands for a system time and "X" stands for another parameter.

10. The base station of claim 8 wherein the different broadcast page cycles are set by assigning different values to the "X" parameter in $\lfloor t/4 \rfloor \bmod (B + X) = 0$, where "t" stands for a system time and "X" stands for another parameter.

11. The base station of claim 6 wherein the first channel is a forward paging channel (F-PCH).

12. The base station of claim 6 wherein the second channel is a forward common control channel (F-CCCH).

13. The base station of claim 6 wherein the third channel is a forward quick paging channel (F-QPCH).

14. A computer readable medium embodying a method for providing broadcast messages, the method comprising:

transmitting a plurality of first broadcast page slots on a first channel;

transmitting a plurality of second broadcast page slots on a second channel; and

transmitting a plurality of broadcast indicators on a third channel, such that each one of the plurality of the broadcast indicators may point to only one of the first or second broadcast page slots.

15. A base station for providing broadcast messages, comprising:

a transmitter configured to transmit a plurality of first broadcast page slots on a first channel, transmit a plurality of second broadcast page slots on a second channel, and transmit a plurality of broadcast indicators on a third channel; and

a processor configured to control the transmitter such that each one of the plurality of broadcast indicators points to only one of the first or second broadcast page slots.

16. The base station of claim 15 wherein the processor is further configured to shift the plurality of first broadcast page slots on the first channel with respect to the plurality of second broadcast page slots on the second channel.

17. The base station of claim 15 wherein the processor is further configured to control the transmitter to transmit the plurality of first broadcast page slots on the first channel and the plurality of second broadcast page slots on the second channel at different broadcast page cycles.

18. The base station of claim 17 wherein the different broadcast page cycles are set by assigning different values to the "B" parameter in $\lfloor t/4 \rfloor \bmod (B + X) = 0$, where "t" stands for a system time and "X" stands for another parameter.

19. The base station of claim 17 wherein the different broadcast page cycles are set by assigning different values to the "X" parameter in $\lfloor t/4 \rfloor \bmod (B + X) = 0$, where "t" stands for a system time and "X" stands for another parameter.

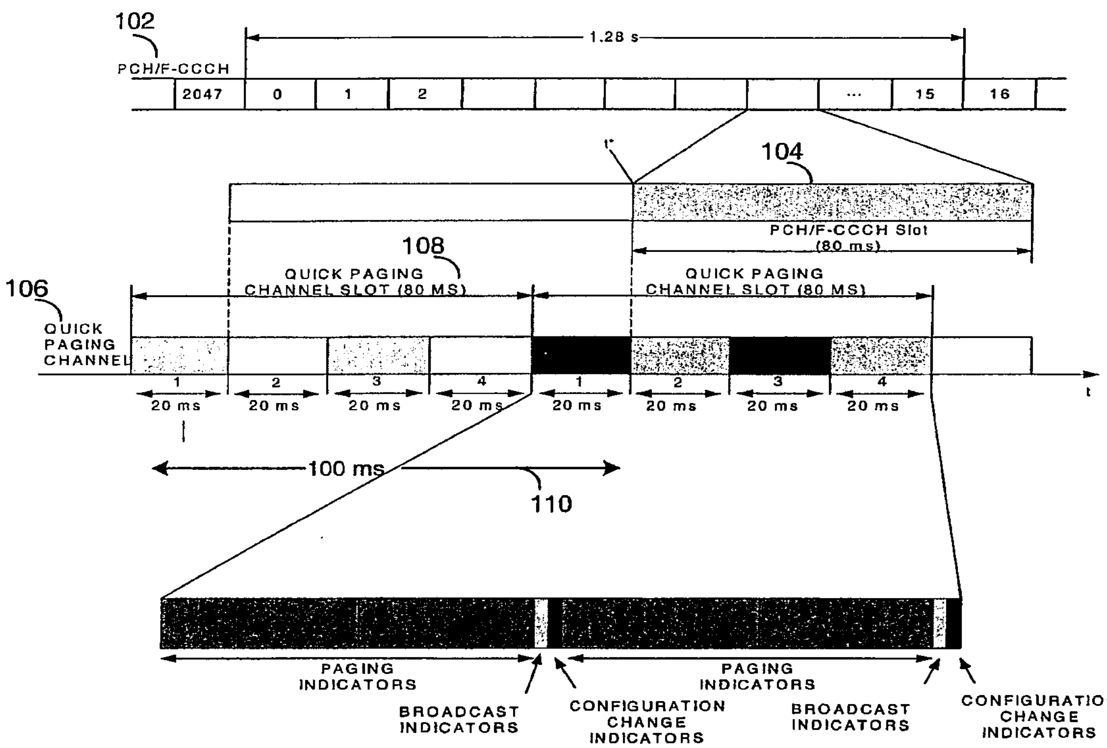
102
PCH/F-CCCH
1.28 s
2047
0
1
2
...
15
16
104
PCH/F-CCCH Slot
(80 ms)
108
QUICK PAGING
CHANNEL SLOT (80 MS)
QUICK PAGING
CHANNEL SLOT (80 MS)
106
QUICK
PAGING
CHANNEL
1
2
3
4
20 ms
t
100 ms
110
PAGING
INDICATORS
BROADCAST
INDICATORS
CONFIGURATION
CHANGE
INDICATORS

FIG. 1

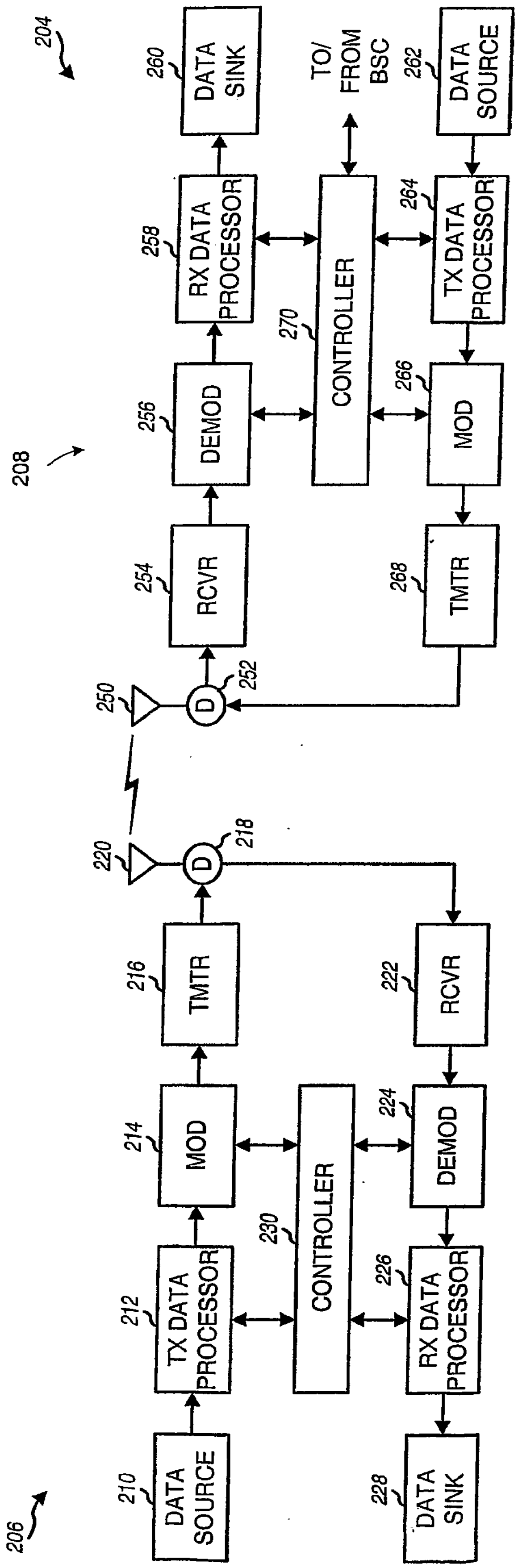
204
208
206
DATA SINK
260
RX DATA PROCESSOR
258
TO/ FROM BSC
CONTROLLER
270
DATA SOURCE
262
TX DATA PROCESSOR
264
DEMOD
256
MOD
266
RCVR
254
TMTR
268
250
D
252
220
D
218
TMTR
216
RCVR
222
MOD
214
DEMOD
224
CONTROLLER
230
TX DATA PROCESSOR
212
RX DATA PROCESSOR
226
DATA SOURCE
210
DATA SINK
228

FIG. 2

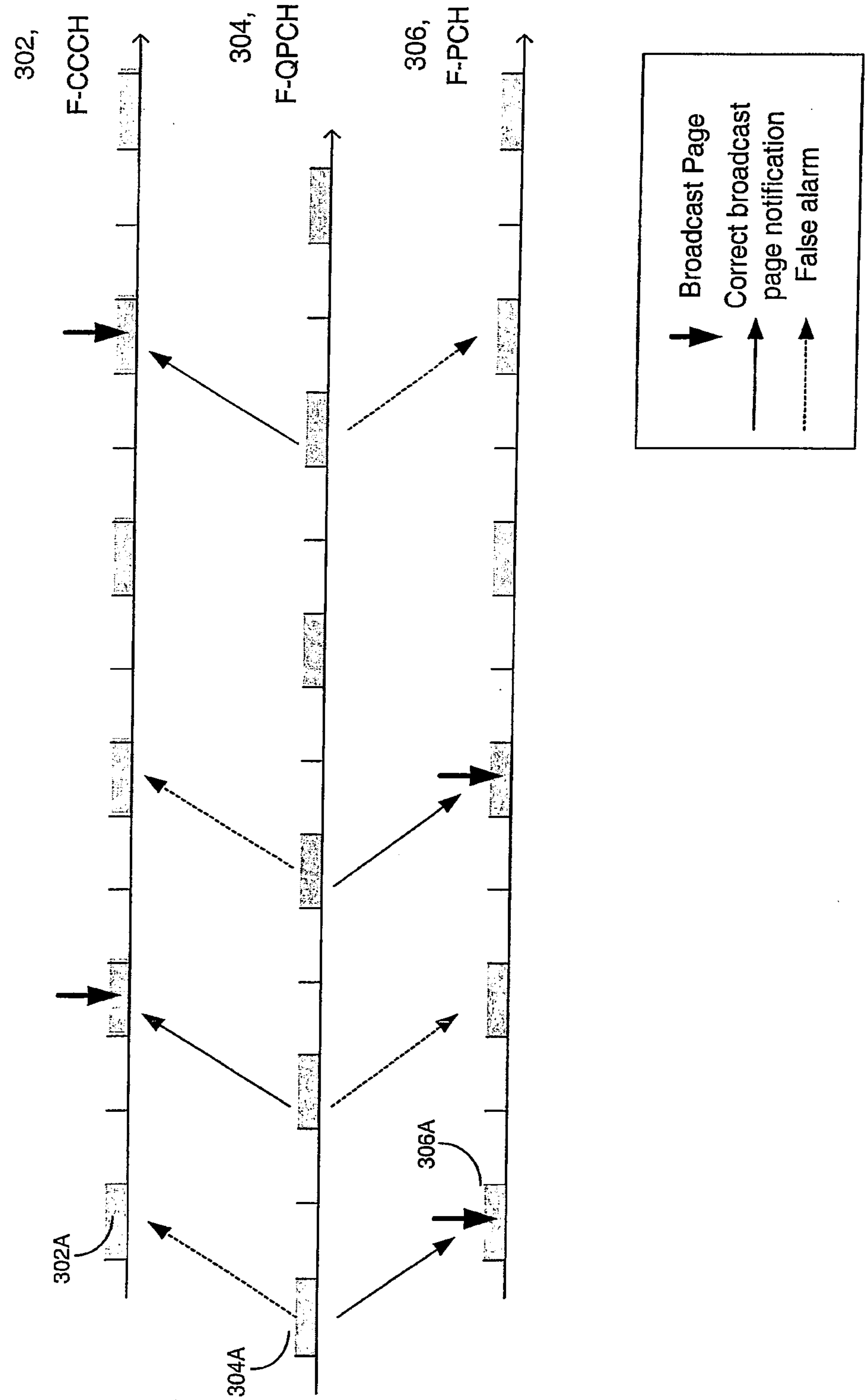
302,
F-CCCH
304,
F-QPCH
306,
F-PCH
Broadcast Page
Correct broadcast page notification
False alarm
302A
304A
306A

FIG. 3

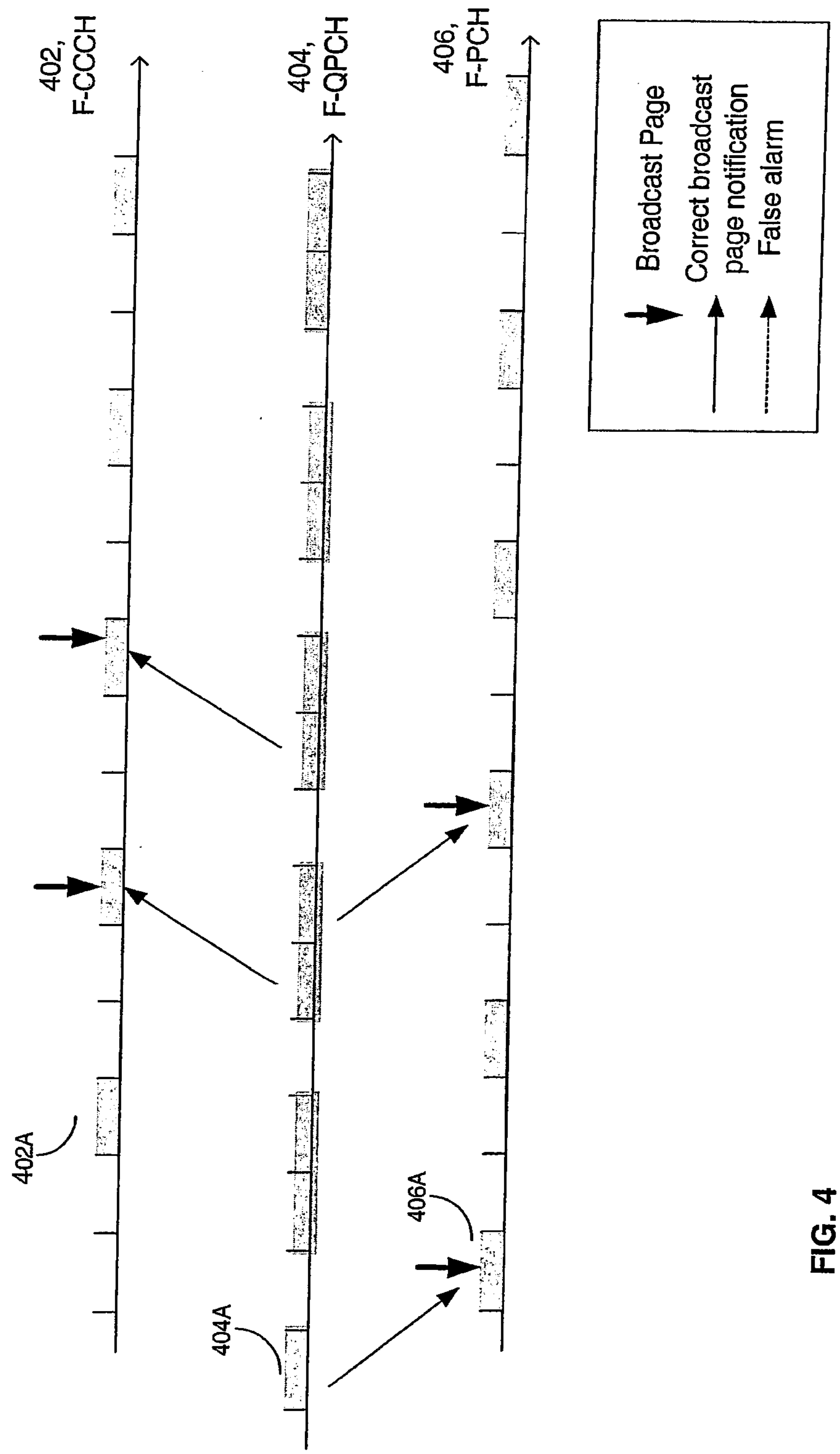
402, F-CCCH
404, F-QPCH
406, F-PCH
402A
404A
406A
Broadcast Page
Correct broadcast page notification
False alarm

FIG. 4

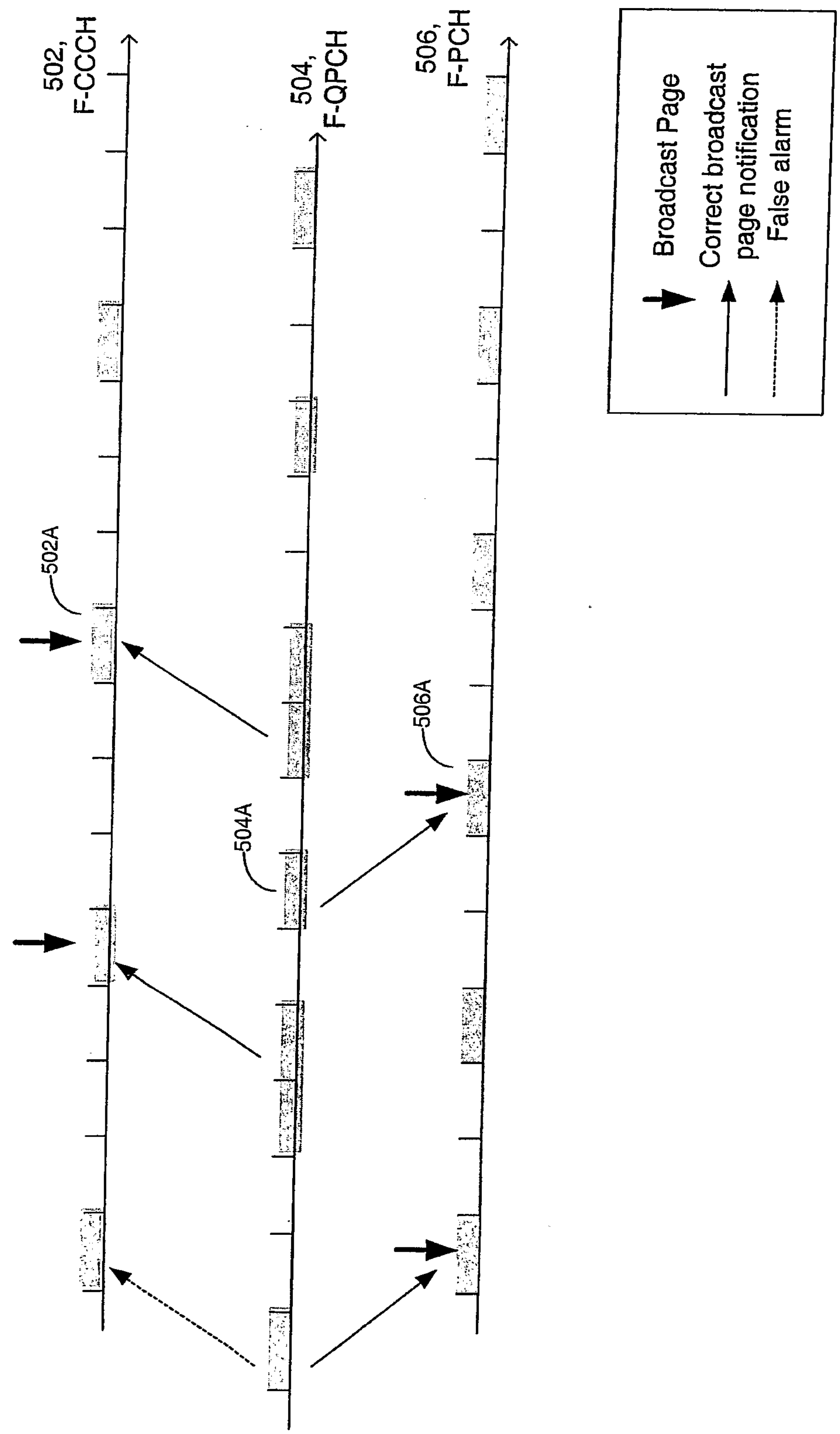
502,
F-CCCH
504,
F-QPCH
506,
F-PCH
502A
504A
506A
Broadcast Page
Correct broadcast page notification
False alarm

FIG. 5

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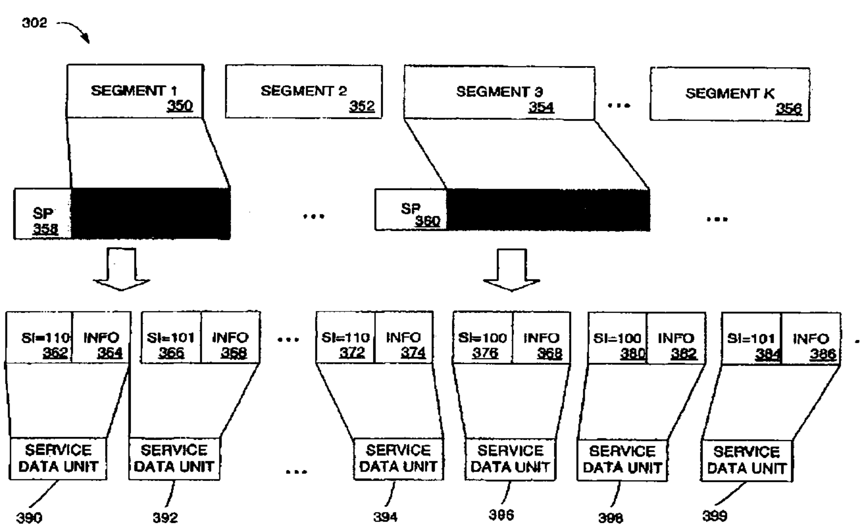
(54) Title: METHOD AND APPARATUS FOR MESSAGE SEGMENTATION IN A WIRELESS COMMUNICATION SYSTEM



(57) Abstract: Method for segmented message transmission wherein each message is first divided into segments and the segments are fragmented. A segment parameter is applied to each segment, and a segment identifier to each fragment. The fragments are provided to a lower level for preparation into frames for transmission. One embodiment is applied to the transmission of short duration messages, such as control messages.

WO 03/017691 A2

METHOD AND APPARATUS FOR MESSAGE SEGMENTATION IN A WIRELESS COMMUNICATION SYSTEM

BACKGROUND

Field

[1001] The present invention relates to communications systems. Specifically, the present invention relates to methods for segmenting and transmitting messages in a wireless communication system.

Background

[1002] In a wireless communications system messages are transmitted from a transmitter to a mobile receiver. Messages are transmitted in frames, wherein a frame defines a predetermined period of time and a protocol is the set of procedures used to perform a given set of operations, such as the exchange of information, wherein a protocol defines the constituent information transmitted in a frame. As wireless communications are performed through a shared air interface, reception quality is interference limited. Poor quality reception at the receiver may result in the loss of a transmitted frame of data, i.e., received signal is not recognizable due to the addition of interference signals. When a frame is lost, typically, the entire message (multiple frames) is retransmitted. Retransmission of an entire message uses bandwidth otherwise used for additional messages. Additionally, retransmission adds to the delay time of a system, and may result in unacceptable performance of the wireless communication system.

[1003] Therefore, there is a need for an accurate method of transmitting messages in a wireless communication system. Additionally, there is a need for an efficient method of retransmitting information in a wireless communication system.

SUMMARY

[1004] Embodiments disclosed herein address the above stated needs by providing a method and apparatus for segmentation of a transmission message, wherein a segment parameter is attached to each segment, and wherein each segment is fragmented into a plurality of fragments. Each of the fragments includes a segment identifier. In one embodiment, the segment identifiers of fragments within a segment identify the start of segment and the end of segment.

[1005] According to one aspect, in a wireless communication system having a base station controller and a plurality of base stations, a method includes segmenting a message into a plurality of segments, dividing the segments into a plurality of fragments, and transmitting the fragments.

[1006] According to another aspect, in a wireless communication system having a base station controller and a plurality of base stations, a base station includes means for building segments of a message from a plurality of transmitted frames, means for identifying a missing segment of the message, and means for requesting a retransmission of the missing segment.

[1007] In one aspect, a wireless apparatus includes receiver for receiving a plurality of transmission frames, segment extraction unit coupled to the fragment extraction unit, adapted to identify and reconstruct segments within a transmission frame, and message reconstruction unit coupled to the segment extraction unit, adapted to determine any missing segment within a message and to request retransmission of the missing segment.

[1008] In still another aspect, a computer data signal embodied on a carrier wave is characterized by a plurality of segments, each segment having a segment parameter, and a plurality of fragments.

BRIEF DESCRIPTION OF THE DRAWINGS

[1009] FIG. 1 is a wireless communication system.

[1010] FIG. 2 is an architectural layering for implementing protocols in a wireless communication system.

[1011] FIG. 3A is a message transmission protocol applicable in a wireless communication system.

[1012] FIG. 3B is a frame configuration according to a transmission protocol such as illustrated in FIG. 3A.

[1013] FIG. 4A is a message transmission protocol implementing segmentation applicable in a wireless communication system.

[1014] FIG. 4B is a frame configuration according to a transmission protocol such as illustrated in FIG. 4A.

[1015] FIG. 5A is an example of a message transmission protocol such as illustrated in FIG. 4A.

[1016] FIG. 5B is a legend defining segmentation indicator bit values used in a message transmission protocol such as illustrated in FIG. 5A.

[1017] FIG. 5C is a legend defining segmentation indicator combinations used in a message transmission protocol such as illustrated in FIG. 5A.

[1018] FIG. 5D is a legend defining segmentation indicator bit values used in a message transmission protocol such as illustrated in FIG. 5A.

[1019] FIG. 5E is a legend defining segmentation indicator combinations used in a message transmission protocol such as illustrated in FIG. 5A.

[1020] FIG. 6 is a flow diagram of a method of message segmentation for transmission.

[1021] FIGs. 7A and 7B are flow diagrams of a method of receiving a segmented message.

[1022] FIG. 8 is an example of message segmentation for transmission.

[1023] FIG. 9A is a timing diagram of a message transmission with retransmission of the message.

[1024] FIG. 9B is a timing diagram of a message segmentation and transmission with retransmission of at least one segment.

[1025] FIG. 10 is a block diagram of a transmitter supporting a message segmentation and transmission protocol.

[1026] FIG. 11 is a block diagram of a receiver supporting a message segmentation and transmission protocol.

[1027] FIG. 12 is a flow diagram illustrating erasure detection in a wireless communication system.

[1028] FIG. 13A and 13B are timing diagrams of transmission frame in a wireless communication system.

DETAILED DESCRIPTION

[1029] The word "exemplary" is used exclusively herein to mean "serving as an example, instance, or illustration." Any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments. While the various aspects of the present invention are presented in drawings, the drawings are not necessarily drawn to scale unless specifically indicated.

[1030] In a spread spectrum system, such as a Code Division Multiple Access, CDMA, communications system, signals are spread over a wide bandwidth via the use of a code, such as a Pseudorandom Noise, PN, spreading sequence. The "TIA/EIA/IS-95 Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System," hereinafter referred to as "the IS-95 standard," and the "TIA/EIA/IS-2000 Standards for cdma2000 Spread Spectrum Systems," hereinafter referred to as "the cdma2000 standard," detail spread spectrum CDMA systems.

[1031] Wireless communication systems are widely deployed to provide various types of communication such as voice, data, and so on. These systems may be based on code division multiple access (CDMA), time division multiple access (TDMA), or some other modulation techniques. A CDMA system provides certain advantages over other types of system, including increased system capacity.

[1032] A system may be designed to support one or more standards such as: (1) the "TIA/EIA/IS-95-B Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System" referred to herein as the IS-95 standard; (2) the standard offered by a consortium named "3rd Generation Partnership Project" referred to herein as 3GPP; and embodied in a set of documents including Document Nos. 3G TS 25.211, 3G TS 25.212, 3G TS 25.213, and 3G TS 25.214, 3G TS 25.302, referred to herein as the W-CDMA standard; (3) the standard offered by a consortium named "3rd Generation Partnership Project 2" referred to herein as 3GPP2, and TR-45.5 referred to herein as the cdma2000 standard, formerly called IS-2000 MC, or (4) some other wireless standard. The standards (1), (2), and (3) cited hereinabove are hereby expressly incorporated herein by reference.

[1033] Each standard specifically defines the processing of data for transmission from base station to mobile, and vice versa. For example, speech information may be coded at a particular data rate, formatted into a defined frame format, and processed (e.g., error correction and/or detection encoded, interleaved, and so on) in accordance with a particular processing scheme. As an illustration of this, the W-CDMA standard defines an Adaptive Multi-Rate, or AMR, speech coding scheme whereby speech information may be encoded based on one of a number of possible data rates and the coded speech data is provided in a particular format that depends on the selected data rate. The codec, frame formats and processing defined by a particular standard (e.g., cdma2000 standard) are likely to be different from those of other standards (e.g., W-CDMA standard).

[1034] There are any numbers of communication systems capable of supporting multiple transport formats, i.e., variable length transmission frames. One such system is defined by the cdma2000 standard. While a CDMA type system is used as an exemplar throughout the following discussion, the present methods and apparatus are applicable to any system that transmits messages in frames, and supports retransmission of frames and/or portions of a frame. Additionally, the methods described herein may be applied to forward link and reverse link, as well as downlink and uplink. For convenience, the descriptions herein use terminology consistent with a CDMA type system. For application to a W-CDMA type system, an uplink communication refers to a communication from a User Equipment, UE, to a node B, i.e., transmitter.

[1035] While some of the terminology used to describe a conventional CDMA type spread spectrum system is consistently used with respect to a W-CDMA type system, there are several terms having specific definitions in each type system.

[1036] In a CDMA system, a mobile user is referred to as a Mobile Station. Multiple MSs communicate through a Base Station having a fixed location in the wireless communication system. The Reverse Link, RL, in a CDMA system refers to transmissions from a mobile user or Mobile Station, MS, to a Base Station, BS. The Forward Link, FL, refers to transmissions from the BS to a MS.

[1037] The terminology specific to a W-CDMA system refers to the mobile users as User Equipment, UE. Multiple UEs communicate through a "Node B" having a fixed location in the wireless communication system. Transmissions from the UE to the Node B are referred to as Up Link, UL. Down Link, DL, refers to transmissions from the Node B to the UE.

[1038] FIG. 1 is a diagram of a spread spectrum communication system 100 that supports a number of users. System 100 provides communication for a number of cells, with each cell being serviced by a corresponding base station 104. Various remote terminals 106 are dispersed throughout the system. System 100 may represent a CDMA wireless communication system, wherein each of the remote terminals 106 is referred to as a MS. Similarly, system 100 may represent a W-CDMA wireless communication system, wherein each of the remote terminals 106 is referred to as a UE. Each remote terminal 106 may communicate with one or more base stations 104 on the forward and reverse links at any particular moment, depending on whether or not the remote terminal is active and whether or not it is in soft handoff. For clarity of understanding, an exemplary embodiment is considered, wherein the system 100 is a CDMA type system consistent with the cdma2000 standard.

[1039] As shown in FIG. 1, base station 104A communicates with remote terminals 106A, 106B, 106C, and 106D, and base station 104B communicates with remote terminals 106D, 106E, and 106F.

[1040] A system controller 102 couples to base stations 104 and typically further couples to other systems, including, but not limited to, a Public Switched Telephone Network, PSTN, the Internet, or other communication network. System controller 102 provides coordination and control for the base stations coupled to it. System controller 102 further controls, via base stations 104, the routing of telephone calls among remote terminals 106, and between remote terminals 106 and the users coupled to other systems. System controller 102 is also referred to as a Base Station Controller, BSC.

[1041] FIG. 2 illustrates an architectural layering 110 of an exemplary embodiment of the present invention. The physical layer 112 indicates the channel structure, frequency, power output, modulation type, and encoding specifications for the forward and reverse links. The Medium Access Control, MAC, layer 114 defines the procedures used to receive and transmit over the physical layer 112.

[1042] The layered structure illustrated in FIG. 2 is designed to provide voice, packet data, and voice and packet data services simultaneously. The physical layer 112 performs coding, interleaving, modulation and spreading functions for the physical channels. The MAC layer 114 and the Link Access Control, LAC, layer 116 together form a link layer to provide protocol support and control mechanisms for data transport services. The link layer further maps the data transport needs of higher layers into specific, capabilities and characteristics of the physical layer 112. The link layer also maps logical and signaling channels into code channels specifically supported by the coding and modulation functions of the physical layer 112. As used herein, signaling refers to the transmission of control information, but may be extended to include data information or other information transmitted as messages in a communications system.

[1043] Control applications and high layer protocols utilize the services provided by the LAC layer 116. The LAC layer 116 performs the functions essential to set up, maintain, and release a logical link connection, including delivery of messages. The MAC layer 114 provides a control function that manages resources supplied by the physical layer 112. For example, the MAC layer 114 controls the physical code channels for communication of information over the air interface. The MAC layer 114 further coordinates the usage of those resources desired by various LAC service entities. Such coordination function resolves contention issues between LAC service entities within a single mobile station, as well as between competing mobile stations. The MAC layer 114 delivers Quality of Service, QoS, level requests from LAC services. For example, the MAC may reserve air interface resources or resolve priorities between competing LAC service entities.

[1044] For an HDR system, the MAC layer 114 includes scheduling capabilities to balance users or connections. Such balancing typically schedules low throughput for channels with poor coverage, thus freeing up resources allowing high throughput for channels with good connections. The next layer, the Link Access Control, LAC, layer 116, provides an access procedure for higher layer applications. In alternate architectures, a radio link, the Radio Link Protocol, RLP, layer (not shown) may provide retransmission and duplicate detection for an octet-aligned data stream in place of or in parallel with the LAC layer 116. In the context of a packet service, the LAC layer 116 carries Point-to-Point Protocol, PPP, packets. The High Level Data Link Control HDLC layer 120 is a link layer for PPP and ML-PPP communications. Control information is placed in specific patterns, which are dramatically different from the data in order to reduce errors. The HDLC layer 120 performs framing of the data prior to PPP processing. The PPP layer 122 then provides compression, authentication, encryption and multi-protocol support. The Internet Protocol, IP, layer 124 keeps track of Internet work addressing for different nodes, routes outgoing messages, and recognizes incoming messages.

[1045] Protocols running on top of PPP, such as IP layer 124, carry user traffic. Note that each of these layers may contain one or more protocols. Protocols use signaling messages and/or headers to convey information to a peer entity on the other side of the air-interface. For example, in a High Data

Rate, HDR, system, protocols send messages with a default signaling application.

[1046] The architecture 110 is applicable to an Access Network, AN, for providing data connectivity between an IP network, such as the Internet, and access terminals, including wireless mobile units. Access Terminals, Ats, provide data connectivity to a user. An AT may be connected to a computing device such as a laptop personal computer or may be a self-contained data device such as a personal digital assistant. There are a variety of wireless applications and an ever- increasing number of devices, often referred to as IP appliances or web appliances. As illustrated in FIG. 2, layers above the LAC layer 116 are service network layers and layers below the HDLC layer 120 are radio network layers. In other words, the radio network layers affect the air-interface protocols. The radio network layers of the exemplary embodiment implement the "TL80-54421-1 HDR Air Interface Specification" referred to as "the HAI specification." The HAI specification is sometimes referred to as "1xEVDO." HDR generally provides an efficient method of transmitting data in a wireless communication system. Alternate embodiments may implement the "TIA/EIA/IS-2000 Standards for cdma2000 Spread Spectrum Systems" referred to as "the cdma2000 standard," the "TIA/EIA/IS-95 Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System," hereinafter referred to as "the IS-95 standard," or other per-user connection systems, such as the "ANSI J-STD-01 Draft Standard for W-CDMA (Wideband Code Division Multiple Access) Air Interface Compatibility Standard for 1.85 to 1.99 GHz PCS Applications" referred to as "W-CDMA."

[1047] The use of a multiple access system for voice and data transmissions is disclosed in the following U.S. Patents:

[1048] U.S. Patent No. 4,901,307, entitled "SPREAD SPECTRUM MULTIPLE ACCESS COMMUNICATION SYSTEM USING SATELLITE OR TERRESTRIAL REPEATERS;"

[1049] U.S. Patent No. 5,103,459, entitled "SYSTEM AND METHOD FOR GENERATING WAVEFORMS IN A CDMA CELLULAR TELEPHONE SYSTEM;"

[1050] U.S. Patent No. 5,504,773, entitled "METHOD AND APPARATUS FOR FORMATTING OF DATA FOR TRANSMISSION;" each assigned to the assignee hereof and expressly incorporated by reference herein. As the frequency spectrum is a finite resource, these systems provide methods for maximizing the use of this resource by sharing the spectrum while supporting a large number of users with minimal interference. The extension of these methods to the high speed transmission of data allows reuse of existing hardware and software. Designers already familiar with such standards and methods may use this knowledge and experience to extend these systems to high speed data transmissions.

[1051] As described hereinabove, in preparing a message for transmission, the transmitter typically spreads the message over multiple frames. The Frame Error Rate, FER, associated with a given communication link is defined as the probability of losing a given frame. Similarly, the Message Error Rate, MER, associated with a given communication link is defined as the probability of losing a given message. The MER is related to the FER as given in equation (1).

$$MER=1-(1-FER)^n, \quad (1)$$

wherein the message is spread over n frames. Equation (1) assumes a statistical independence of events, specifically; the probability of an error in any given frame is equal to the probability of an error in any other frame. For a fixed FER value, the MER increases with increases in message length. If one frame is lost, the entire message is lost. Note that a frame is a basic timing interval in a wireless communication system. The time length defining a frame for different transmission channels may be different.

[1052] The risk of losing a message, i.e., MER, increases with the length of the message. As the message length increases, the number of frames required for transmission of the message increases. As the loss of one frame will result in the loss of the entire message, the risk of losing the message is affected by the number of frames per message. Additionally, for a constant length message, increases in the FER directly impacts the MER as given in equation (1).

[1053] FIGs. 3A and 3B illustrate a transmission protocol implemented in a LAC layer 114, wherein each message 200 includes multiple fields including: a header 202; multiple fields 204 to 206; information 208; and a tail 210. The header 202 includes control information for transmission and receipt of the message, including but not limited to, message length, message identifier, protocol version discriminator, etc. The fields 204 to 206 include any number of fields, including but not limited to addressing fields, encryption fields, authentication field and fields that are used to provide message retransmissions (ARQ). In one embodiment, the information field 208 provides signaling information, such as control messages, from the transmitter to receiver. The tail frame 210 includes termination information for the message, including a Code Redundancy Check, or CRC, to ensure the correctness of the message.

[1054] The message 200 is transmitted in a number of fragments, labeled as 1, 2, ..., X. Each fragment 220 includes a Start Of Message, SOM, indicator 222, and an information portion 224. In one embodiment, the SOM is a one to indicate a first fragment in the message, and a zero to indicate successive fragments in the message. The MER of the message 200 is given in equation (1). The fragments are then provided to the MAC layer 114, which arranges the fragments into frames for transmission. The MAC layer 114 may add information to the fragments and may reorder the fragments for transmission. Each fragment 220 may correspond to a transmission frame. On receipt of the message at a receiver, if any fragment is lost, the entire message is retransmitted. A lost fragment is typically referred to as an erasure, wherein the receiver receives signal energy but is unable to process and/or decode the information. If a portion of a message is lost, the entire message may be considered lost if the receiver is not able to process the message without the lost portion. The lost portion may be referred to as an erasure or a missing portion.

[1055] In one system, when the receiver receives a message and is able to decode and process the message, the receiver acknowledges the receipt of the message by transmission of an Acknowledgement, ACK, message. If the message is lost, the receiver does not respond to the transmitter. The transmitter waits for receipt of the ACK message from the target recipient. If the ACK message is not received at the transmitter within a predetermined wait time period, the transmitter retransmits the message. The transmitter has little or no information as to the lost portion(s) of the message.

[1056] The retransmission of a message on the loss of only a portion, or fragment, of the message and upon the expiration of a wait time incurs delay time to the receiver and consumes transmission bandwidth of the transmitter. To provide retransmission of the lost portion(s) or fragment(s) an exemplary embodiment of the present invention provides a method of message segmentation, illustrated in FIGs. 4A and 4B, that separates the message 200 into multiple segments 302. Each of the segments 302 is assigned a unique identifier. The first segment of the message is further identified by a Start Segment, SS, indicator. The last segment of the message is identified by an End Segment, ES, indicator. The segmentation process is defined as segmenting a given message into multiple parts. The multiple segments 302 may have varying lengths. The determination of the length of each of the segments 302 may be based on a channel quality estimate, or other criteria specific to a given communication system. The determination of the length of segments balances efficiency and performance. Shorter segment length incurs a greater total number of segments for the same message. Shorter segment length provides increases reliability and thus enhanced performance. A large total number of segments incur processing and storage overhead that reduce efficiency, e.g., generation of transmission of more segment parameter bits to identify the multiple segments. Ideally a system will optimize performance while maintaining low overhead.

[1057] As illustrated in FIG. 4A, message 200 is segmented into K segments. Each of the K segments is then further divided into X fragments. According to the exemplary embodiment, the number of fragments X is variable for each of the segments 302. Alternate embodiments may specify a constant number X of fragments per segment within a given message. The determination of the length of each of the fragments 304 as well as the number of fragments X is determined by parameters of the physical layer 112 and the

MAC layer 114. As illustrated in FIG. 4A, SEGMENT 3 of segments 302 is divided into X fragments 304. The fragments 304 are then provided to the MAC layer 114 for transmission via multiple transmission frames (not shown).

[1058] As discussed hereinabove, each of the K segments 302 is segmented into X fragments, wherein the total number of fragments n is given as:

$$n=K*X. \quad (2)$$

In the exemplary embodiment, the total number of fragments is equal to the total number of frames generated by the MAC layer 114 for transmission on the physical layer 112, while alternate embodiments may provide the total number of fragments as a function of the total number of frames. The resultant message error is defined as a function of the Segment Error Rate, SER, as:

$$MER=1-(1-SER)^K, \quad (3)$$

wherein the SER is defined as:

$$SER=1-(1-FER)^X. \quad (4)$$

[1059] As illustrated in FIG. 4B, each fragment 306 includes a Segment Identifier, SI, 308 and information 310. The information 310 is a portion of the content of a segment from segments 304. According to the exemplary embodiment, the SI includes at least two bits, SI_1 and SI_2. One of the bits indicates whether segmentation is enabled, and the other of the two bits identifies a first segment of the message.

[1060] In one embodiment of message transmission illustrated in FIG. 5A, a message 200 is divided into X fragments, identified as fragments 304 labeled MSG_1 to MSG_X. As illustrated, boundaries between fragments 304 are not necessarily the same as boundaries between fields of the message 200, although some segment boundaries may coincide with some field boundaries. The fragments 304 are portions of the information contained in the message 200, including information contained in each of the fields 202, 204, 206, 208, and 210, as well as any other fields included in the message 200.

[1061] Each of the X fragments (of fragments 304) corresponds to a transmission frame of frames 360 for a total number of X frames per segment message. Each frame is referred to as containing a Service Data Unit, SDU. Each of the fragments 304 includes a Segment Identifier, SI, value appended as a prefix to a portion of the message 200. The fragment identifier is determined sequentially. Alternate embodiments may implement other methods of assigning identifiers to frames and segments. The identification is used to reconstruct the message at the receiver. Similarly, alternate embodiments may append the SI at the end of the segment information or may integrate the SI information with the segment information. In each of these embodiments, when the organization of the frame is known at the receiver, the receiver is then able to reconstruct the message accordingly.

[1062] As illustrated in FIG. 5A, the X fragments 304 include fragments 320, 330, 340, and 350, wherein each fragment 320, 330, 340, and 350 includes a portion of message 200 and an SI. In the embodiment of FIG. 5A, the system supports message segmentation as defined by the protocol of FIG. 4A, however for the example transmission message segmentation is inactive. For active segmentation, segment retransmission requests are supported. In other words, the receiver may request a retransmission of a segment or portion of the transmitted message. For inactive segmentation, segment retransmission requests are not supported. The receiver may request retransmission of the entire message, but not a smaller unit thereof.

[1063] In the embodiment of FIG. 5A, each SI includes three bits. The significance of the SI bits is illustrated in FIGs. 5B and 5C. As illustrated in FIG. 5B, the first bit of the SI, labeled SI_1, indicates whether segmentation is active or inactive, wherein a high logic value indicates segmentation is active, else segmentation is inactive. The first bit of the SI, labeled SI_2, identifies a segment start, wherein a high logic value indicates the start of a segment. The third bit of the SI, labeled SI_3, indicates a segment end, wherein a high logic value indicates the end of a segment. The significance of various bit combinations is provided in the table of FIG. 5C. Alternate embodiments may use any number of bits each having a predetermined significance. Additionally, alternate embodiments may implement an alternate polarity scheme for the SI bits.

[1064] Continuing with FIG. 5A, the first fragment 320 (of fragments 304) includes a segment identifier portion, SI 322, appended to a message portion MSG_1 324. The frame 320 is the first fragment in the transmission of message

200, and therefore the SI 322 is designated as 010, wherein SI_1=0, SI_2=1, and SI_3=0. As segmentation is inactive for this example, the second bit, SI_2, may be used to identify the start of the message, and the third bit, SI_3, may be used to identify the end of the message. The next fragment 330 includes SI portion 332 and information portion 334. The SI 332 indicates a middle transmission fragment. As last fragment 350 includes SI portion 352 and information portion 354. The SI 352 indicates an end of segment, or message.

[1065] Each of the fragments 304 corresponds to an SDU 360 generated by the MAC layer 114. Specifically, as illustrated, fragment 320 corresponds to SDU 362, fragment 330 corresponds to SDU 364, fragment 340 corresponds to SDU 366, and fragment 350 corresponds to SDU 368. The SDUs 360 corresponds to transmission frames sent over the physical layer 112.

[1066] Continuing with FIG. 5A, SI 322 indicates segmentation inactive for this transmission. Even though segmentation is inactive, the message 200 is divided to form fragments 304 resulting in SDUs 360. SDUs 360are modulated and transmitted. In one embodiment, an error checking mechanism is also applied to the SDUs 360. As the frames are received at the receiver, the error checking is evaluated to find frame errors. On detection of a frame error, the receiver is not able to request a particular segment for retransmission as segmentation is inactive. Instead the receiver will request retransmission of the entire message 200. As discussed hereinbelow, and particularly with respect to FIGs. 8 and 9, when segmentation is active, the receiver is provided sufficient information to request the segment in which a frame error was detected. In this way, bandwidth is conserved and transaction time is reduced.

[1067] FIGs. 5D and 5E illustrate an alternate embodiment, wherein the SI includes two bits. The first bit, SI_1, indicates whether segmentation is active. The second bit, SI_2, identifies the start of a segment. The significance of combinations of the two bits is provided in the table of FIG. 5E.

[1068] FIG. 6 illustrates a method 400 of message segmentation applied at a transmitter in a wireless communication system according to one embodiment. The transmitter receives a message for transmission at step 402. The message may be a control message or other short duration message for transmission to a target receiver. If segmentation is active at decision diamond 404, processing continues to step 412 to segment the message into *K* segments. The transmitter determines an appropriate Segment Parameter, SP, to add to each segment and generates the SP at step 414. The structures formed in step 414 are divided to form *X* fragments at step 416. The transmitter determines the appropriate SI to apply to each fragment. The SI is then appended to each fragment at step 418. . Each fragment, including SI, is passed to the MAC layer for processing at step 420. Processing then returns to step 402 to process the next message.

[1069] Returning to decision diamond 404, if message segmentation is inactive, processing continues to step 406 to divide the message into X portions. An SI is appended to each message portion to form a fragment at step 408. The fragments are then passed to the MAC layer at step 410. Processing returns to step 402 to process a next message.

[1070] At the receiver, the SI bits are extracted from the received fragment to determine processing of a transmitted message. FIGs. 7A and 7B illustrate a method 420 of processing a transmitted segmented message at the receiver. The receiver receives a transmitted frame at step 422. The receiver determines if segmentation is active by evaluating the SI bits included in the frame. If segmentation is active processing continues to step 442 to process the fragment contained in the frame. Processing of the fragment is further detailed in FIG. 7B. The process then determines from the SI bits if the frame is a start of segment at decision diamond 444. If the frame is a start of segment, the receiver stores the information portion of the fragment in a memory storage buffer at step 446. Processing then returns to step 422 to receive a next frame.

[1071] Returning to decision diamond 444, if the received frame is not a start of segment, the receiver determines if the frame is an end of segment based on the SI bits at decision diamond 448. If the received frame is not an end of segment, the receiver stores the information from the fragment into the buffer and processing returns to step 422. If the frame is the end of a segment, the receiver reconstructs the segment and places the segment in order at step 450. If this segment completes a message at decision diamond 452, the receiver checks for missing segments at decision diamond 454. If there are no missing segments processing continues to step 432 to reconstruct the message. If missing segments are determined at decision diamond 454, the receiver sends a Negative Acknowledge, NACK, message at step 454 and processing returns to step 422. If the segment is not the end of the message at decision diamond 452, processing returns to step 422.

[1072] If segmentation is not active at decision diamond 424, processing continues to step 426 to process the fragment. Processing of the fragment is further detailed in FIG. 7B. The receiver then stores the information contained in the fragment into a memory storage buffer at step 428. The receiver determines if the frame marks the end of a message at decision diamond 430. If the receiver does not detect a message end, processing returns to step 422 to process a next frame. If the receiver detects a message end the message is reconstructed at step 432. The receiver then checks for errors in the message at decision diamond 434. On detection of an error, the receiver discards the message at step 436 and processing returns to step 422. If no error is detected in the message, the receiver delivers the message at step 438 to the corresponding application or service. The receiver sends an ACK message at step 440 and processing returns to step 433.

[1073] A portion of the processing of a fragment, as contained in a frame, is further detailed in FIG. 7B. The method 460 illustrates processing of a fragment in a wireless communication system supporting message segmentation. If the fragment is a start of segment, the receiver determines if the storage buffer is empty at step 470. If the buffer is not empty the method 460 flushes the buffer and stores the information from the received frame in the buffer at step 474. If the buffer is empty, the process stores the information in the buffer at step 474. If the fragment is not a start of segment, the receiver checks the status of the buffer at decision diamond 464. If the buffer is empty the receiver discards the received frame at step 468. For example, if the start of segment fragment is lost, the receiver will not process the remainder of the segment. If the buffer is not empty the information from the frame is stored in the buffer at step 466.

[1074] In one embodiment of message transmission illustrated in FIG. 8, a message 200 is segmented consistent with the method 400 of FIG. 6. Message segmentation is active in processing of the message 200 as illustrated in FIG. 8. The message 200 is segmented into segments 302. Each of the segments 302 includes a portion of the message 200. Each of the segments 302 has a sequential identifier. To each segment 350, 352, 354, ..., 356 a Segment Parameter, SP, is added. The combination of segment plus SP is further divided to form fragments. The fragments are then modified to include an SI, wherein in the present embodiment the SI includes three bits and has significance as specified in FIGs. 5B and 5C. Each fragment is then used to generate an SDU.

[1075] Message segmentation allows retransmission of a portion of the message avoiding the time delays and resource allocation required by full retransmission of the entire message. A comparison of a method of message transmission without segmentation and a method of message transmission with segmentation is provided in FIGs. 9A and 9B.

[1076] FIG. 9A illustrates a message transmission without segmentation, wherein message retransmission is requested and completed. The transmitter, designated as Tx, sends the message from time t1. The receiver, designated as Rx, begins receiving the message at time t2 and the message is completed at time t3. The transmitter then waits for an ACK message from the receiver. The receiver is not able to process the received message and therefore no ACK is sent. At time t4 the transmitter retransmits the message. The receiver receives the retransmitted message at time t5. The entire message is received at time t6 and sends an ACK message at time t6. The transmitter receives the ACK message from time t8 to t9. At time t9 the message transmission and retransmissions are complete.

[1077] In comparison to FIG. 9A, FIG. 9B illustrates a message transmission with segmentation, wherein a segment retransmission is requested and completed. The transmitter transmits the message from time t1, and the receiver receives the message from time t2 to t3. A NAK message is sent from time t3 to t4, wherein the NAK identifies the missing segment of the transmitted message. The transmitter receives the NAK at time t11 and retransmits the segment, designated as SGM, at time t12. At time t14 the receiver receives the retransmitted segment, and sends an ACK at time t15. The transmitter receives the ACK from time t17 to t18. The retransmission of a segment or portion of a message reduces the latency of the entire message transmission and frees up transmitter resources for other transmissions. As illustrated, the segmented message transmission provides a reduction in the total transaction time.

[1078] A transmitter 500 is illustrated in FIG. 10 supporting segmented message transmission. A control processor 502 is coupled to a communication bus. The control processor 502 controls operation of a message generator 504. The message generator 504 provides a control and/or signaling message, or other short duration message, for transmission to a segmentation unit 506. When segmentation is active, the segmentation unit segments the message and adds a segment parameter to each segment. The segmentation unit 506 further divides each of combination of SP and segment into fragments. The segmentation unit 506 determines a Segment Identifier, SI, applicable to each segment. The fragments are then modified to include the appropriate SI. The segmentation unit 506 provides the multiple modified fragments to a framing unit 506 where transmission frames are prepared. An error check generator 510 applies an error checking mechanism to the transmission frames. The transmitter 500 further includes a modulation unit 512 and a transmission unit 514 coupled to an antenna 516. The transmitter 500 further includes a buffer 518 for storing the message or portions of a message in preparation for transmission.

[1079] A receiver 600 is illustrated in FIG. 11 supporting segmented message transmission. The receiver 600 includes a control processor 602 coupled to a communication bus. Frames are received at antenna 616 and processed by receive unit 614. A demodulation unit 612 demodulates the received frames and error check unit 610 checks for transmission errors. A deframing unit 608 extracts the individual fragments from the received frames. Segment extract unit 606 determines the segments of each fragment and determines the ordering of the segments based on the SI and SP information.

The message is reconstructed by placing the segments in order in the message reconstruct unit 604. If the received message has no missing segments, the message is then passed to higher layer applications in the receiver 600. If the received message has a missing segment(s), the receiver 600 requests retransmission of the missing segment(s).

[1080] In one embodiment, a receiver method as in FIGs. 7A and 7B, further determines if an end of segment fragment is lost. FIG. 12 illustrates a method 700 of identifying a missing end of segment fragment or frame. The method 700 initializes an index at step 702. If a first erasure is detected at the receiver, the receiver starts a timer. The timer is scheduled for a time period defined as:

$$\text{Timer } i = \alpha * \text{AIT} \qquad (5)$$

wherein α is a constant value, and AIT is the average inter-arrival time of frames. The timer i continues to count until a message or erasure is received. If the timer i expires before a frame or erasure is received, the receiver considers the first erasure as an end of segment. If prior to expiration of the timer i a second erasure is received, the receiver resets the timer i and starts a timer i+1. The timer i+1 is defined by the time period:

$$\text{Timer } i+1 = \beta * (\text{timer } I) + \gamma * (t2 - t1) \qquad (6)$$

wherein β and γ are constant values. Any number of additional timers may be used, each having a similar time assignment. Alternate embodiments may employ a variety of time periods and ways of implementing the timer. Effectively, each erasure initiates a timer. The number of erasures is then used to determine the length of the segment. When any timer expires without receipt of a frame or an erasure, the receiver identifies the end of segment as the last received erasure.

[1081] Continuing with method 700 of FIG. 12, if a frame is received at decision diamond 704, the information from the frame is stored in a memory storage buffer at step 718. The receiver updates an average inter-arrival time of segments referred to as AIT at step 720. At step 722 the receiver resets a timer i. At decision diamond 724, if the frame was the end of a segment, processing continues to step 726 to check for errors. If no segment errors are found the segment is processed as part of the message at step 730. If an error is found, the receiver requests a retransmission at step 728. If the frame was not the end of a segment at decision diamond 724, the index value *i* is incremented at step 716 and processing continues to decision diamond 704 to wait for a next frame. If no frame is received at decision diamond 704, the receiver checks for an erasure at step 706. An erasure is a message received that the receiver cannot process, such as due to a transmission error. If an erasure is received, the timer i is reset and a second timer i+1 is started. Processing then continues to step 716 to increment the index. If no erasure is found at decision diamond 706 the receiver checks for errors at decision diamond 712. If the timer i has not expired at decision diamond 712 processing returns to decision diamond 704 to wait for a next frame. If the timer has expired, the ordering of segments reflects the cumulative erasures.

[1082] FIGs. 13A and 13B provide examples at a receiver. In FIG. 13A, a first frame is received at time t1 and a second frame at time t2. The first and second frames are processed by the receiver and contained no errors. When the third frame is expected, an erasure is received at time t3. The occurrence of the erasure triggers the start of a first timer. The time period for expiration of the timer is defined by the average interval between frames. A fourth frame is received at time t4 prior to expiration of the timer. The timer is reset at time t4.

[1083] In the example of FIG. 13B, the first two frames are received and the next two frames are not. An erasure is received at time t3, and a first timer is started in response. A second erasure is received at time t4 prior to expiration of the first timer. The first timer is reset, and a second timer is started at time t4, wherein the timer period for expiration of the second timer is a function of the first timer value. Again, when any timer expires, the receiver is able to identify the last received erasure as an end of segment. Calculation of the number of erasures allows the receiver to calculate the number of frames per segment.

[1084] According to one embodiment, a method of using multiple timers to identify an end of segment or end of message (such as illustrated in FIG. 12) is applicable to an Asynchronous Transport Method, ATM, wherein the ATM protocol defines a start of message and an end of message. The timers described hereinabove with details provided in equations (5) and (6), identify an end of message and any intervening missing segments and/or fragments, thus avoiding the loss of an end of message in a transmission.

[1085] According to an alternate embodiment, a method of using multiple timers to identify an end of segment or end of message (such as illustrated in FIG. 12) is applicable to a Transport Communication Protocol, TCP, wherein the TCP protocol defines an end of message as a FIN field. The timers described hereinabove with details provided in equations (5) and (6), identify an end of message and any intervening missing segments and/or fragments, thus avoiding the loss of an end of message in a transmission. Alternate embodiments may apply implementation of a timing mechanism to determine missing portions of a transmission, wherein multiple timing mechanisms may be implemented.

[1086] As disclosed hereinabove, a method for segmented message transmission is provided. Each message is first segmented and then the segments are fragmented. A segment parameter is applied to each segment, and a segment identifier to each fragment. The fragments are provided to a lower level for preparation into frames for transmission. The exemplary embodiment may be applied to the transmission of short duration messages, such as control messages, etc.

[1087] Thus a variety of methods have been illustrated hereinabove for transmitting segmented messages in a wireless system. Each method finds application according to the design and resource requirements of a given system. While the various embodiments have been described with reference to a CDMA type spread spectrum communication system, the concepts are applicable to alternate spread spectrum type systems, as well as other type communication systems. The methods and algorithms presented hereinabove may be implemented in hardware, software, firmware, or a combination thereof. For example, using the MMSE approach to a non-time gated pilot, the equations for solving for the combiner weights may be performed in software or using a Digital Signal Processor, DSP, to perform the calculations. Similarly, the adaptive algorithms may be implemented in software in the form of computer readable instructions stored on a computer readable medium. A Central

Processing Unit, such as a DSP core, operates to perform the instructions and provide signal estimates in response. Alternate embodiments may implement hardware, such as an Application Specific Integrated Circuit, ASIC, where feasible.

[1088] Those of skill in the art would understand that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

[1089] Those of skill would further appreciate that the various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present invention.

[1090] The various illustrative logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration.

[1091] The steps of a method or algorithm described in connection with the embodiments disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. A software module may reside in RAM memory, flash memory, ROM memory, EPROM memory, EEPROM memory, registers, hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. An exemplary storage medium is coupled to the processor such the processor can read information from, and write information to, the storage medium. In the alternative, the storage medium may be an integral part of the processor. The processor and the storage medium may reside in an ASIC. The ASIC may reside in a user terminal. In the alternative, the processor and the storage medium may reside as discrete components in a user terminal.

[1092] The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

[1093] **WHAT IS CLAIMED IS:**

CLAIMS

1. In a wireless communication system having a base station controller and a plurality of base stations, a method comprising:
   segmenting a message into a plurality of segments;
   dividing the segments into a plurality of fragments; and
   transmitting the fragments.

2. The method as in claim 1, further comprising:
   retransmitting one of the plurality of fragments.

3. The method as in claim 1, further comprising:
   applying a segment parameter to each segment.

4. The method as in claim 1, further comprising:
   applying a segment indicator to each fragment.

5. In a wireless communication system having a base station controller and a plurality of base stations, a base station, comprising:
   means for building segments of a message from a plurality of transmitted frames;
   means for identifying a missing segment of the message; and
   means for requesting a retransmission of the missing segment.

6. The base station as in claim 5, further comprising:
   means for segmenting a message to form a plurality of segments;
   means for fragmenting the segments to form a plurality of fragments;
   means for transmitting the plurality of fragments; and
   means for retransmitting one of the plurality of fragments.

7. A method for receiving transmissions in a wireless communication system, comprising:

receiving a transmission frame having a plurality of segments, each segment having a plurality of fragments;
determining if any of the plurality of segments is missing;
if no segment is missing, reconstructing the message; and
if a segment is missing, requesting retransmission of the missing segment.

8. The method as in claim 7, further comprising:
processing fragments of the transmission frame.

9. The method as in claim 7, further comprising:
determining an end of a segment; and
reconstructing the segment.

10. The method as in claim 7, further comprising:
if a segment is missing, sending a negative acknowledge message to the transmitter of the transmission frame.

11. The method as in claim 7, further comprising:
if no segment is missing, sending an acknowledge message to the transmitter of the transmission frame.

12. The method as in claim 7, further comprising:
determining a start of a segment; and
storing information in a buffer from the start of the segment.

13. The method as in claim 12, further comprising:
if the buffer is not empty at the start of a segment, flushing the buffer.

14. The method as in claim 13, further comprising:
if a fragment is not a start of segment and the buffer is empty, marking the fragment as missing.

15. A wireless apparatus, comprising:
receiver for receiving a plurality of transmission frames;
segment extraction unit coupled to the fragment extraction unit, adapted to identify and reconstruct segments within a transmission frame; and
message reconstruction unit coupled to the segment extraction unit, adapted to determine any missing segment within a message and to request retransmission of the missing segment.

16. A computer data signal embodied on a carrier wave, characterized by:
a plurality of segments, each segment comprising:
a segment parameter; and
a plurality of fragments.

17. The computer data signal as in claim 16, wherein each of the fragments, comprising:
segment identifier; and
an information portion.

18. The computer data signal as in claim 17, wherein the segment identifier indicates if segmentation is active for transmission of the computer data signal.

19. The computer data signal as in claim 16, wherein the segment error rate is given as:

$$SER=1-(1-FER)^x$$

wherein FER is a frame error rate of the computer data signal, and x is the number of fragments in the plurality of fragments.

20. The computer data signal as in claim 19, wherein the message error rate is given as:

$$MER=1-(1-SER)^k$$

wherein k is the number of segments in the plurality of segments.

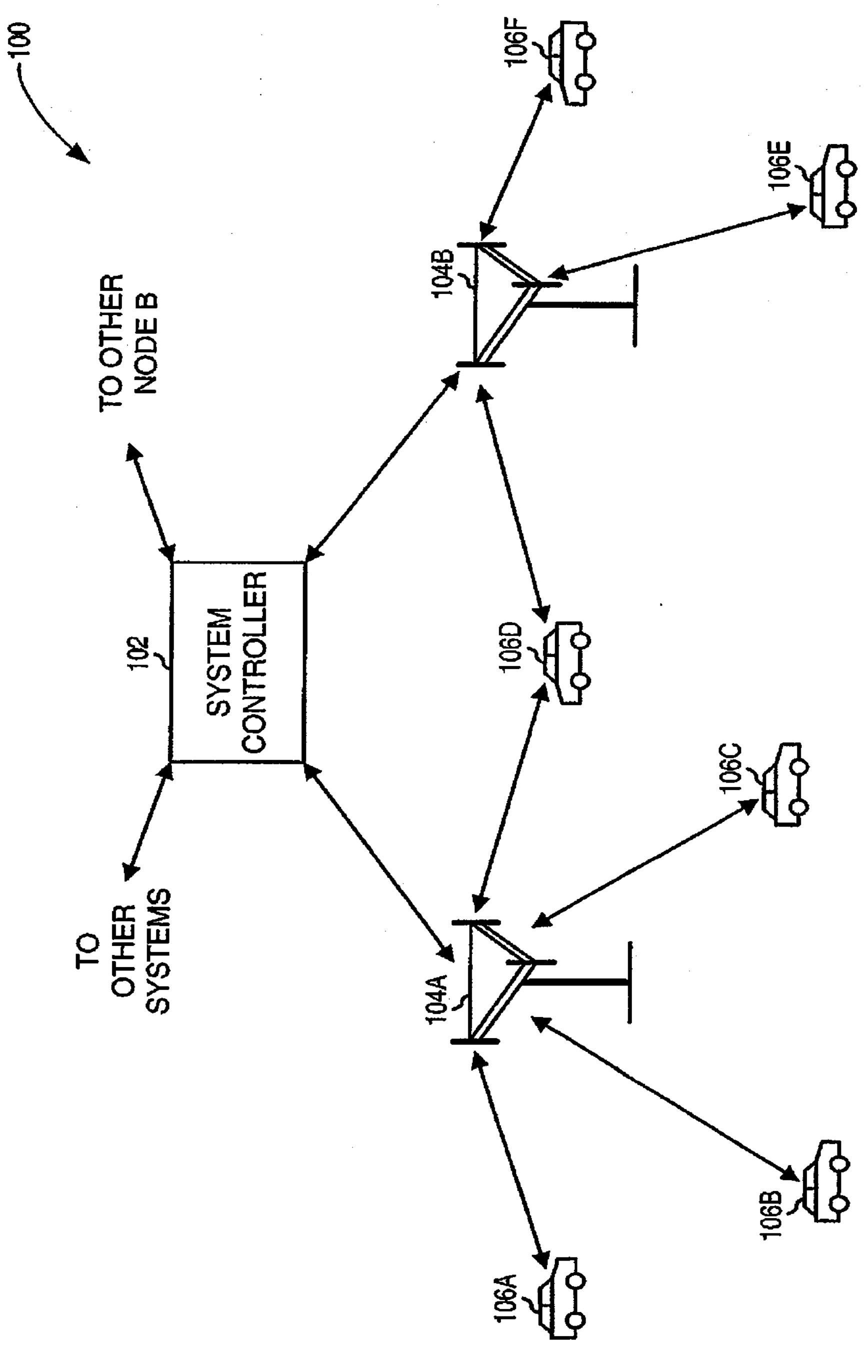
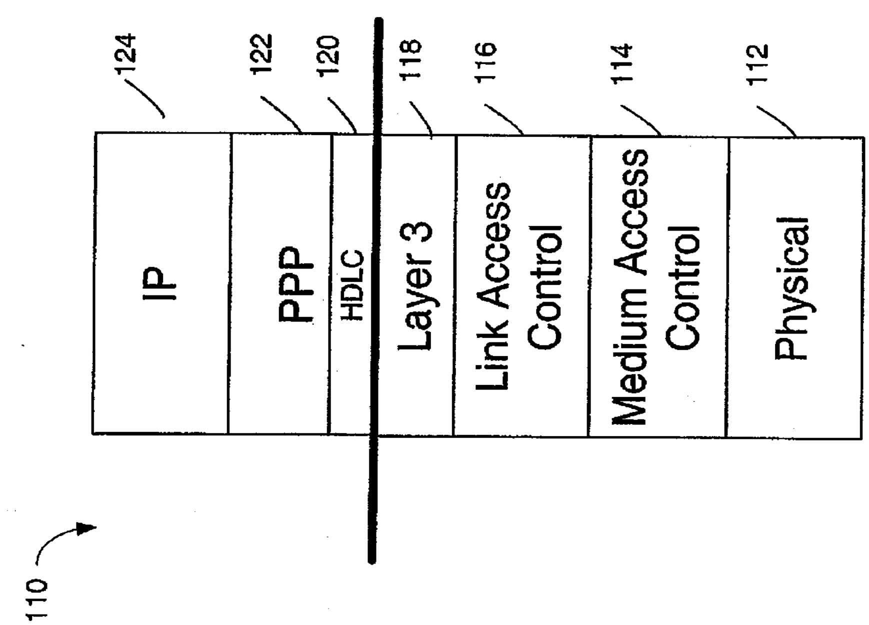

100
TO OTHER NODE B
TO OTHER SYSTEMS
102
SYSTEM CONTROLLER
104A
104B
106A
106B
106C
106D
106E
106F

FIG. 1



110
124
122
120
118
116
114
112
IP
PPP
HDLC
Layer 3
Link Access Control
Medium Access Control
Physical

FIG. 2

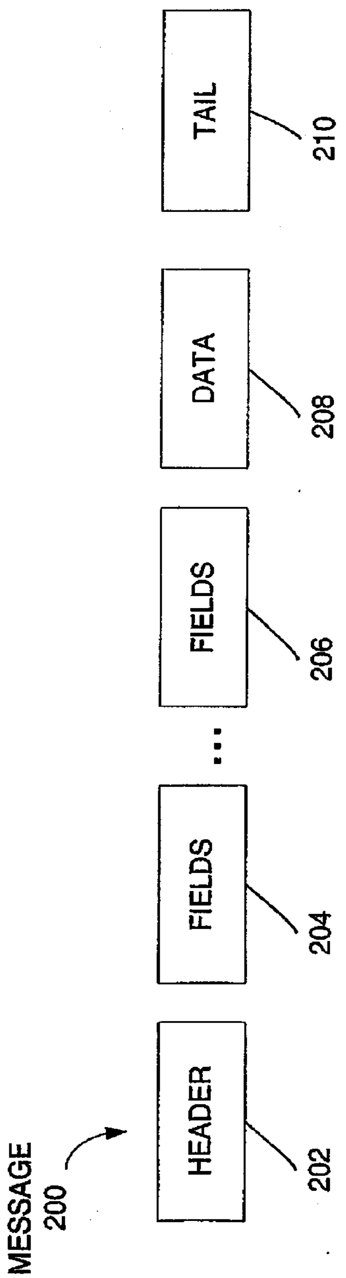

MESSAGE
200
HEADER
202
FIELDS
204
...
FIELDS
206
DATA
208
TAIL
210

FIG. 3A

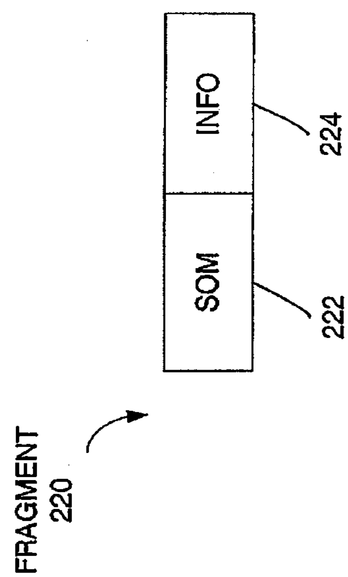

FRAGMENT
220
SOM
222
INFO
224

FIG. 3B

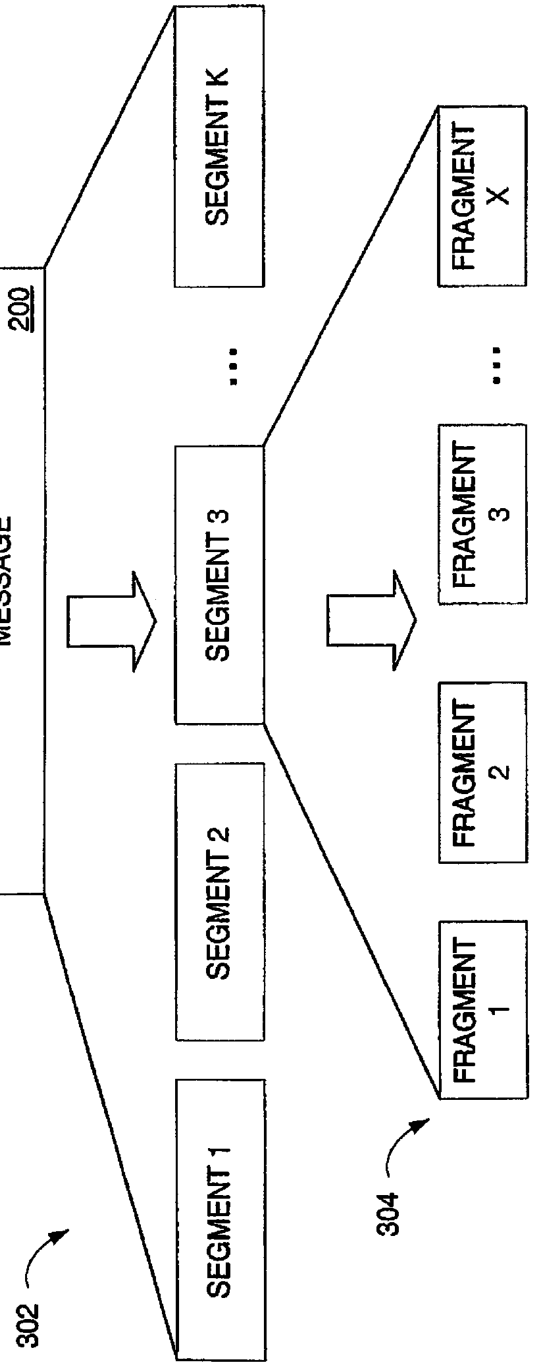

MESSAGE
200
SEGMENT 1
SEGMENT 2
SEGMENT 3
...
SEGMENT K
FRAGMENT 1
FRAGMENT 2
FRAGMENT 3
...
FRAGMENT X
302
304

FIG. 4A

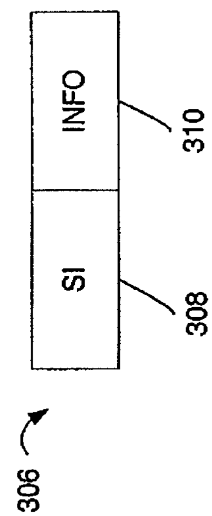

SI
INFO
306
308
310

FIG. 4B

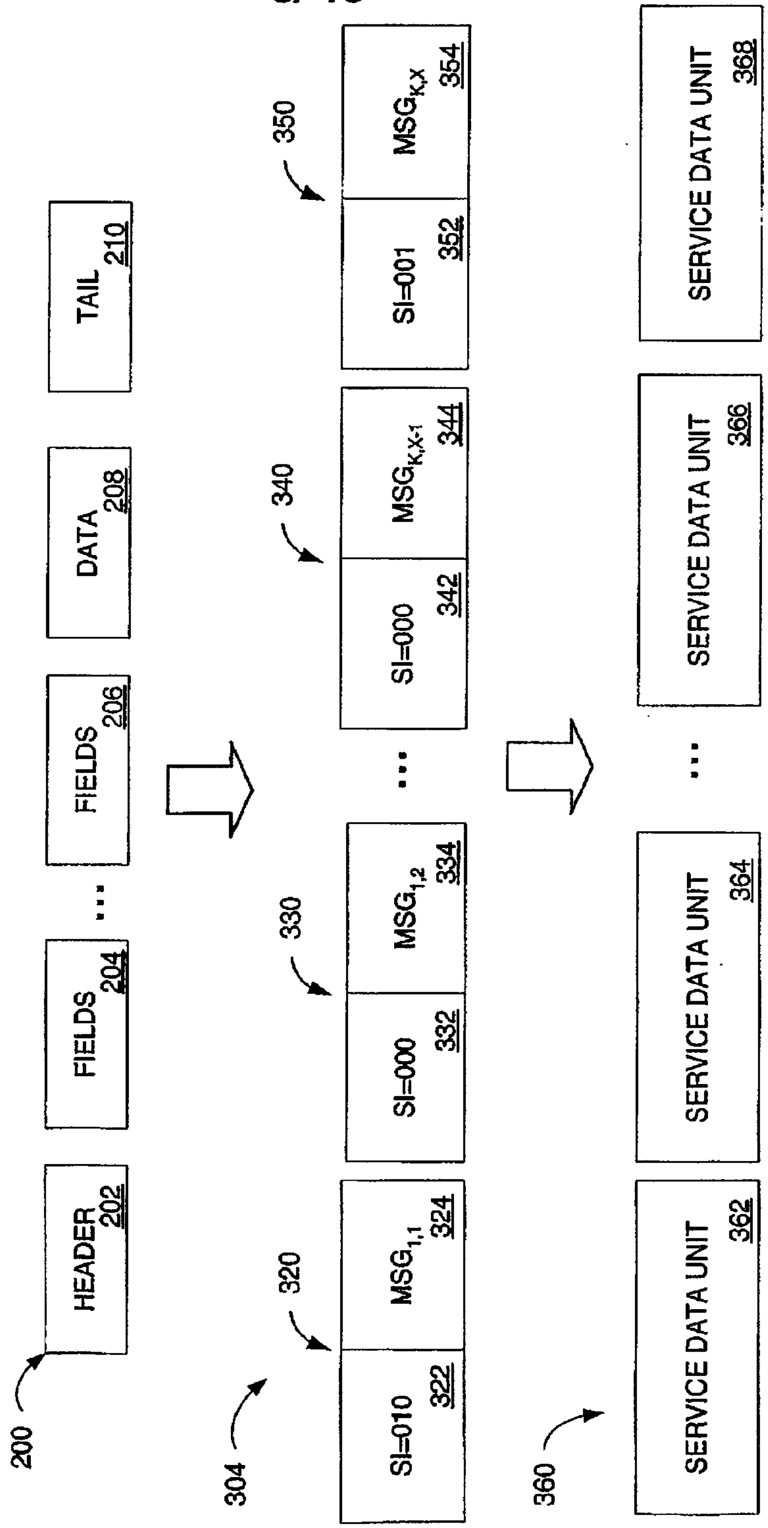

200
HEADER 202
FIELDS 204
FIELDS 206
DATA 208
TAIL 210
304
320
SI=010 322
MSG1,1 324
330
SI=000 332
MSG1,2 334
340
SI=000 342
MSGK,X-1 344
350
SI=001 352
MSGK,X 354
360
SERVICE DATA UNIT 362
SERVICE DATA UNIT 364
SERVICE DATA UNIT 366
SERVICE DATA UNIT 368

FIG. 5A

SEGMENTATION	SEGMENT START	SEGMENT END
1= ACTIVE	1=SEGMENT START	1=SEGMENT END
0=INACTIVE	0=ELSE	0=ELSE

FIG. 5B

SI_1	SI_2	SI_3	DEFINITION
0	0	0	SEGMENTATION INACTIVE
0	0	1	SEGMENTATION INACTIVE
0	1	0	SEGMENTATION INACTIVE
0	1	1	SEGMENTATION INACTIVE
1	0	0	SEGMENT MIDDLE
1	0	1	SEGMENT END
1	1	0	SEGMENT START
1	1	1	RESERVED

FIG. 5C

SEGMENTATION	SEGMENT START
1= ACTIVE	1=SEGMENT START
0=INACTIVE	0=ELSE

FIG. 5D

SI_1	SI_2	DEFINITION
0	0	SEGMENTATION INACTIVE
0	1	SEGMENTATION INACTIVE
1	1	SEGMENT START
1	0	SEGMENT CONTINUATION

FIG. 5E

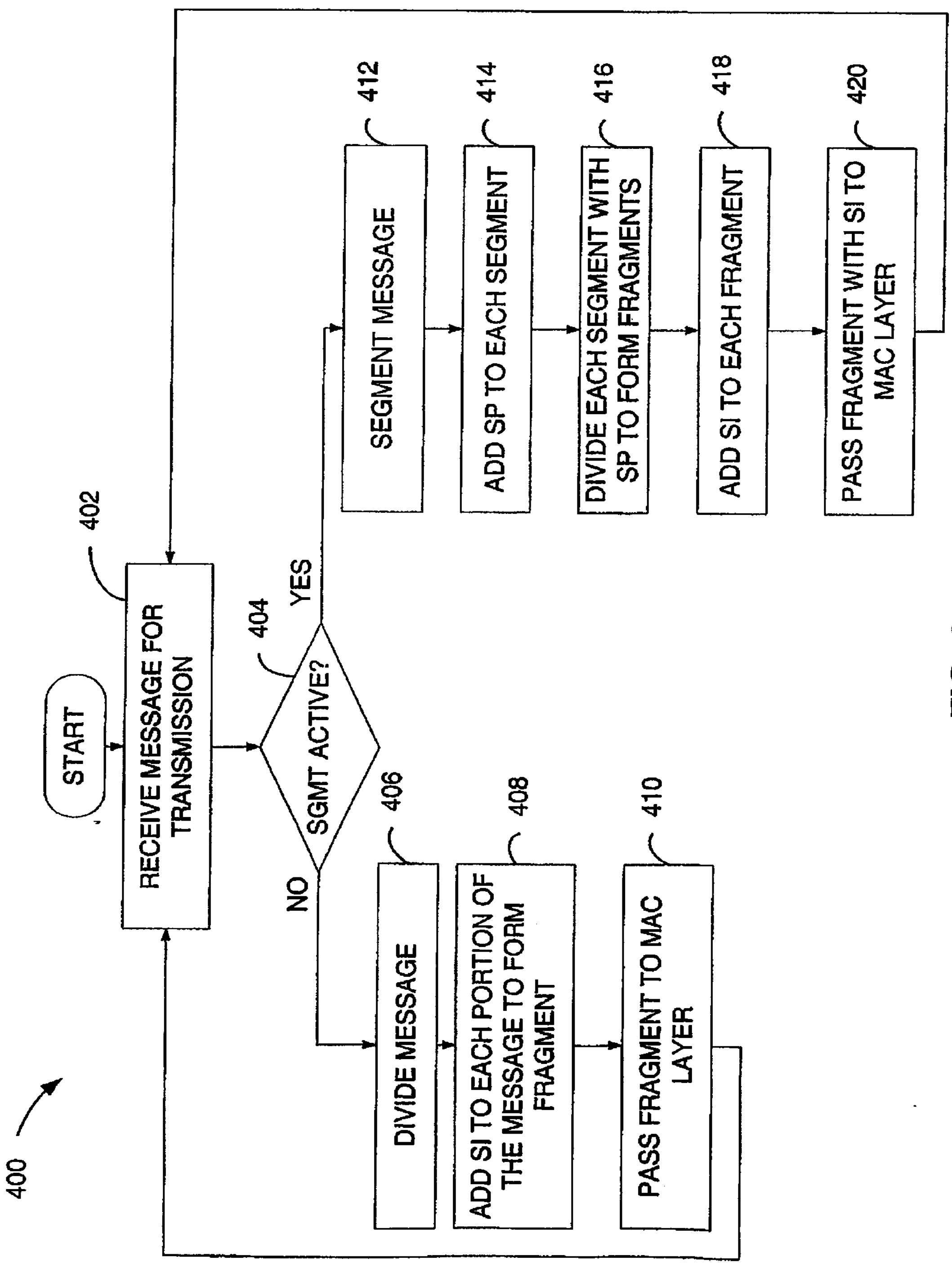

400
START
RECEIVE MESSAGE FOR TRANSMISSION
402
SGMT ACTIVE?
404
YES
NO
SEGMENT MESSAGE
412
ADD SP TO EACH SEGMENT
414
DIVIDE EACH SEGMENT WITH SP TO FORM FRAGMENTS
416
ADD SI TO EACH FRAGMENT
418
PASS FRAGMENT WITH SI TO MAC LAYER
420
DIVIDE MESSAGE
406
ADD SI TO EACH PORTION OF THE MESSAGE TO FORM FRAGMENT
408
PASS FRAGMENT TO MAC LAYER
410

FIG. 6

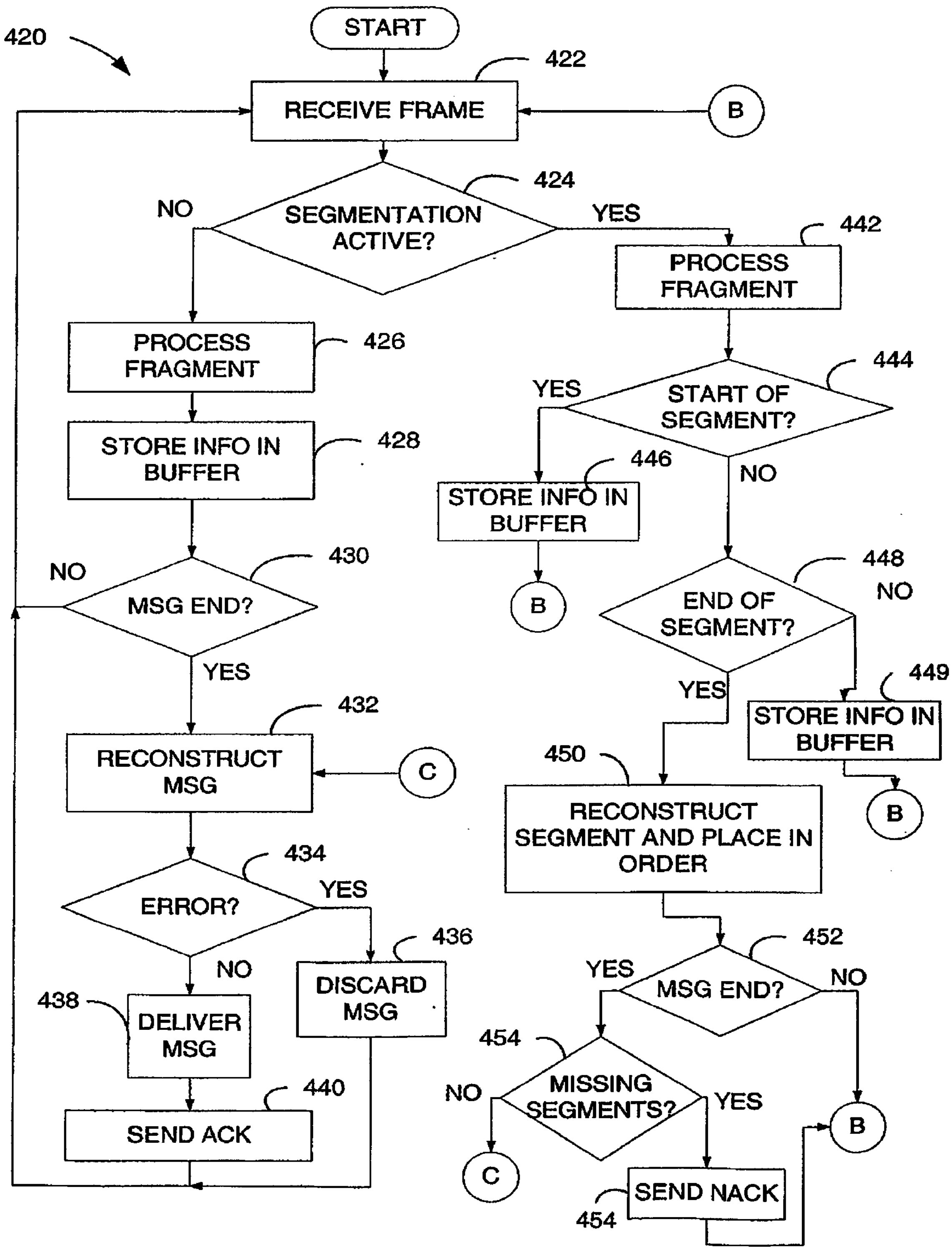

420
START
RECEIVE FRAME
422
B
SEGMENTATION ACTIVE?
424
NO
YES
PROCESS FRAGMENT
442
PROCESS FRAGMENT
426
STORE INFO IN BUFFER
428
START OF SEGMENT?
444
YES
NO
STORE INFO IN BUFFER
446
B
MSG END?
430
NO
YES
END OF SEGMENT?
448
NO
YES
STORE INFO IN BUFFER
449
B
RECONSTRUCT MSG
432
C
RECONSTRUCT SEGMENT AND PLACE IN ORDER
450
ERROR?
434
YES
NO
DISCARD MSG
436
DELIVER MSG
438
SEND ACK
440
MSG END?
452
YES
NO
MISSING SEGMENTS?
454
NO
YES
C
B
SEND NACK
454

FIG. 7A

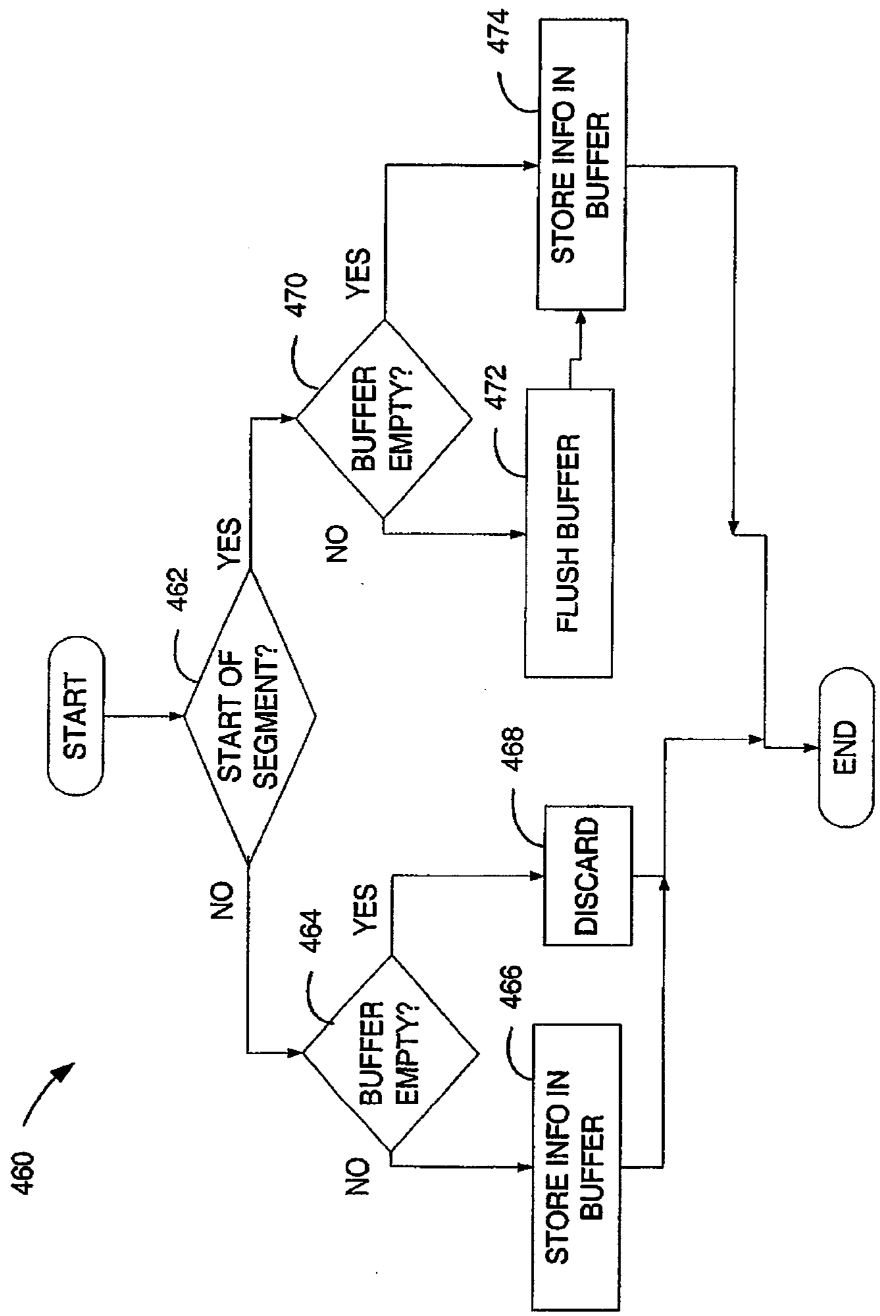

460
START
START OF SEGMENT?
462
YES
NO
BUFFER EMPTY?
470
YES
NO
BUFFER EMPTY?
464
YES
NO
STORE INFO IN BUFFER
474
FLUSH BUFFER
472
DISCARD
468
STORE INFO IN BUFFER
466
END

FIG. 7B

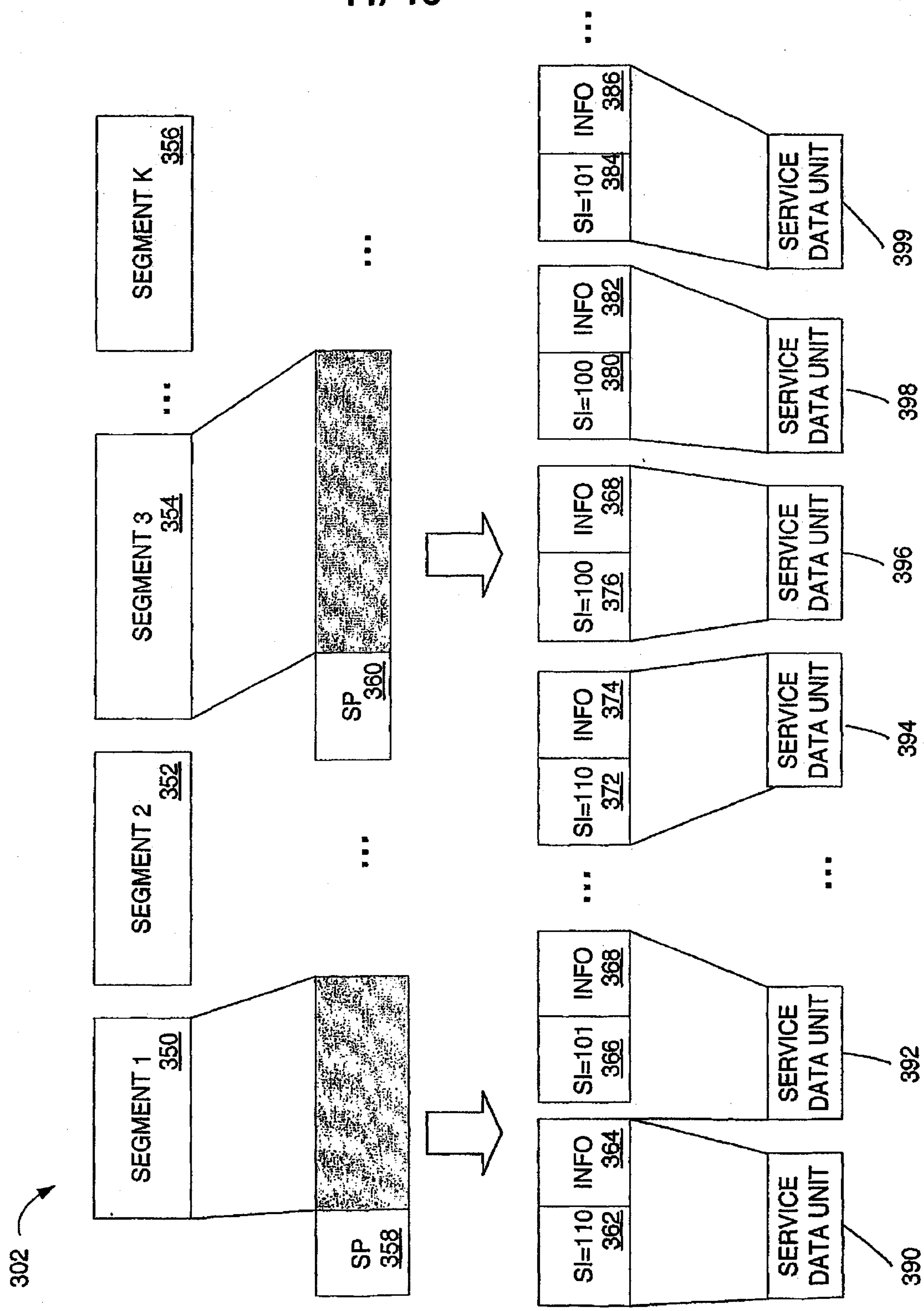

302
SEGMENT 1 350
SEGMENT 2 352
SEGMENT 3 354
SEGMENT K 356
SP 358
SP 360
SI=110 362
INFO 364
SI=101 366
INFO 368
SI=110 372
INFO 374
SI=100 376
INFO 368
SI=100 380
INFO 382
SI=101 384
INFO 386
SERVICE DATA UNIT
390
392
394
396
398
399

FIG. 8

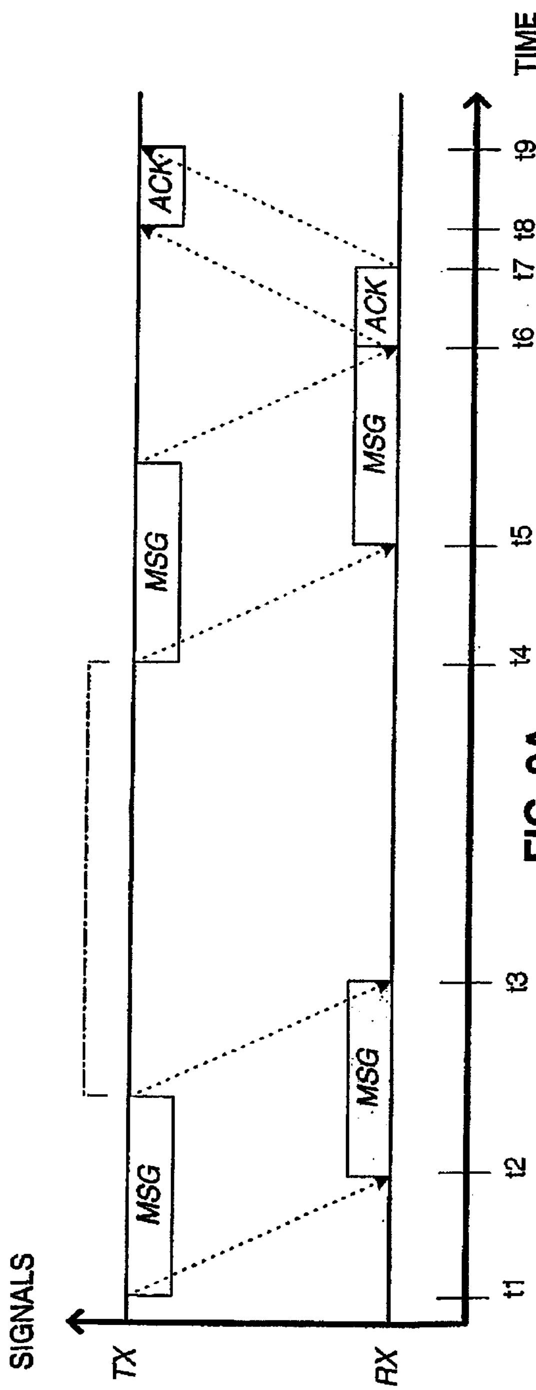

SIGNALS
TX
RX
TIME
MSG
MSG
MSG
MSG
ACK
ACK
t1
t2
t3
t4
t5
t6
t7
t8
t9

FIG. 9A

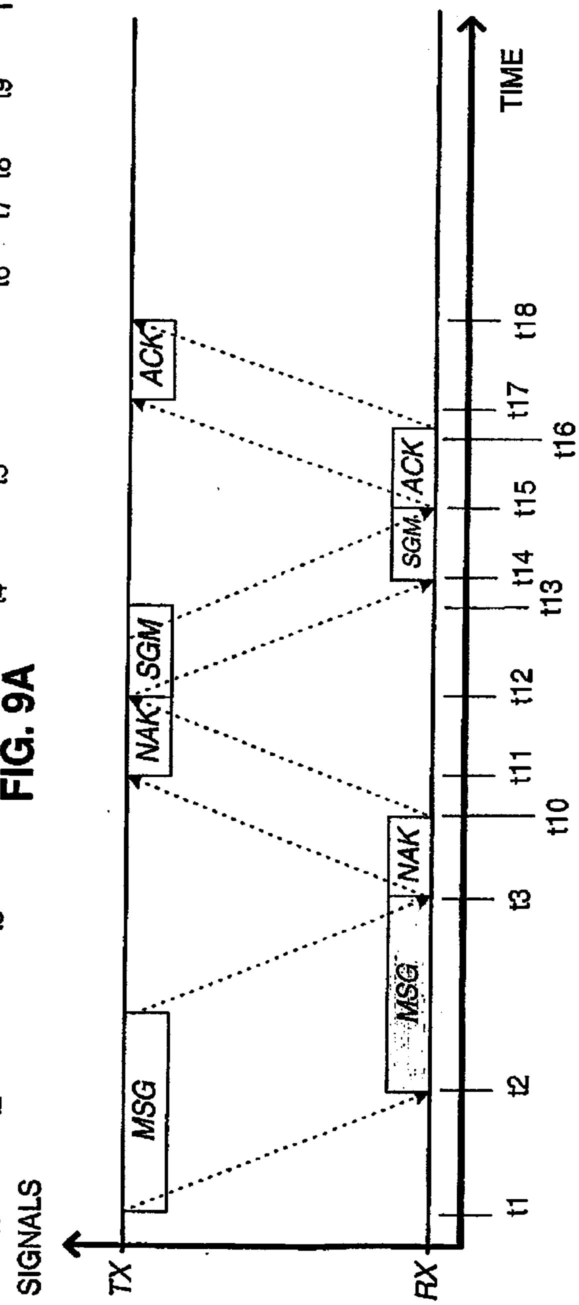

SIGNALS
TX
RX
TIME
MSG
MSG
NAK
NAK
SGM
SGM
ACK
ACK
t1
t2
t3
t10
t11
t12
t13
t14
t15
t16
t17
t18

FIG. 9B

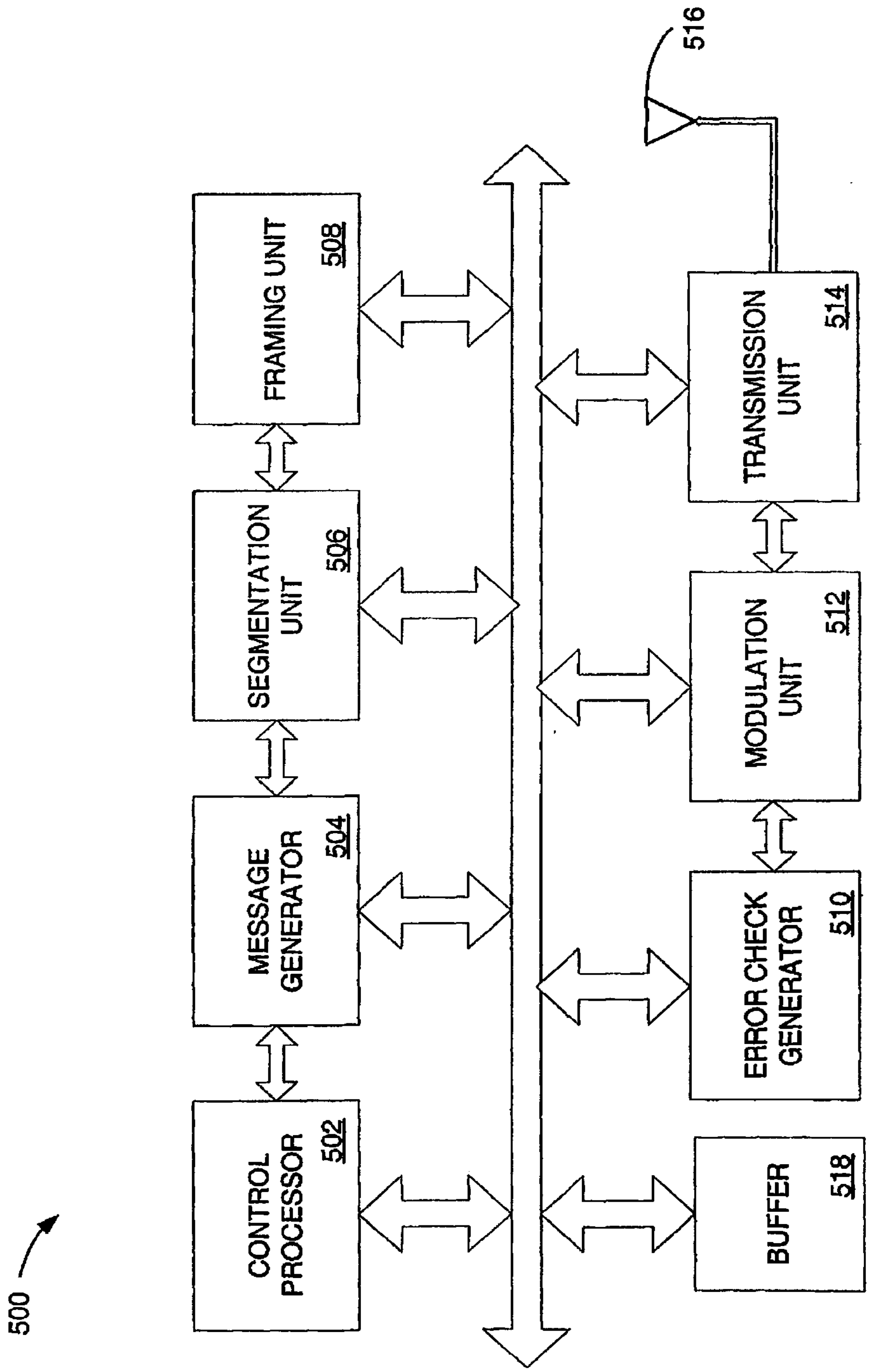

500
CONTROL PROCESSOR 502
MESSAGE GENERATOR 504
SEGMENTATION UNIT 506
FRAMING UNIT 508
BUFFER 518
ERROR CHECK GENERATOR 510
MODULATION UNIT 512
TRANSMISSION UNIT 514
516

FIG. 10

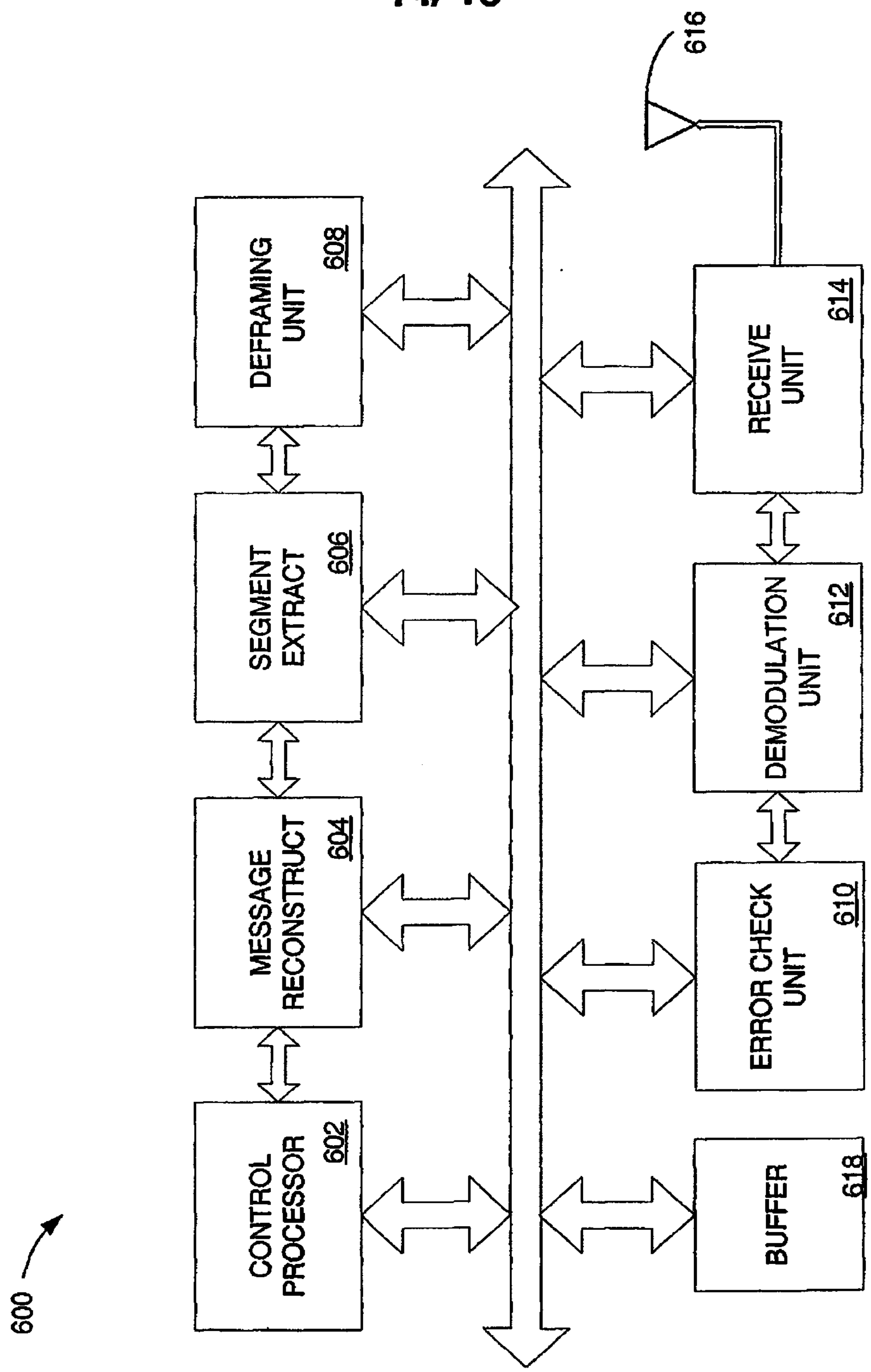
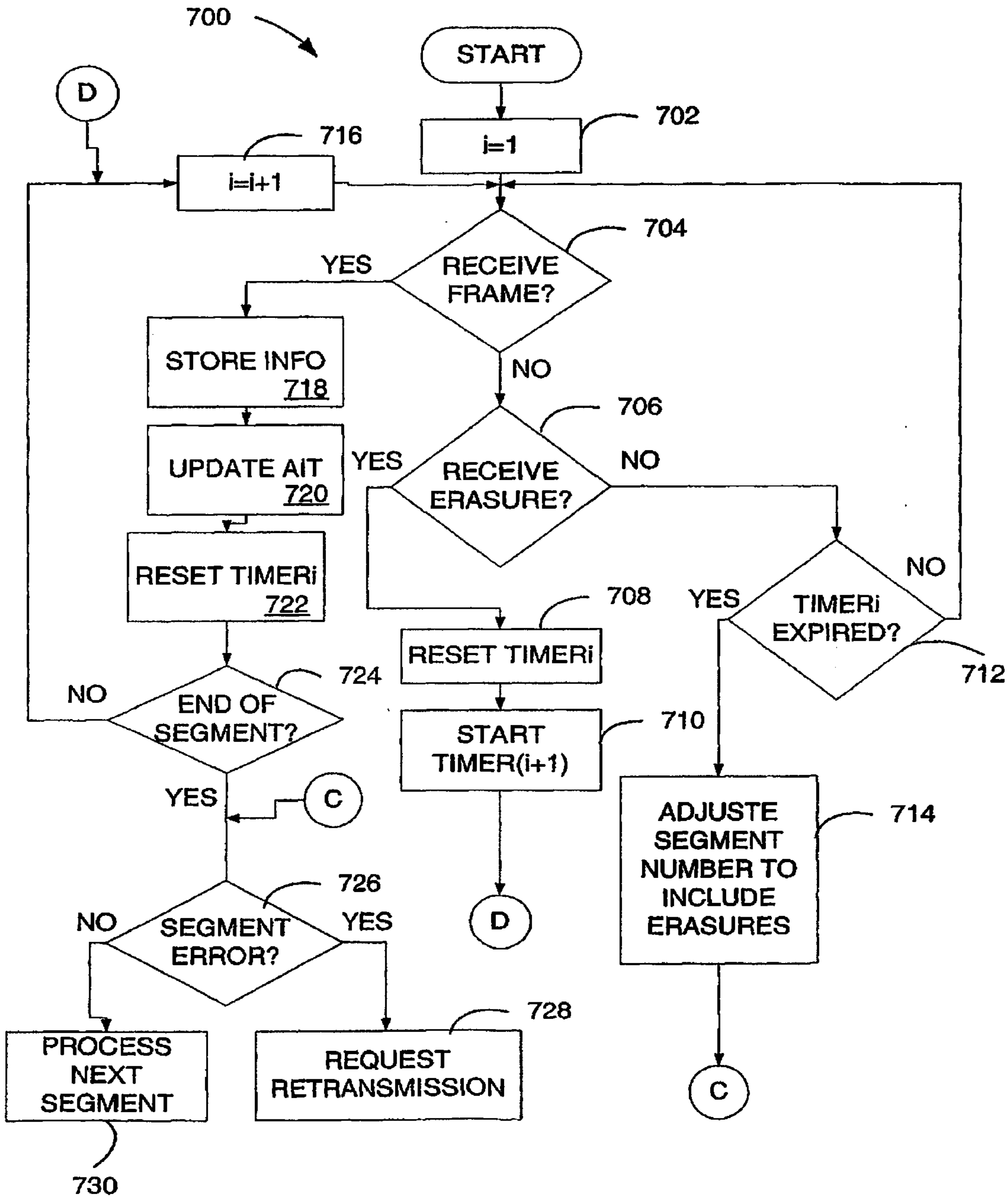

600
CONTROL PROCESSOR 602
MESSAGE RECONSTRUCT 604
SEGMENT EXTRACT 606
DEFRAMING UNIT 608
ERROR CHECK UNIT 610
DEMODULATION UNIT 612
RECEIVE UNIT 614
616
BUFFER 618

FIG. 11



700
START
i=1
702
D
716
i=i+1
704
RECEIVE FRAME?
YES
NO
STORE INFO 718
UPDATE AIT 720
RESET TIMERi 722
706
RECEIVE ERASURE?
YES
NO
708
RESET TIMERi
TIMERi EXPIRED?
YES
NO
712
724
END OF SEGMENT?
NO
YES
C
710
START TIMER(i+1)
D
714
ADJUSTE SEGMENT NUMBER TO INCLUDE ERASURES
726
SEGMENT ERROR?
NO
YES
728
PROCESS NEXT SEGMENT
REQUEST RETRANSMISSION
C
730

FIG. 12

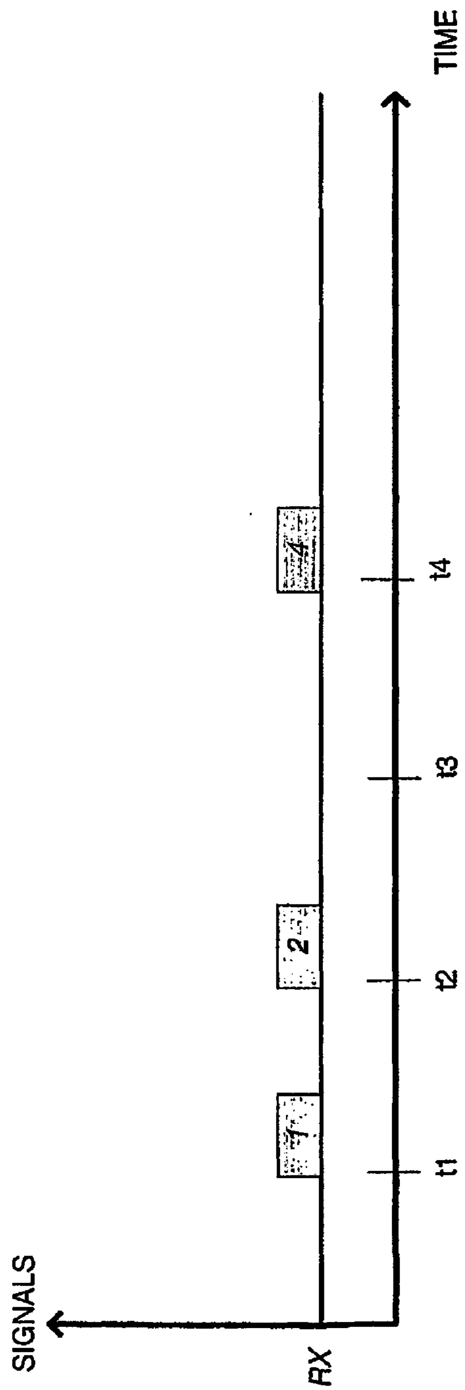


FIG. 13A

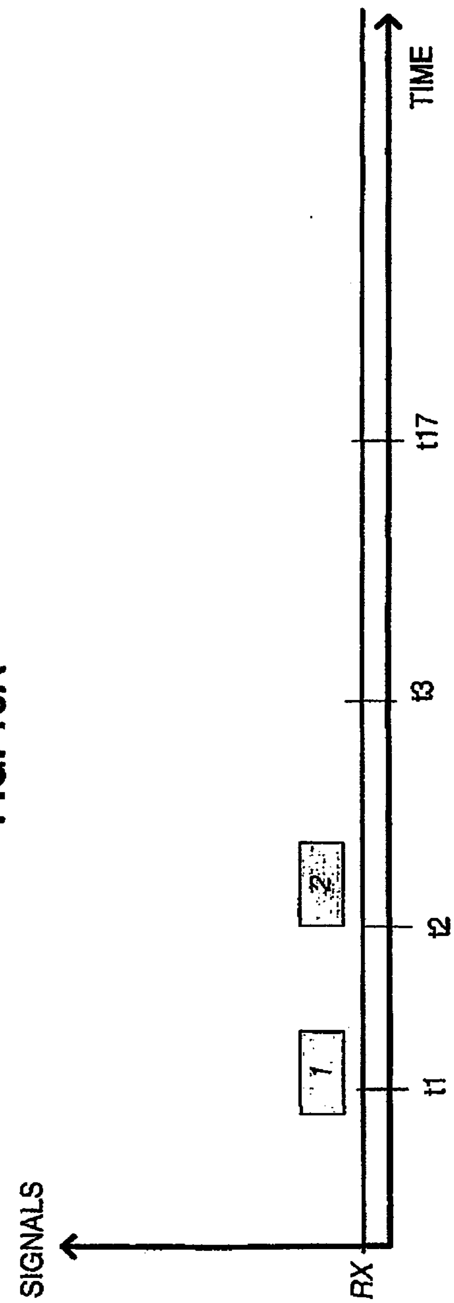


FIG. 13B

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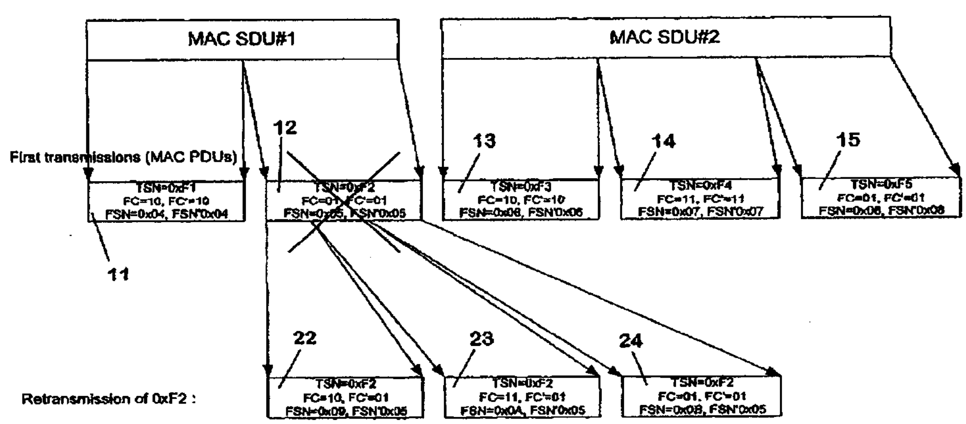
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD AND DEVICE FOR RETRANSMISSION OF TRANSMITTED UNITS



(57) Abstract: The invention relates to a method for retransmitting a transmission unit (12) via an air interface in a wireless access system employing fragmentation for transmissions, wherein the available transmission capacity on said air interface is variable, and wherein said transmission unit (12) was transmitted a first time together with fragmentation information. In order to enable such a retransmission, it is proposed that the transmission unit (12) is retransmitted after a refragmentation with information FC, FSN on this refragmentation and with at least some of the fragmentation information FC', FSN', TSN that was transmitted before with said transmission unit (12) in the first transmission. The invention equally relates to a corresponding wireless access system and to a corresponding transmitting unit for such a wireless access system.

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METHOD AND DEVICE FOR RETRANSMISSION OF TRANSMITTED UNITS

FIELD OF THE INVENTION

The invention relates to a method for retransmitting a transmission unit via an air interface in a wireless access system employing fragmentation for transmissions. The transmission capacity on the air interface is assumed to be variable in this system and a transmission unit that is to be retransmitted was transmitted a first time together with fragmentation information. The invention equally relates to a transmitting unit for such a wireless access system and to a corresponding wireless access system.

BACKGROUND OF THE INVENTION

A wireless access system employing fragmentation and an adaptive modulation for transmitting signals is specified e.g. in the IEEE draft P802.16/D5-2001: "Local and Metropolitan Area Networks - Part 16: Standard Air Interface for Fixed Broadband Wireless Access Systems", which is incorporated by reference herein. The standard specifies the air interface, including the medium access control layer (MAC) and a physical layer (PHY), of fixed point-to-multipoint broadband wireless access systems providing multiple services. In this system, MAC SDUs (service data units) that are to be transmitted from a transmitting unit to a receiving unit are fragmented for transmission into MAC PDUs (protocol data units). The defined system operates at frequencies of 10-66 GHz.

An amendment 802.16a of this standard is currently under development for systems operating between 2 GHz and 11 GHz. The amendment introduces new functionality for this frequency range, such as an Automatic Repeat Request (ARQ). With ARQ, a receiving unit may request a retransmission of transmission units that were for instance lost during transmission over the air interface by transmitting an ARQ feedback to the transmitting unit. The proposed algorithm for repeating a transmission is a selective repeat algorithm, i.e. only those fragments are retransmitted which are not received satisfactorily at the receiving unit after the first transmission. A selective repeat ARQ mechanism will often require a packet reordering.

Variations of the environmental conditions on the transmission path are compensated in a system according to the 802.16a standard with a variation of the modulation and with a forward error correction (FEC). The transmission capacity of the radio link can thus vary significantly between the time of a first transmission and the time of a retransmission. In case the environmental conditions deteriorate, it might be necessary for the retransmission to refragment the fragments that are to be retransmitted into shorter MAC PDUs. The conventional method of sequence numbering employed for a single fragmentation is not suited for handling such a refragmentation.

The currently proposed solution for refragmentation in the 802.16a system mandates that the MAC SDUs are chopped into fixed sized ARQ blocks. Only the last block will be a shortened block if the MAC SDU size is not an exact multiple of the ARQ block size. Each ARQ block is identified by an ARQ block number assigned to it by the MAC. A set of ARQ blocks that are to be transmitted or retransmitted are included in a MAC PDU. The block number of the first block is carried in a subheader in each MAC PDU, or in each packing element in case a MAC PDU carries packed MAC SDUs or MAC SDU fragments. The MAC level fragmentation function is restricted to fragment MAC SDUs on ARQ block boundaries.

The restriction put on the fragmentation protocol in the current proposal, however, is incompatible with the fragmentation procedure specified in the 802.16 standard, since it does not allow a variable fragmentation. The block numbering scheme also limits the possibilities of using implementations designed for a 802.16 system also for 802.16a systems.

SUMMARY OF THE INVENTION

It is an object of the invention to enable a retransmission of a transmission unit in a wireless access system which has a variable available transmission capacity and which employs fragmentation for transmissions. It is moreover an object of the invention to enable a retransmission of transmission units which is compatible with the fragmentation protocol defined in the IEEE standard 802.16.

The objects of the invention are reached with a method for retransmitting a transmission unit via an air interface in a wireless access system employing fragmentation for transmissions. The available transmission capacity on the air interface is variable, and the transmission unit is transmitted a first time together with fragmentation information. It is proposed that the transmission unit is retransmitted after a refragmentation with information on this refragmentation and with at least some of said fragmentation information that was transmitted before with said transmission unit in said first transmission.

The objects of the invention are equally reached with a transmitting unit for a wireless access system which transmitting unit comprises means for realizing the proposed method. Finally, the objects of the invention are reached with a wireless access system comprising such a transmitting unit and a receiving unit for receiving transmitted transmission units and for requesting a retransmission of a transmission unit if necessary.

The invention proceeds from the idea that in case a transmission unit which has to be retransmitted comprises on the one hand fragmentation information of the original transmission unit and on the other hand fragmentation information describing the fragmentation employed for retransmission, an easy refragmentation mechanism is enabled which allows to rebuild and reorder the fragments as required for a retransmission. In particular, the fragments of a transmission unit resulting in refragmentation can be assigned their own fragmentation information as any transmission unit which is transmitted for the first time.

It is to be understood that the proposed method does not require that each transmission unit that is to be retransmitted is refragmented into new fragments. For example, if the available transmission capacity is the same for a first transmission and for a repeated transmissions of a transmission unit, the transmission unit may be transmitted again without the necessity for a different fragmentation than before.

It is an advantage of the invention that it provides a simple solution for retransmitting transmission units.

It is moreover an advantage of the invention that it provides a transmission unit numbering scheme that allows the reuse of the 802.16 fragmentation protocol. The invention further allows implementations more easily to address both, the 802.16 standard and the amendment 802.16a.

Preferred embodiments of the invention become apparent from the subclaims.

Since traffic is usually to be transmitted bi-directionally, and since in most of the remaining cases at least a feedback is to be enabled after a transmission, the transmitting unit is advantageously part of a first transceiver device. Accordingly, the transmitting unit advantageously transmits the transmission units to a receiving unit which is part of a second transceiver device.

Preferably, a retransmission of a transmission unit is carried out upon request by a receiving unit, e.g. because the receiving unit notes that a transmission unit is missing or that a transmission unit was received with too many errors. The request for a retransmission can be for example the selective ARQ mechanism proposed in the above mentioned amendment 802.16a.

The transmission unit of the invention can be in particular a MAC SDU transmitted in a MAC PDU without packing, a MAC SDU fragment transmitted in a MAC PDU without packing, a MAC SDU transmitted in a MAC PDU with packing, or a MAC SDU fragment transmitted in a MAC PDU with packing.

Preferably, fragmentation information is included in a subheader of each fragment that is to be transmitted. For wireless access systems that are based on the IEEE standard 802.16, this subheader has preferably an ARQ subheader format that consists of the fragmentation or packing subheader defined in this standard and of an additional part. The additional part may comprise for example a field extending the fragmentation sequence number (FSN) field present in the 802.16 Fragmentation Subheader and Packing Subheader, an FSN' field replicating the FSN field of the respective first transmission unit, an FC' field replicating the fragmentation control (FC) field in the respective first transmission unit, and a transmission unit sequence number TSN field.

The fields employed for a fragmentation control FC, FC' preferably comprise 2 bits. The values assigned to the fragmentation control fields FC and FC' may correspond for example to the values defined in the above mentioned IEEE standard 802.16. In this standard, a value of 00 is used for transmission units that are not fragmented, a value of 01 for a respective last fragment, a value of 10 for a respective first fragment, and a value of 11 for each middle fragment.

The fields employed for a fragmentation sequence number FSN, FSN' preferably comprise 5 bits. The fields for the transmission sequence number TSN preferably comprise 7 bits.

It is to be noted that the lengths of the fields and the codings in the fragmentation control fields can be selected differently. However, these lengths and codings ensure that the method and the system according to the invention comply with the definitions of the IEEE standard 802.16.

The invention can be employed in particular, though not exclusively, in wireless local area networks (LAN) or metropolitan area networks (MAN).

The invention is moreover applicable for example in point-to-multipoint wireless broadband access networks and in point-to-point wireless broadband access networks, but equally in other system.

The invention can further be employed in particular, though not exclusively, in systems in which the transmission capacity may change due to an adaptive modulation which is applied to signals that are to be transmitted.

BRIEF DESCRIPTION OF THE FIGURES

In the following, the invention is explained in more detail with reference to drawings, of which

Fig. 1 illustrates an embodiment of the method of the invention in a first situation; and

Fig. 2 illustrates an embodiment of the method of the invention in a second situation.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 and figure 2 illustrate transmissions and retransmissions of transmitting units in a broadband wireless access system according to the invention. The wireless access system employs fragmentation and an adaptive modulation for transmissions from a base station of a network of the system to a subscriber station of the system.

Figure 1 depicts in a first row two MAC SDUs #1 and #2 which are to be transmitted by a base station via the air interface to a subscriber station. Both MAC SDUs are fragmented for a first transmission into MAC PDUs 11-15, which are depicted in a second row of figure 1. The first MAC SDU #1 is fragmented into two MAC PDUs 11, 12 as indicated by arrows between the first and the second row. The second MAC SDU #2 is fragmented into three MAC PDUs 13-15, which is equally indicated by arrows.

The number of fragments into which the MAC SDUs are fragmented depends on the size of the respective MAC SDU and on the size of the available MAC PDUs. In case of good conditions, a modulation is selected that results in larger MAC PDUs and that thus requires less fragments than a modulation employed for bad conditions.

Each of the MAC PDUs 11-15 comprises a subheader with five fields containing fragmentation information.

The first field in each subheader is a TSN field of 7 bits, which is employed for identifying the respective MAC PDU. The second field is an FC field of 2 bits indicating for the current transmission the position of the respective PDU among the PDUs comprising the fragments of a single MAC SDU. The third field is an FC' field of 2 bits indicating the position of the PDU containing the same data as the PDU in a first transmission. The fourth field is an FSN field of 5 bits containing a fragmentation sequence number for the respective PDU for the current transmission. The fifth field, finally, is an FSN' field of 5 bits containing a fragmentation sequence number for the PDU containing the same data as the PDU in a first transmission. The values for the fields for the current transmission are selected as specified in the above mentioned standard 802.16.

The first MAC PDU 11 for the first MAC SDU #1 is assigned a TSN of 0xF1, and an FC of 10, since this MAC PDU 11 is the first fragment of the first MAC SDU #1.

The second MAC PDU 12 for the first MAC SDU #1 is assigned a TSN of 0xF2, and an FC of 01, since this MAC PDU 12 is the last fragment of the first MAC SDU #1.

The first MAC PDU 13 for the second MAC SDU #2 is assigned a TSN of 0xF3, and an FC of 10, since this MAC PDU 13 is the first fragment of the second MAC SDU #2.

The second MAC PDU 14 for the second MAC SDU #2 is assigned a TSN of 0xF4, and an FC of 11, since this MAC PDU 14 is a middle fragment of the second MAC SDU #2.

The third MAC PDU 15 of the second MAC SDU #2 is assigned a TSN of 0xF5, and an FC of 01, since this MAC PDU 15 is the last fragment of the second MAC SDU #2.

The respective value in the FC' fields is identical to the respective value in the FC fields for each of the MAC PDUs 11-15, since the transmission of the MAC PDUs 11-15 in the second row of figure 1 constitutes at the same time the first transmission. For the same reason, the respective value in the FSN' fields is identical for each of the MAC PDUs 11-15 to the respective value in the FSN fields.

The assembled MAC PDUs 11-15 are transmitted by the base station via the air interface to the subscriber station. During the transmission, the second MAC PDU 12 of the first MAC SDU #1, i.e. fragment 0xF2, is lost. This is reported by the subscriber station to the network in an ARQ feedback message. The lost fragment 12 thus has to be retransmitted. In figure 1, MAC PDU 12 of the second row is crossed out in order to indicate the loss during the first transmission.

When a transmission unit is retransmitted, a copy of the original fragmentation control information and of the original fragmentation number is transmitted along with the transmission unit itself. The transmission unit that is to be retransmitted is treated like a new MAC SDU called retransmission SDU and is inserted at an appropriate position into the queue of MAC SDUs that are to be transmitted. The retransmission SDU undergoes the standard fragmentation process if necessary and obeys the same rules for setting the FC and FSN field values as an SDU which is transmitted for the first time.

In the example of figure 1, the applied modulation is not changed between the first transmission and the retransmission and the transmission capacity on the air interface stays the same. Therefore, the retransmission can be carried out without refragmentation. This means that the MAC PDU 12 with the TSN value of 0xF2 is transmitted again as a single fragment 21, which fragment 21 is depicted in a third row of figure 1. The relation of this fragment 21 to the second MAC PDU 12 of the first MAC SDU #1 is indicated in figure 1 by arrows. The values in some of the fields in the subheader of the fragment 21 are changed for retransmission, however, in order to enable the subscriber station to make use of the received, retransmitted fragment 21.

The TSN field in the subheader of the fragment 21 is provided with the same value 0xF2 as before, since this field identifies the lost MAC PDU 12. Also the fields FC' and FSN' contain the same values as before, these field containing the information about the lost transmission. The three fields TSN, FC' and FSN' enable the subscriber station to relate the retransmitted fragment 21 to the lost MAC PDU 12.

The value of the FC field, in contrast, is changed to 00, since the retransmitted PDU 12 is not fragmented further, fragment 21 thus constituting the only fragment. In addition, the value of the FSN field is incremented according to the conventional rules to 0x09, the last transmitted MAC PDU 15 of the first transmission having been assigned the value 0x08.

Figure 2 illustrates the retransmission for a different situation. The retransmission is based on the same embodiment of the method according to the invention as in figure 1.

Again, two MAC SDUs #1 and #2 are to be transmitted by a base station via the air interface to a subscriber station. The first fragmentation of the MAC SDUs into MAC PDUs 11-15 corresponds exactly to the first fragmentation in the example of figure 1. This is depicted in figure 2 by MAC SDUs and MAC PDUs in a first and a second row which are identical to the first and the second row of figure 1. Again, the second MAC PDU 12 of the first MAC SDU #1 is lost during transmission, which is reported to the network by an ARQ feedback message of the subscriber substation.

In contrast to the first example, the employed modulation is changed after the first transmission to be more robust. With the new modulation, the content of the second MAC PDU 12 of the first MAC SDU #1 can no longer be transmitted in a single PDU. Therefore, the second MAC PDU 12 has to be rearranged for retransmission.

The MAC PDU 12 with the TSN value 0xF2 is refragmented for retransmission into three new fragments 22-24, which are depicted in the third row of figure 2. Arrows relate the new fragments 22-24 to the lost MAC PDU 12 of the second row.

The respective TSN field of the three fragments 22-24 contains again the same value 0xF2, which identifies the lost MAC PDU 12 that has to be retransmitted. Also the fields FC' and FSN' contain the same values as before, since these fields contain further information about the lost MAC PDU 12.

The FC and FSN fields in the retransmitted fragments are set according to the normal rules. Therefore, the first fragment 22 is provided with a value of 10, the second fragment 23 with a value of 11 and the third fragment 24 with a value of 01 for the respective FC field. Further, the first fragment 22 is provided with a value of 0x09, the second fragment 23 with a value of 0x0A and the third fragment 24 with a value of 0x0B for the respective FSN field.

The refragmentation mechanism of the invention thus makes it possible to rebuild and reorder fragments in retransmission.

It is to be noted that the described embodiment of the invention constitutes only an example that may be varied in any suitable way.

C l a i m s

1. Method for retransmitting a transmission unit (12) via an air interface in a wireless access system employing fragmentation for transmissions, wherein the available transmission capacity on said air interface is variable, wherein said transmission unit (12) was transmitted a first time together with fragmentation information (TSN,FC',FSN'), and wherein said transmission unit (12) is retransmitted after a refragmentation with information (FC,FSN) on said refragmentation and with at least some of said fragmentation information (TSN,FC',FSN') that was transmitted before with said transmission unit (12) in said first transmission.

2. Method according to claim 1, wherein said fragmentation information on a fragmentation for a first transmission comprises at least one of a fragmentation control (FC'), a fragmentation sequence number (FSN') and a transmission unit sequence number (TSN).

3. Method according to claim 1 or 2, wherein said refragmentation information comprises at least one of a fragmentation control (FC) and a fragmentation sequence number (FSN).

4. Method according to one of the preceding claims, wherein each fragment (21,22-24) of a refragmented transmission unit (12) is provided with a subheader comprising for the fragmentation and refragmentation information:
   - a field for a fragmentation sequence number (FSN') assigned to said transmission unit (12) in the first transmission;
   - a field for a fragmentation sequence number (FSN) assigned to said fragment (21,22-24) of said transmission unit (12) for the retransmission;
   - a field for a fragmentation control (FC') assigned to said transmission unit (12) in the first transmission;
   - a field for a fragmentation control (FC) assigned to said fragment (21,22-24) of said transmission unit (12) for the retransmission; and
   - a field for a transmission unit sequence number (TSN) assigned to said transmission unit (12) in the first transmission.

5. Method according to claim 4, wherein said fields for a fragmentation sequence number (FSN,FSN') are fields of 5 bits, wherein said fields for a fragmentation control (FC,FC') are fields of 2 bits, and wherein said field for a transmission unit sequence number (TSN) is a field of 7 bits.

6. Method according to one of the preceding claims, wherein each transmission unit (12) transmitted a first time and each fragment (21,22-24) of a transmission unit (12) refragmented for retransmission is provided with a subheader

comprising the same dedicated fields (TSN,FC,FC',FSN,FSN') for fragmentation information.

7. Method according to one of the preceding claims, wherein said transmission unit (12) is one of:
   - a MAC (medium access control) SDU (service data unit) transmitted in a MAC PDU (protocol data unit) without packing;
   - a MAC SDU fragment transmitted in a MAC PDU without packing;
   - a MAC SDU transmitted in a MAC PDU with packing; and
   - a MAC SDU fragment transmitted in a MAC PDU with packing.

8. Method according to one of the preceding claims, wherein said transmission unit (12) is retransmitted upon a request by a receiving unit of said wireless access system to which said transmission unit (12) was to be transmitted.

9. Transmitting unit for a wireless access system comprising means for transmitting transmission units (11-15) and for retransmitting transmission units (12) according to one of the preceding claims.

10. Transmitting unit according to claim 9, wherein said transmitting unit is part of a first transceiver device, and wherein said transmitting unit is transmitting transmission units (11-15) to a receiving unit which is part of a second transceiver device.

11. Transmitting unit according to claim 9 or 10, comprising:
    - means for fragmenting each data unit (MAC SDU#1,MAC SDU#2) that is to be transmitted via an air interface into at least one transmission unit (11-15) and for providing each transmission unit (11-15) with corresponding fragmentation information (TSN,FC',FSN');
    - means for transmitting transmission units (11-15) to a receiving unit via said air interface;
    - means for receiving a retransmission request by a receiving unit requesting that a transmission unit (12) is to be retransmitted; and
    - means for refragmenting a transmission unit (12) for which a retransmission was requested by a receiving unit, and for providing said transmission unit (12) for retransmission with information (FC,FSN) on said refragmentation and with at least some of said fragmentation information (TSN,FC',FSN') provided to said transmission unit (12) for a first transmission.

12. Wireless access system comprising a transmitting unit according to one of claims 9 to 11 and a receiving unit comprising means for receiving transmission units transmitted by said transmitting unit and means for requesting a retransmission of transmission units (12) if required.

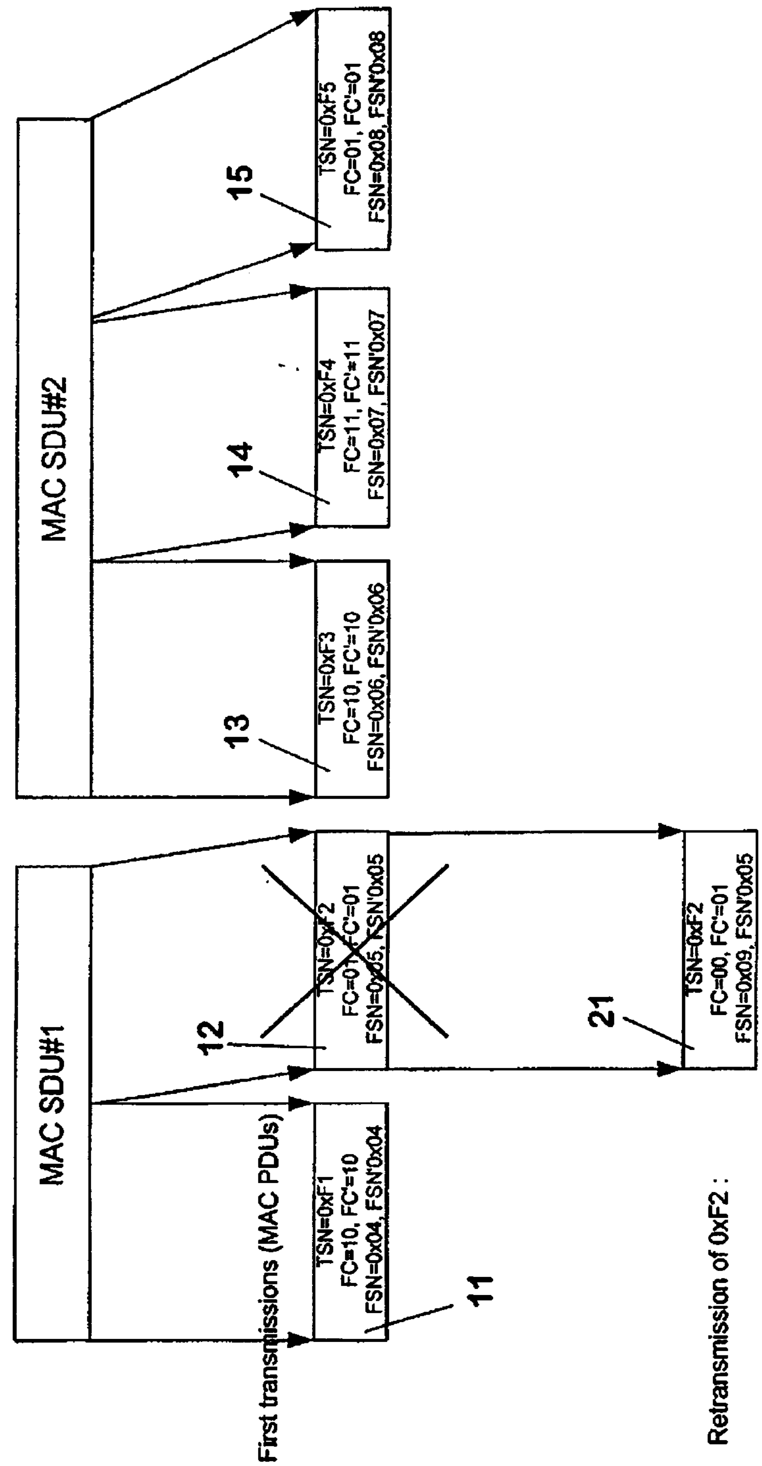
MAC SDU#1
MAC SDU#2
First transmissions (MAC PDUs)
11
TSN=0xF1
FC=10, FC'=10
FSN=0x04, FSN'0x04
12
TSN=0xF2
FC=01, FC'=01
FSN=0x05, FSN'0x05
13
TSN=0xF3
FC=10, FC'=10
FSN=0x06, FSN'0x06
14
TSN=0xF4
FC=11, FC'=11
FSN=0x07, FSN'0x07
15
TSN=0xF5
FC=01, FC'=01
FSN=0x08, FSN'0x08
Retransmission of 0xF2 :
21
TSN=0xF2
FC=00, FC'=01
FSN=0x09, FSN'0x05

FIG. 1

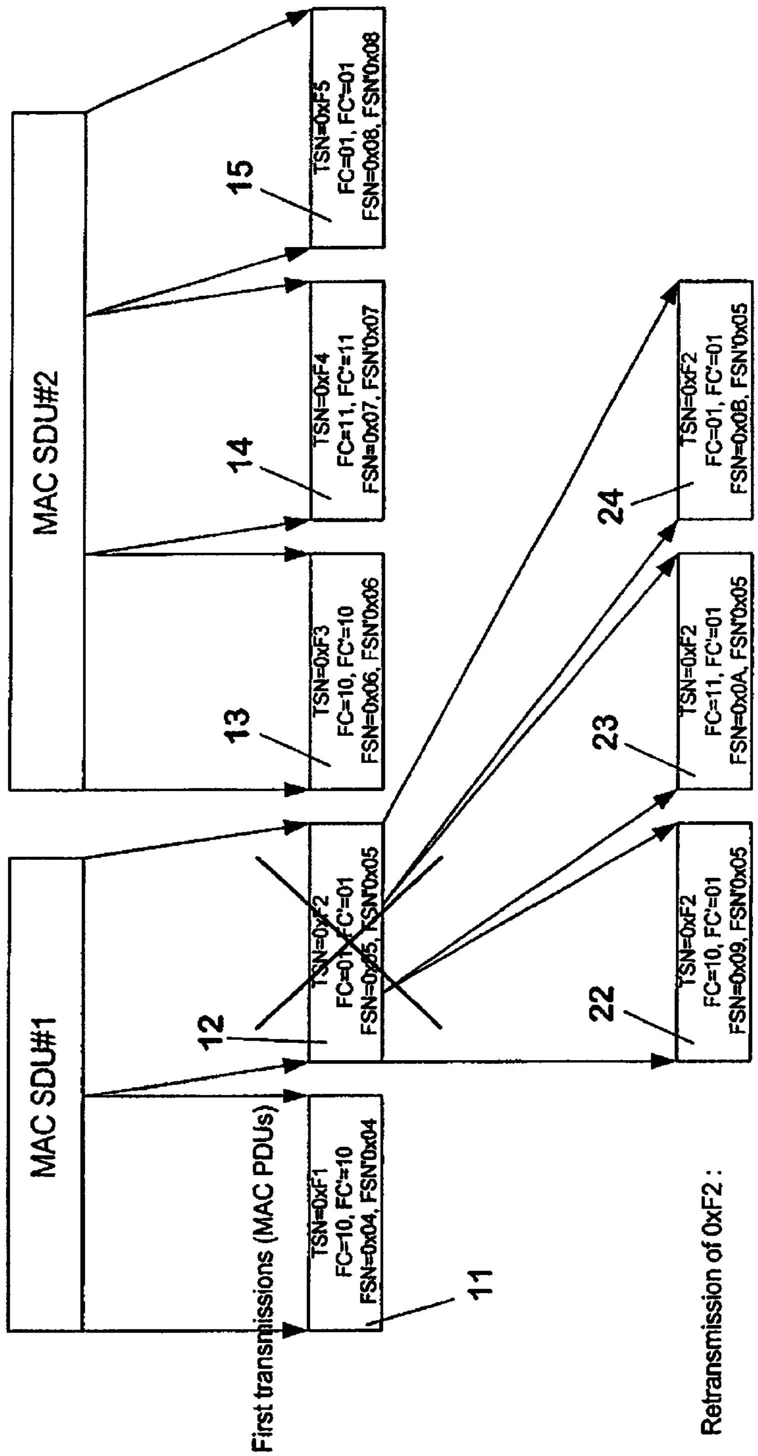
MAC SDU#1
MAC SDU#2
First transmissions (MAC PDUs)
TSN=0xF1 FC=10, FC'=10 FSN=0x04, FSN'0x04
TSN=0xF2 FC=01, FC'=01 FSN=0x05, FSN'0x05
TSN=0xF3 FC=10, FC'=10 FSN=0x06, FSN'0x06
TSN=0xF4 FC=11, FC'=11 FSN=0x07, FSN'0x07
TSN=0xF5 FC=01, FC'=01 FSN=0x08, FSN'0x08
Retransmission of 0xF2 :
TSN=0xF2 FC=10, FC'=01 FSN=0x09, FSN'0x05
TSN=0xF2 FC=11, FC'=01 FSN=0x0A, FSN'0x05
TSN=0xF2 FC=01, FC'=01 FSN=0x0B, FSN'0x05
11
12
13
14
15
22
23
24

FIG. 2

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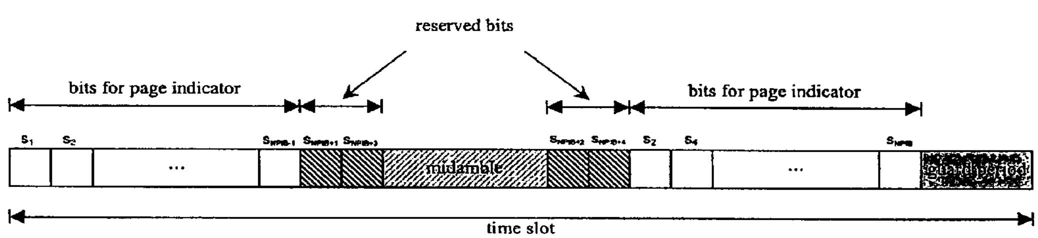

(57) Abstract: The present invention provides a method, a device and a system for High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode of a wireless communication system, especially of a Universal Mobile Telecommunication System (UMTS) Terrestrial Radio Access Network (UTRAN) and more particular to a method, a device and a system employing a Paging Indicator Channel (PICH) for signaling High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode. The structure of Paging Indicator Channel (PICH) is modified to enable a transmission of a High-Speed Indicator (HI) to a certain addressed mobile terminal device initiating the High-Speed Downlink Packet Access (HSDPA).

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METHOD AND DEVICE FOR DOWNLINK PACKET ACCESS SIGNALLING FOR TIME DIVISION DUPLE X (TDD) MODE OF A WIRELESS COMMUNICATION SYSTEM

The present invention related to a method, a device and a system for High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode of a wireless communication system, especially of a Universal Mobile Telecommunication System (UMTS) Terrestrial Radio Access Network (UTRAN). More particular, the present invention relates to a method, a device and a system employing a Paging Indicator Channel (PICH) for signaling High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode.

The 3rd Generation Partnership Project (3GPP) currently discusses methods for downlink signaling of Universal Mobile Telecommunication System (UMTS) Terrestrial radio access network (UTRAN) High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode.

For dedicated (transport) Channel (DCH) associated two-step signaling, the associated dedicated channel (DCH) and High-Speed Shared Control Channel (HS-SCCH) are needed for each mobile terminal device employing high-speed downlink services to transmit downlink signaling information. The Dedicated Channel (DCH) carries High-Speed Indicator (HI) bits used to indicate or designate a mobile terminal device to receive downlink signaling information on the High-Speed Shared Control Channel (HS-SCCH). This High-Speed Shared Control Channel (HS-SCCH) carries data comprising a mobile terminal device identification (UE ID), Transport Format Resource Indicator (TFRI), Hybrid Automatic Repeat Request (HARQ) mode and further signaling information for the mobile terminal device. These signaling information carried on the High-Speed Shared Control Channel (HS-SCCH) may be employed for receiving and decoding the packet data transmitted through the Downlink Shared Channel (DSCH).

This method for signaling High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode includes several disadvantages.

Each mobile terminal device employing High-Speed Downlink Packet Access (HSDPA) should have one associated Dedicated Channel (DCH) to transmit High-Speed Indicator (HI) bits. The number of Dedicated Channel (DCH) supported by the system will be matching the number of mobile terminal devices employing High-Speed Downlink Packet Access (HSDPA). Since these associated Dedicated Channels (DCH) are exclusively involved to carry High-Speed Indicator (HI) information comprising a few single bits (for example one or two bits) resources are not efficiently used and overall performance is wasted.

Further, the associated Dedicated Channel (DCH) is shared in the time domain upon the mobile terminal devices employing High-Speed Downlink Packet Access (HSDPA).A packet scheduler controlling the sequence in time of the associated Dedicated Channel (DCH) may have to be rescheduled if a mobile terminal device employing High-Speed Downlink Packet Access (HSDPA) exits and/or accesses the network for sharing the Dedicated Channel (DCH) in the time domain in Time Division Duplex (TDD) mode. The rescheduling is time consuming and lacks of flexibility in case of fast changing conditions, particularly in case of a high number of exiting mobile terminal devices employing High-Speed Downlink Packet Access (HSDPA).

The present invention offers a new approach for sending High-Speed Indicator (HI) information in the downlink signaling of High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode, particular for Universal Mobile Telecommunication System (UMTS) Terrestrial radio access network (UTRAN). The present invention aims to overcome the above described disadvantages of the method of state of the art. The basic idea of the present invention resides in that reserved and currently unused bits on the Paging Indicator Channel (PICH) are used to transmit High-Speed Indicator (HI) information to indicate a mobile terminal device to receive and decode signaling information on the High-Speed Shared Control Channel (HS-SCCH).

The usage of the Paging Indicator Channel (PICH) and the reserved bits thereon offers the possibility to establish a High-Speed Downlink Packet Access (HSDPA) without involving associated the Dedicated Channel (DCH) for each mobile terminal device employing the access service and thus saving Dedicated Channel (DCH) resources. Further, the implementation of a scheduler controlling the High-Speed Downlink Packet Access (HSDPA) and signaling thereof may be easier. Different coding of the reserved bits of the Paging Indicator Channel (PICH) used for signaling may offer additional flexibility since the coding may allow different mapping with respect to the configuration of the system. Moreover, the Paging Indicator Channel (PICH) is transmitted with high power. The high power transmission ensures that all mobile terminal devices within a cell may receive an adequate signal for decoding.

According to a first aspect of the present invention, a High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode of a wireless communication system, preferably of a Universal Mobile Telecommunication System (UMTS) and more preferably of a Universal Mobile Telecommunication System (UMTS) Terrestrial Radio Access Network (UTRAN) based on the usage of a Paging Indicator Channel is provided. The sender, i.e. a base station (node B) first sends indication information to a mobile terminal device (UE). The mobile terminal device (UE) identified by the said indication information further receives signaling information. Said mobile terminal device then, based on said signaling information, decodes packet data information. The invention is characterized by including a High-Speed Indicator (HI) into the slot structure of the Paging Indicator Channel (PICH). Therefore, the High-Speed Indicator (HI) comprises a plurality of identification bits. The identification bits are assigned to certain values.

The High-Speed Indicator (HI) is used to determine a specific mobile terminal device out of a plurality of mobile terminal devices. The mobile terminal device may be a participant of the corresponding mobile communication network and the High-Speed Downlink Packet Access (HSDPA) service provided by a sender. The sender may be a Base Station (BS) of a Universal Mobile Telecommunication System (UMTS), preferably a Node B Base Station (BS). The determined mobile terminal device is accessible in a downlink channel.

Conveniently, the High-Speed Indicator (HI) comprising identification bits may define an identification address. The address may be coded in different ways.

Preferably, the plurality of identification bits are four identification bits. The identification bits may be arranged adjacent to a midamble of the Paging Indicator Channel according to the slot structure thereof. The identification bits may be groups in two pairs each comprising two bits. The pairs are arranged on either side of the midamble.

Additionally, a plurality of mobile terminal devices may be divided upon a plurality groups and assigned thereto. Each group may comprise several mobile terminal devices. The dividing of the mobile terminal devices upon several groups may be dynamical which means that mobile terminal devices may exit and/or access a group. The dividing upon groups may be rearranged according to certain operational conditions.

Preferably, each group may have assigned periods of time. Within the assigned periods of time certain services may be offered to the mobile terminal devices of the group and these mobile terminal devices may have to listen on certain channels in order to be able to receive information and/or data which are destined to one or more mobile terminal devices of the group. Mobile terminal devices of the remaining groups do not have to listen to the corresponding channels since the services are provided to the first mobile terminal devices.

The assigning of the groups to certain periods of time may instruct the mobile terminal devices of the groups only to listen, receive and decode information transmitted on the Paging Indicator Channel (PICH) within the assigned periods. Further, the assigning of the groups to certain periods of time may instruct the mobile terminal devices of the groups only to listen, receive and decode information transmitted on the High-Speed Shared Control Channel (HS-SCCH) within the assigned periods of time and/or the assigning of the groups to certain periods of time may instruct the mobile terminal devices of the groups only to listen, receive and decode information transmitted on the Downlink Shared Channel (DSCH) within the assigned periods of time

An address coded in the High-Speed Indicator using the identification bits may be used to code an address of the mobile terminal device which is preferably unique within a group. Addresses of mobile terminal devices assigned to different groups may be equal.

The periods of time assigned to a group may be periodical. Correspondingly, a repetition time may be assigned to each group and may define the respective periods of time for the groups. The repetition time of the groups may vary analog to the periods of time described above. The repetition time may be a static repetition time or a dynamic repetition time. The dynamic repetition time may be adapted to traffic load. A static repetition time may be assigned to each group while dividing the plurality of mobile terminal devices upon the plurality of groups. Further, accessing and exiting mobile terminal devices of the groups may make an adaptation of the repetition time necessary.

A mobile terminal device may receive information on the Paging Indicator Channel (PICH) including said identification bits. The receiving of identification bits included in the Paging Indicator Channel (PICH) may indicate a following transmission of high-speed downlink packets. The identification bits representing an address of a mobile terminal device may have to match to an address assigned to a mobile terminal device, wherein the address of the mobile terminal device may be coded according to the coding of the address with respect to the identification bits.

A mobile terminal device may receive signaling information on a High-Speed Shared Control Channel (HS-SCCH). Preferably, the mobile terminal device may also receive a High-Speed Indicator (HI) on the Paging Indicator Channel (PICH) and the High-Speed Indicator (HI) comprises an address coded by the identification bits, determining the receiving mobile terminal device.

More preferably, the High-Speed Indicator (HI) comprises an address determining a mobile terminal device and instructing this mobile terminal device to receive and decode signaling information transmitted on a High-Speed Shared Control Channel (HS-SCCH).

Additionally, the High-Speed Shared Control Channel (HS-SCCH) may comprise mobile terminal device identification (user identification or UE ID), Transport Format and Resource related Information (TFRI), Hybrid Automatic Repeat Request (HARQ) information, Uplink Synchronization information and Transport Power Control (TPC) information.

A mobile terminal device may receive and decode data packets on a Downlink Shared Channel (DSCH). The signaling information received on the High-Speed Shared Control Channel (HS-SCCH) before may be employed for receiving and decoding of the data packets. Especially the transmission related information comprised in the signaling information transmitted on a High-Speed Shared Control Channel (HS-SCCH) may be employed for decoding.

The mobile terminal device may transmit a transmission related information. Preferably, the mobile terminal device may transmit transmission related information on a High-Speed Information Channel (HICH). The transmission related information may comprise an acknowledgement / non acknowledgement (ACK/NAK) indicating if the transmission on the Downlink Shared Channel (DSCH) may have been received and decoded correctly or erroneously. Further, the transmission related information may also comprise a quality indicator and a Transport Power Control (TPC).

The identification bits may be used to code an address of a mobile terminal device, preferably of a mobile terminal device within a group.

Preferably, the address coding may be based on a binary coding. Since four identification bits may be reserved for coding the address the binary coding may enable to code $2^4 = 16$ different addresses. Certain addresses, such as 0000_2 and 1111_2 may be dedicated to special functions, wherein the index 2 may denote the binary coding. For example, the address 0000_2 may indicate that no mobile terminal device is addressed and the address1111_2 may indicate that all mobile terminal devices are addressed. Each mobile terminal device of a group may have assigned a unique address.

Moreover, the address coding may be based on a logic coding. Each bit may be assigned to a corresponding mobile terminal device. Since a bit may represent two different states the logic one state, e.g. the state "1" may indicate that the corresponding mobile terminal device is addressed whereas the state "0" may indicate that the corresponding mobile terminal device is not addressed. Address coding may enable to address a selection of mobile terminal devices at the same time. The four identification bits may allow to address four mobile terminal devices according to the logic address coding.

The grouping of the mobile terminal devices into different groups may be based on the data traffic generated by the mobile terminal devices. Further, the grouping of the mobile terminal devices into different groups may be based on N channel Hybrid Automatic Repeat Request (HARQ) scheme.

According to a second aspect of the present invention, a computer program for carrying out the method for High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode of a wireless communication system is provided, which comprises program code means for performing all of the steps of the preceding method description when the program is run on a computer, a network device, a mobile terminal device or an application specific integrated circuit.

According to a third aspect of the present invention, a computer program product is provided comprising program code means stored on a computer readable medium for carrying out the method for High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode of a wireless communication system of the preceding description, when the computer program product is run on a computer, a network device, a mobile terminal device or an application specific integrated circuit.

According to a fourth aspect of the present invention, a mobile terminal device for the High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode of a wireless communication system is provided, which is adapted to perform a method for the High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode of a wireless communication system as described in the aforementioned description. The mobile terminal device can be a computer, a network device or a mobile terminal device such as a mobile phone.

Preferably, the mobile terminal device may comprise means for decoding information transmitted on the Paging Indicator Channel (PICH) which enables to extract the included identification bits determining a specific mobile terminal device. An address corresponding to the coding of the identification bits may be assigned to the mobile terminal device. The address coding is described above in detail. In case of matching received signaling information transmitted on a High-Speed Shared Control Channel (HS-SCCH) may be employed to receive and decode data packet on a Downlink Shared Channel (DSCH).

The mobile terminal device may be assigned to a certain group according to the above described dividing of a plurality of mobile terminal devices upon a plurality of groups.

According to a fifth aspect of the present invention, a wireless communication system for the High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode is provided, which is adapted to perform a method for the High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode of a wireless communication system as described in the aforementioned description.

The wireless communication system may comprise a plurality of mobile terminal devices for the High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode described above in detail. Further a sender comprised by the wireless communication system may generate a signal according to the signal structure of the Paging Indicator Channel (PICH) comprising identification bits using an adequate generating means. The identification bits may be a High-Speed Indicator (HI) determining a specific one of the plurality of mobile terminal devices. The Paging Indicator Channel (PICH) may be transmitted to a plurality of mobile terminal devices. The plurality of mobile terminal devices may be grouped according to the aforementioned grouping procedure.

Moreover, the wireless communication system may also provide and transmit signaling information on a High-Speed Shared Control Channel (HS-SCCH) and/or data packets on a Downlink Shared Channel (DSCH). Corresponding means for generating and transmitting of corresponding radio signals may preferably provided by a sender of the mobile communication system.

Additionally, the sender may also provide means to divide or group a plurality of mobile terminal devices, respectively, to assign addresses according to the coding of the identification bits of the High-Speed Indicator and to assign periods of time for accessing for the grouped mobile terminal devices to the mobile communication network. The means for dividing or grouping, respectively and for assigning addresses and periods of time may be operated according to the above described operational procedures for dividing or grouping, respectively and for assigning addresses and periods of time.

In the following, the invention will be described in detail by referring to the enclosed drawing in which:

Fig. 1 shows a slot structure of a Paging Indicator Channel (PICH) according to an embodiment of the invention.

Fig. 2 shows a grouping of a plurality of mobile communication terminals according to an embodiment of the invention.

Fig. 3 shows frame diagram of a high data transmitting situation according to an embodiment of the invention.

Fig. 1 shows a slot structure of a Paging Indicator Channel (PICH) according to an embodiment of the invention. The shown slot structure depicts a Paging Indicator Channel (PICH) burst with respect to the 3GPP (3rd Generation Partnership Project) and the number of bits and their arrangement within the burst structure.

The communication of data via a time duplex division (TDD) radio frequency communication system between a plurality of communication members such as base stations and mobile communication terminal is based on time slotted transmission structure within the time domain whereupon the certain periods of time are dedicated and assigned for the communication of a certain member of the time duplex division (TDD) radio frequency communication system. According to a standard defined by the 3GPP (3rd Generation Partnership Project) a time duplex division (TDD) radio communication system, especially time duplex division (TDD) based universal mobile telecommunication services terrestrial radio access network (UTRAN), the time structure of a time duplex division radio communication network may be described by radio frames and time slots, wherein each radio frame comprises a plurality of time slots. According to the 3GPP standard definition each time division multiple access (TDMA) frame has duration of 10 ms and is subdivided into fifteen time slots (TS), whereas each time slot may be further subdivided into 2560.

The time slots may be allocated to either an uplink or a downlink transmission between a mobile terminal device and a base station. The time slot may be allocated completely to one of the transmission direction so that a frame may comprise an arbitrary sequence of uplink and downlink transmissions. The 2560 chips of a time slot may be primarily used for coding or spreading the communicated data within a time slot, respectively. The spreading of communicated data within a time slot is out of the scope of this invention and known to those skilled in the art and described in available standard documents of the 3rd Generation Partnership Project (3GPP).

A burst of data may be designated as a physical channel of a time division duplex radio communication system. A burst may be transmitted in a time slot within an allocated frame and its duration is one time slot. Each burst may include a first data part, a midamble, a second data part and a guard part. Different type of burst may be available for data communication, particularly a type 1, type 2 and type 3, wherein the both burst types 1 and 2 may be employed for uplink and downlink data communication whereas burst type 3 may be employed exclusively for uplink data transmission. Type 2 burst may be distinguished by a larger data amount in comparison with type 1 burst. At maximum, a type 1 burst may comprise 1952 symbols of data (or bits, respectively) at spread factor 1 (SF 1) whereas a type 2 burst may comprise 2208 symbols of data (or bits, respectively) at spread factor 1. Correspondingly, at a spread factor 16 (SF 16) the burst may comprise 122 or 138 symbols of data, respectively.

The midamble may comprise training sequences. Since the total length of a burst may be defined by a time slot the training sequence or midamble of a type 1 burst comprises a training sequence of more data symbols than a type 2 burst. The guard period of both the type 1 and type 2 burst may comprise the same number of data symbols.

The Paging Indicator Channel (PICH) indicates or designates a mobile terminal device for which it is provided that a Paging Message might be accepted thereby on the Paging Channel (PCH). The mobile terminal devices may be assigned to a paging group when it is registered with the network. These paging groups may be indicated by the use of Paging Indicators (PI) carried on the Paging Indicator Channel (PICH).

Two different burst types, type 1 and type 2, are employed for defining different numbers of bits N_{pib} or number of data symbols within the structure, respectively. The burst type 1 may carry a

Paging Indicator (PI) with a number of bits $N_{pib} = 240$, whereas the burst type 2 may carry another Paging Indicator (PI) with a number of bits $N_{pib} = 272$. The bits s_{NPIB+1}, ..., s_{NPIB+4} adjacent to the midamble are reserved up to now for future usage. The usage of the remaining bits s_1, ..., s_{NPIB} are defined by the 3GPP standard.

These four reserved bits s_{NPIB+1}, ..., s_{NPIB+4} may be used for addressing an individual mobile terminal device out of a group of mobile terminal devices and indicating to the mobile terminal device to receive a high-speed downlink packet. Therefore, the four reserved bits may be designated in the following description as an address or a High-Speed Indicator (HI). Two different coding may be employed for enabling an addressing of a mobile terminal device.

A first address coding may be based on a binary coding of an individual address of each mobile terminal device out of the group of mobile terminal devices. The first address coding may be based on a binary coding of the addresses. This coding method may be employed in case of one device which may be allowed to transmit high-speed downlink packets in each frame. The employed four bits for coding an individual address of a mobile terminal device may allow to assign $2^4 = 16$ different addresses for addressing. In the following binary coded numbers and hence also the binary coded addresses may be indicated by a subscript "2", whereas the respective decimal spelling is indicated by a subscript "10". In the following description of this invention the states of the four bits may be denoted enclosed within quotation marks, such as "0010".

The addresses $0000_2 = 0_{10}$, $1111_2 = 15_{10}$ may be reserved for special addressing operations and not assigned to any certain mobile terminal device. The address $0000_2 = 0_{10}$ may indicate that no one of the mobile terminal devices of the group thereof may is addressed, whereas the address $1111_2 = 15_{10}$ may indicate that all mobile terminal devices of the group thereof may be addressed.

Thus, fourteen remaining addresses may be used for addressing individual mobile terminal devices when the both addresses $0000_2 = 0_{10}$, $1111_2 = 15_{10}$ may be employed for the above described special operations. The remaining addresses $0001_2 = 1_{10}$, $0010_2 = 2_{10}$, $0011_2 = 3_{10}$, ...,

$1110_2 = 14_{10}$ may allow to address maximum fourteen different mobile terminal devices and may be assigned correspondingly thereto.

A second address coding may be based on a non binary coding of addresses. Each bit of the reserved four identification bits may be assigned to a certain mobile terminal device for addressing. This coding method may be employed advantageously in case of several devices which may be allowed to transmit high-speed packet data in each frame. Therefore, it may be possible to address four different mobile terminal devices and hence, the group of mobile terminal devices may comprise maximal four different mobile terminal devices. Each bit may offer two different bits states, a bit state "1" and a bit state "0", respectively.

The address "1000" may indicate that, for example, the first mobile terminal device out of the group of the four mobile terminal devices may be addressed, whereas the remaining three mobile terminal devices (second, third and fourth) may be not addressed. Correspondingly further, the address "0100" may indicate that, for example, the second mobile terminal device out of the group of the four mobile terminal devices may be addressed, whereas the remaining three mobile terminal devices (first, third and fourth) may be not addressed. Correspondingly further, the address " 0010" may indicate that, for example, the third mobile terminal device out of the group of the four mobile terminal devices may be addressed, whereas the remaining three mobile terminal devices (first, second and fourth) may be not addressed. Correspondingly further, the address " 0001" may indicate that, for example, the fourth mobile terminal device out of the group of the four mobile terminal devices may be addressed, whereas the remaining three mobile terminal devices (first, second and third) may be not addressed.

This second address coding allows to address a selected subgroup out of the group of four mobile terminal devices. For example, the address coding "1001" may indicate that, for example, the first and fourth mobile terminal devices are addressed whereas the second and the third mobile terminal devices are not addressed. For example, the address coding "1011" may indicate that, for example, the first, third and fourth mobile terminal devices are addressed whereas the second mobile terminal device is not addressed.

The usage and functionality connected to the addresses "0000" and "1111" is the same like described in combination with the first address coding procedure. A coded address "0000" may indicate that no one of the mobile terminal devices is addressed to initiate a data transmission. Correspondingly, an address "1111" may indicate an initialization of a data transmission to all four mobile terminal devices of the group.

In the following description, the address coding of the mobile terminal devices may be based on the first address coding mentioned and described above. The below presented description may be employed in a similar manner in combination with the above mentioned second address coding.

Fig. 2 shows a grouping of a plurality of mobile communication terminal according to an embodiment of the invention. A plurality of mobile terminal devices is shown in Fig. 2. The mobile terminal devices are grouped in five separate groups each comprising a subset of plurality of mobile terminal devices. The grouping and the number of mobile terminal devices within the different groups is exemplary and the grouping may performed in another arrangement. Since the address coding is based on the first address coding procedure the different groups may comprise maximal fourteen mobile terminal devices. Further, the number of groups may also be exemplary and not limited to the depicted five different groups.

A first group designated as group 1 may comprise exemplary four mobile terminal devices and the mobile terminal devices may be designated as UE 1, UE 2, UE 3 and UE 4, respectively. According to the address coding procedure, the addresses "0001", "0010", "0011" and "0100" may be assigned to the corresponding mobile terminal devices UE 1, UE 2, UE 3 and UE 4.

A second group designated as group 2 may comprise exemplary six mobile terminal devices and the mobile terminal devices may be designated as UE 5, UE 6, UE 7, UE 8, UE 9 and UE 10, respectively. According to the address coding procedure, the addresses "0001", "0010", "0011" "0100" "0101" and "0111" may be assigned to the corresponding mobile terminal devices UE 5, UE 6, UE 7, UE 8, UE 9 and UE 10.

A third group designated as group 3 may comprise exemplary three mobile terminal devices and the mobile terminal devices may be designated as UE 11, UE 12 and UE 13, respectively.

According to the address coding procedure, the addresses "0001", "0010" and "0011" may be assigned to the corresponding mobile terminal devices UE 11, UE 12 and UE 13.

A fourth group designated as group 4 may comprise exemplary six mobile terminal devices and the mobile terminal devices may be designated as UE 14, UE 15, UE 16, UE 17, UE 18 and UE 19, respectively. According to the address coding procedure, the addresses "0001", "0010", "0011" "0100" "0101" and "0111" may be assigned to the corresponding mobile terminal devices UE 14, UE 15, UE 16, UE 17, UE 18 and UE 19.

A fifth group designated as group 5 may comprise exemplary four mobile terminal devices and the mobile terminal devices may be designated as UE 20, UE 21, UE 22, UE 23 and UE 24, respectively. According to the address coding procedure, the addresses "0001", "0010", "0011", "0100" and "0101" may be assigned to the corresponding mobile terminal devices UE 20, UE 21, UE 22, UE 23 and UE 24.

The plurality of mobile terminal devices are divided into a plurality groups. The number of groups may and the division thereupon may be performed dynamically or statically. For example, the grouping (arrangement and/or number of groups) may be based on traffic load or N channel Hybrid Automatic Repeat Request (HARQ) scheme.

The following Fig. 3 may represent a time flow diagram according to an embodiment of the method of the present invention. The time flow diagram is based on the grouping presented above according to Fig. 2.

Fig. 3 shows frame diagram of a high data transmitting situation according to an embodiment of the invention. The five groups each comprising mobile terminal devices, shown in Fig. 2 may listen to the Paging Indicator Channel (PICH). According to this embodiment of the invention, the mobile terminal devices of one group may listen to the Paging Indicator Channel (PICH) every fifth frame. Correspondingly, group 1 may listen to frame 1, group 2 to frame 2, group 3 to frame 3, group 4 to frame 4 and group 5 to frame 5. Beginning with frame 6 group 1 may listen again thereto and further group 2 may follow in listening to frame 7. This sequencing of the groups may be continued. Analog to the grouping of the mobile terminal devices, the period of repetition may be defined both dynamically or statically. For example, the period of repetition may be based on traffic load or N channel Hybrid Automatic Repeat Request (HARQ) scheme. Further, the groups may have the same periods of repetition.

The following channels may be involved in and used by the embodiment of the present invention. A short describing introduction of the channels will be given since the complete definition of the respective channels may be known to those skilled in the art.

The Paging Indicator Channel (PICH) may indicate to a mobile terminal device that a Paging Message might be expected thereby on the Paging Channel (PCH). The mobile terminal devices may be assigned to a paging group when it is registered with the network. These paging groups may be indicated by the use of Paging Indicators (PI) carried on the Paging Indicator Channel (PICH). Here in the invention, the reserved bits as in Fig. 1are used as High Speed Indicator (HI) which comprise the coded address of a mobile terminal device of the respective group for initialing a high-speed downlink transmission.

The High-Speed Shared Control Channel (HS-SCCH) may be used to carry indicator and signaling information to be employed for receiving and decoding information transmitted through a Downlink Shared Channel (DSCH).

The Downlink Shared Channel (DSCH) is used to carry dedicated user data or control signal to one or more mobile terminal devices in a communication cell. The decoding of the dedicated user data or control signal may be enabled and controlled by information transmitted via the above mentioned High-Speed Shared Control Channel (HS-SCCH)

The Uplink High-Speed Downlink Packet Access (HSDPA) Information Channel (UL-HICH) may be used to carry indicator and signaling information to a base station or Node B, respectively. Three different fields may be comprised, an acknowledge / negative acknowledge (ACK/NAK) field, a Quality Indicator field and a Transmit Power Control (TPC) field.

Each mobile terminal device of a corresponding group according to a specific frame assigned to the corresponding group may listen to the Paging Indicator Channel (PICH) of this frame while the mobile terminal device of the other groups do not listen. Further, the mobile terminal device of this group may share the Downlink Shared Channel (DSCH).

In the following, the time sequence provided in Fig. 3 will be described with respect to each single frame.

In a frame 1, all mobile terminal devices comprised by the group 1 may listen to the Paging Indicator Channel (PICH). An address of a mobile terminal device out of group 1 may be comprised in the high speed indicator (HI) carried by the Paging Indicator Channel (PICH) and received by the mobile terminal devices of group 1. The address "0001" may be coded in the High speed indicator (HI) according to the above described first coding procedure (shown in Fig. 1). The mobile terminal device UE 1 which may have been assigned the address "0001" decodes its address and hence may be indicated to receive and decode the downlink signaling information which may be transmitted through and obtained on the High-Speed Shared Control Channel (HS-SCCH). The downlink signaling information may enable the mobile terminal device to receive and decode the high-speed packet data in the Downlink Shared Channel (DSCH) by using this received and decoded downlink signaling information. A confirmation may be transmitted to the high-speed downlink packet sender, such as a Node B. The confirmation may comprise an acknowledge / negative acknowledge (ACK/NAK) and measurement report. Preferably the confirmation may be transmitted via the Uplink High-Speed Downlink Packet Access (HSDPA) Information Channel (UL-HICH) carrying the above described information.

The operations of the following frames are carried out analog to the operations described with respect to frame 1.

In a frame 2, the mobile terminal devices of group 2 may listen to the Paging Indicator Channel (PICH) which may transmit an address of a mobile terminal device "0101" corresponding to mobile terminal device UE 9 of group 2. The mobile terminal device UE 9 which may have been assigned the address "0101" decodes its address and hence may be indicated to receive and decode the downlink signaling information which may be transmitted through and obtained on the High-Speed Shared Control Channel (HS-SCCH). The downlink signaling information may enable the mobile terminal device to receive and decode the high-speed packet data in the

Downlink Shared Channel (DSCH) by using this received and decoded downlink signaling information. A confirmation may be transmitted to the high-speed downlink packet sender, such as a Node B. The confirmation may comprise an acknowledge / negative acknowledge (ACK/NAK) and measurement report and preferably transmitted via the Uplink High-Speed Downlink Packet Access (HSDPA) Information Channel (UL-HICH).

In a frame 3, the mobile terminal devices of group 3 may listen to the Paging Indicator Channel (PICH) which may transmit an address of a mobile terminal device "0010" corresponding to mobile terminal device UE 12 of group 3. The mobile terminal device UE 12 which may have been assigned the address "0010" decodes its address and hence may be indicated to receive and decode the downlink signaling information which may be transmitted through and obtained on the High-Speed Shared Control Channel (HS-SCCH). The downlink signaling information may enable the mobile terminal device to receive and decode the high-speed packet data in the Downlink Shared Channel (DSCH) by using this received and decoded downlink signaling information. A confirmation may be transmitted to the high-speed downlink packet sender, such as a Node B. The confirmation may comprise an acknowledge / negative acknowledge (ACK/NAK) and measurement report and preferably transmitted via the Uplink High-Speed Downlink Packet Access (HSDPA) Information Channel (UL-HICH).

In a frame 4, the mobile terminal devices of group 4 may listen to the Paging Indicator Channel (PICH) which may transmit an address of a mobile terminal device "0010" corresponding to mobile terminal device UE 15 of group 4. The mobile terminal device UE 15 which may have been assigned the address "0010" decodes its address and hence may be indicated to receive and decode the downlink signaling information which may be transmitted through and obtained on the High-Speed Shared Control Channel (HS-SCCH). The downlink signaling information may enable the mobile terminal device to receive and decode the high-speed packet data in the Downlink Shared Channel (DSCH) by using this received and decoded downlink signaling information. A confirmation may be transmitted to the high-speed downlink packet sender, such as a Node B. The confirmation may comprise an acknowledge / negative acknowledge (ACK/NAK) and measurement report and preferably transmitted via the Uplink High-Speed Downlink Packet Access (HSDPA) Information Channel (UL-HICH).

In a frame 5, the mobile terminal devices of group 5 may listen to the Paging Indicator Channel (PICH) which may transmit an address of a mobile terminal device "0100" corresponding to mobile terminal device UE 23 of group 5. The mobile terminal device UE 23 which may have been assigned the address "0100" decodes its address and hence may be indicated to receive and decode the downlink signaling information which may be transmitted through and obtained on the High-Speed Shared Control Channel (HS-SCCH). The downlink signaling information may enable the mobile terminal device to receive and decode the high-speed packet data in the Downlink Shared Channel (DSCH) by using this received and decoded downlink signaling information. A confirmation may be transmitted to the high-speed downlink packet sender, such as a Node B. The confirmation may comprise an acknowledge / negative acknowledge (ACK/NAK) and measurement report and preferably transmitted via the Uplink High-Speed Downlink Packet Access (HSDPA) Information Channel (UL-HICH).

In a frame 6, the mobile terminal devices of group 1 may listen to the Paging Indicator Channel (PICH) which may transmit an address of a mobile terminal device "0011" corresponding to mobile terminal device UE 3 of group 1. The mobile terminal device UE 3 which may have been assigned the address " 0011" decodes its address and hence may be indicated to receive and decode the downlink signaling information which may be transmitted through and obtained on the High-Speed Shared Control Channel (HS-SCCH). The downlink signaling information may enable the mobile terminal device to receive and decode the high-speed packet data in the Downlink Shared Channel (DSCH) by using this received and decoded downlink signaling information. A confirmation may be transmitted to the high-speed downlink packet sender, such as a Node B. The confirmation may comprise an acknowledge / negative acknowledge (ACK/NAK) and measurement report and preferably transmitted via the Uplink High-Speed Downlink Packet Access (HSDPA) Information Channel (UL-HICH).

In a frame 7, the mobile terminal devices of group 2 may listen to the Paging Indicator Channel (PICH) which may transmit an address of a mobile terminal device "0010" corresponding to mobile terminal device UE 6 of group 2. The mobile terminal device UE 6 which may have been assigned the address " 0010" decodes its address and hence may be indicated to receive and decode the downlink signaling information which may be transmitted through and obtained on the High-Speed Shared Control Channel (HS-SCCH). The downlink signaling information may enable the mobile terminal device to receive and decode the high-speed packet data in the Downlink Shared Channel (DSCH) by using this received and decoded downlink signaling information. A confirmation may be transmitted to the high-speed downlink packet sender, such as a Node B. The confirmation may comprise an acknowledge / negative acknowledge (ACK/NAK) and measurement report and preferably transmitted via the Uplink High-Speed Downlink Packet Access (HSDPA) Information Channel (UL-HICH).

This specification contains the description of implementations and embodiments of the present invention with the help of examples. It will be appreciated by a person skilled in the art, that the present invention is not restricted to details of the embodiments presented above, and that the invention can be also implemented in another form without deviating from the characteristics of the invention. The embodiment presented above should be considered as illustrative, but not restricting. Thus, the possibilities of implementing and using the invention are only restricted to the enclosed claims. Consequently, various options of implementing the invention as determined by the claims, including equivalent implementations, also belong to the scope of the invention.

Claims

1. Method for High-Speed Downlink Packet Access (HSDPA) signaling for Time Division Duplex (TDD) mode of a wireless communication system, comprising the following steps: a base station (node B) sending indication information to a mobile terminal device (UE); the mobile terminal device (UE) identified by the said indication information receiving signaling information; said mobile terminal device, based on the said signaling information, decoding packet data information; characterized by the steps of:
   - including a High-Speed Indicator (HI) into the slot structure of a Paging Indicator Channel (PICH), said High-Speed Indicator (HI) comprising a plurality of identification bits, each identification bit being assigned,
   - said High-Speed Indicator (HI) designating a specific mobile terminal device accessible in a downlink channel.

2. Method according to claim 1, wherein said plurality of identification bits are four identification bits arranged in two pairs each of two bits on either side of and adjacent to a midamble area of said Paging Indicator Channel (PICH).

3. Method according to anyone of the preceding claims, comprising following further steps:
   - dividing a plurality of mobile terminal devices upon a plurality of groups.

4. Method according to claim 3, comprising following further steps:
   - assigning certain periods of time to each group,

   wherein each mobile terminal device of a group receives data transmitted within said periods of time assigned to said respective group via said Paging Indicator Channel (PICH).

5. Method according to claim 3 or claim 4, comprising following further steps:
   - assigning a High-Speed Indicator (HI) to each mobile terminal device of a group.

6. Method according to anyone of the claims 3 to 5, wherein said periods of time of a group are assigned according to the data traffic of the group..

7. Method according to anyone of the preceding claims, comprising following further steps:
   - receiving information on said Paging Indicator Channel (PICH) by a mobile terminal device.

8. Method according to anyone of the preceding claims, comprising the following further steps:
   - receiving signaling information on a High-Speed Shared Control Channel (HS-SCCH) by a mobile terminal device.

9. Method according to claim 7, comprising the following further steps:
   - receiving and decoding data packets on a Downlink Shared Channel (DSCH) by a mobile terminal device,

   wherein the receiving and decoding step employs said signaling information received on said High-Speed Shared Control Channel (HS-SCCH).

10. Method according anyone of the preceding claims, comprising following further steps:
    - transmitting transmission related information.

11. Method according anyone of the preceding claims, wherein said identification bits codes a binary address of a mobile terminal device.

12. Method according claim 1 to 11, wherein said identification bits codes a logical address of a mobile terminal device.

13. Method according anyone of the preceding claims, wherein said dividing a plurality of mobile terminal devices upon a plurality of groups is based on the data traffic.

14. Method according anyone of the preceding claims, wherein said dividing a plurality of mobile terminal devices upon a plurality of groups is based on an N channel Hybrid Automatic Repeat Request (HARQ) scheme.

15. Computer program for executing method for High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode of a wireless communication system, comprising program code means for carrying out the steps of anyone of claims 1 to 14 when said program is run on a computer, a network device, a mobile device, or an application specific integrated circuit.

16. Computer program product comprising program code means stored on a computer readable medium for carrying out the method for High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode of a wireless communication system of anyone of claims 1 to 14 when said program product is run on a computer, a network device, a mobile device, or an application specific integrated circuit.

17. Mobile terminal device for High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode of a wireless communication system, comprising means adapted to perform a method for High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode of a wireless communication system according to anyone on the claims 1 to 14.

18. Wireless communication system for High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode, comprising means adapted to perform a method for High-Speed Downlink Packet Access (HSDPA) for Time Division Duplex (TDD) mode of a wireless communication system according to anyone on the claims 1 to 14.

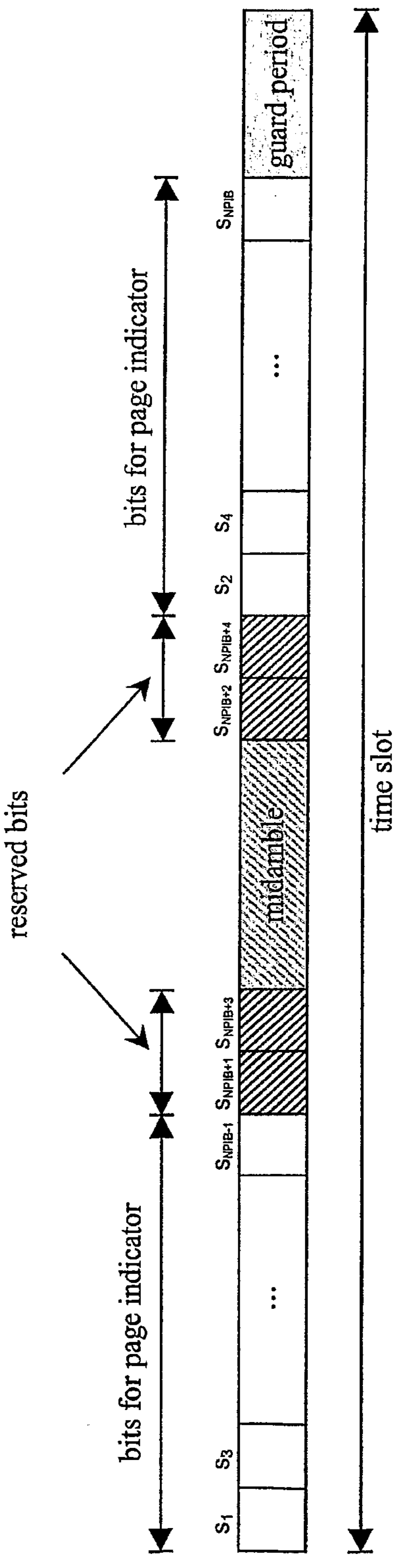
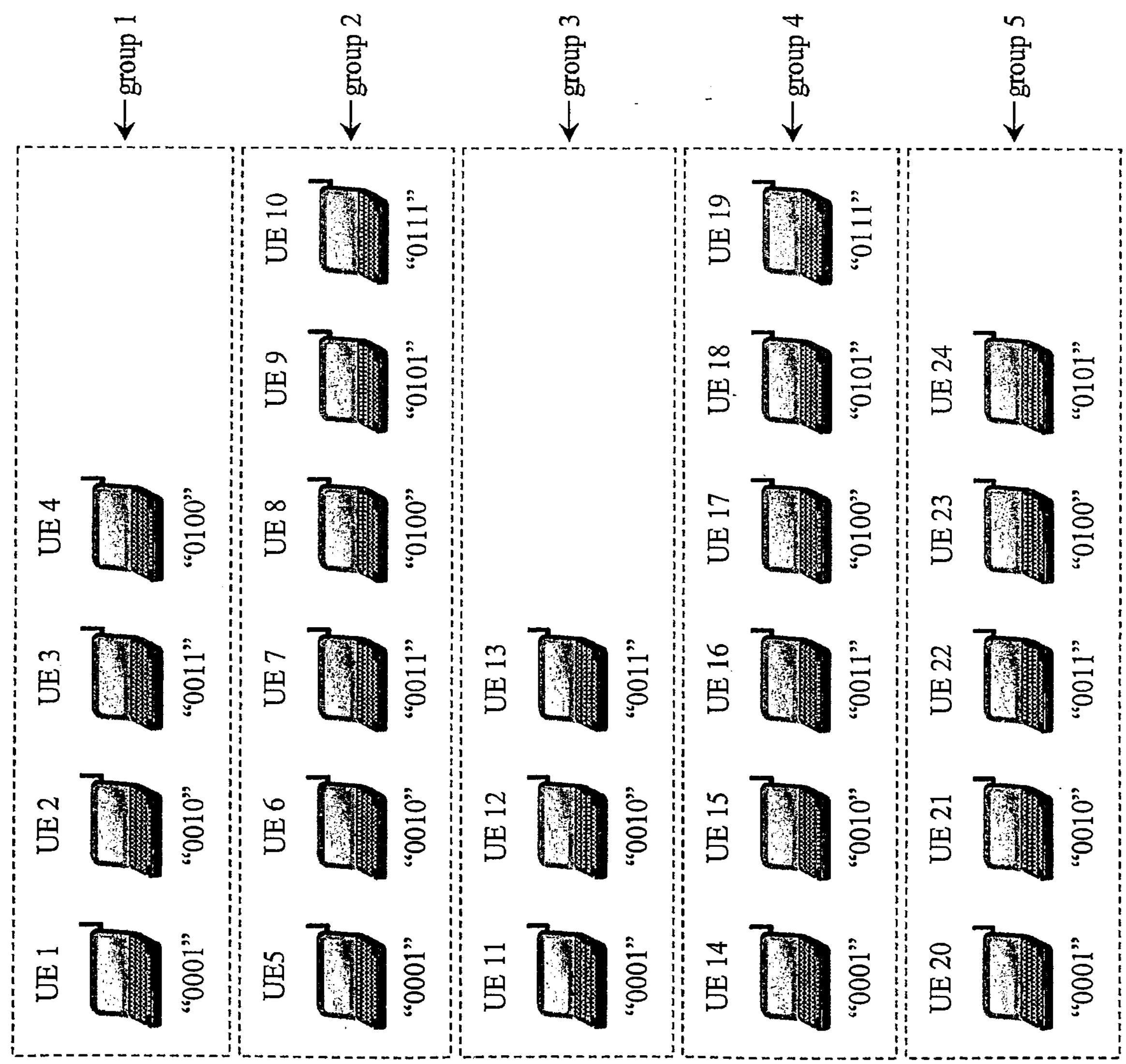

guard period
bits for page indicator
reserved bits
midamble
bits for page indicator
time slot
S_{NPIB}
S_4
S_2
S_{NPIB+4}
S_{NPIB+2}
S_{NPIB+3}
S_{NPIB+1}
S_{NPIB-1}
S_3
S_1

Fig. 1

Fig. 2


group 1
UE 1
"0001"
UE 2
"0010"
UE 3
"0011"
UE 4
"0100"
group 2
UE5
"0001"
UE 6
"0010"
UE 7
"0011"
UE 8
"0100"
UE 9
"0101"
UE 10
"0111"
group 3
UE 11
"0001"
UE 12
"0010"
UE 13
"0011"
group 4
UE 14
"0001"
UE 15
"0010"
UE 16
"0011"
UE 17
"0100"
UE 18
"0101"
UE 19
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group 5
UE 20
"0001"
UE 21
"0010"
UE 22
"0011"
UE 23
"0100"
UE 24
"0101"

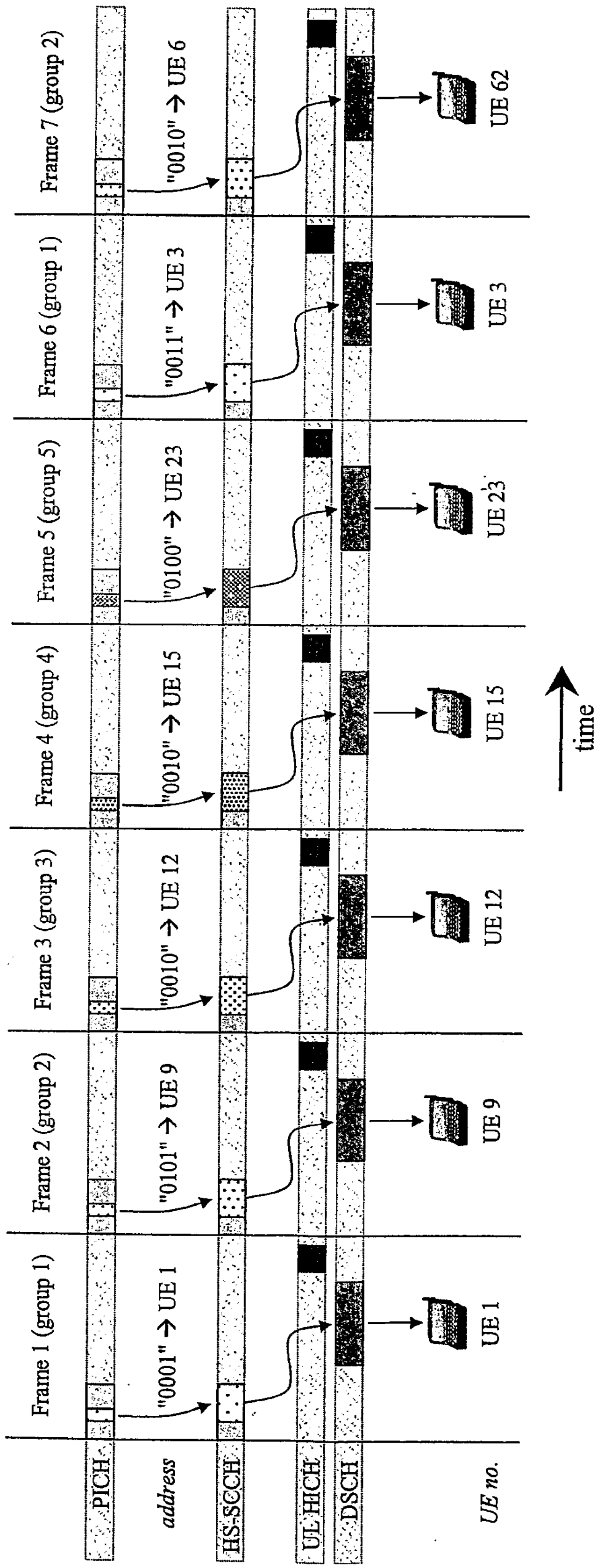
PICH
address
HS-SCCH
UL HICH
DSCH
UE no.
Frame 1 (group 1)
"0001" → UE 1
UE 1
Frame 2 (group 2)
"0101" → UE 9
UE 9
Frame 3 (group 3)
"0010" → UE 12
UE 12
Frame 4 (group 4)
"0010" → UE 15
UE 15
Frame 5 (group 5)
"0100" → UE 23
UE 23
Frame 6 (group 1)
"0011" → UE 3
UE 3
Frame 7 (group 2)
"0010" → UE 6
UE 62
time

Fig. 3

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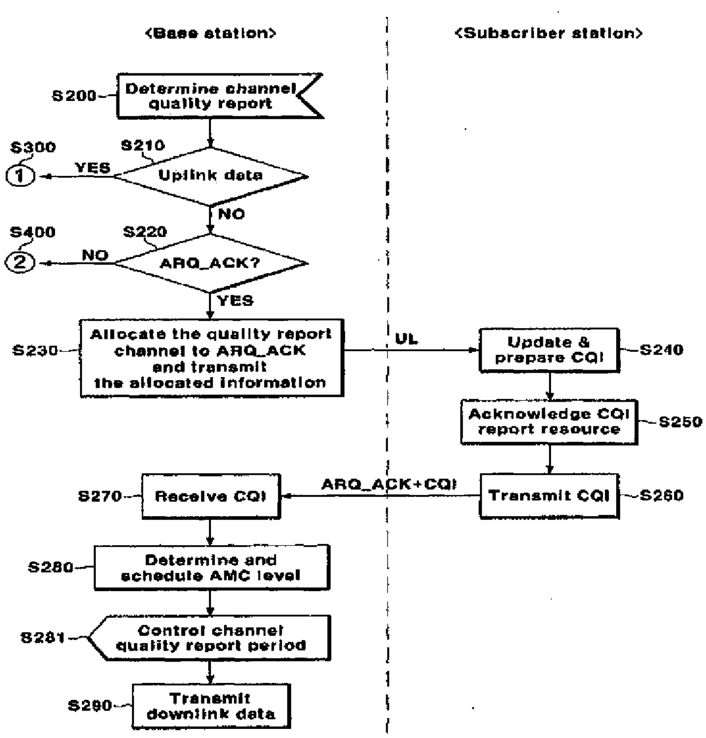
[Continued on next page]

(54) Title: A METHOD FOR REQUESTING AND REPORTING CHANNEL QUALITY INFORMATION IN WIRELESS PORTABLE INTERNET SYSTEM



(57) Abstract: A method for requesting and reporting channel quality information (CQI) in a wireless portable Internet system is disclosed. Timing of a channel quality information request by a base station is determined, existence of an automatic repeat request acknowledgment (ARQ_ACK) message of downlink data is determined on requesting the channel quality information from the subscriber station, the automatic repeat request acknowledgment message and the radio resource for the channel quality report to the subscriber station is allocated, the automatic repeat request acknowledgment message and the channel quality report information is received, and a modulating and coding level of downlink data is determined by extracting the channel quality report information from the automatic repeat request acknowledgment message.

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[DESCRIPTION]

[INVENTION TITLE]

A METHOD FOR REQUESTING AND REPORTING CHANNEL QUALITY INFORMATION IN WIRELESS PORTABLE INTERNET SYSTEM

[TECHNICAL FIELD]

The present invention relates to a mobile communication system. More specifically, the present invention relates to a method and apparatus for requesting and reporting channel quality information (CQI) in a wireless portable Internet system.

[BACKGROUND ART]

The wireless portable Internet is a next generation communication system for further supporting mobility, in addition to a short range data communication system which uses stationary access points (APs) such as the conventional wireless local area network (LAN). Various standards have been proposed for the wireless portable Internet, and the international standardization on the portable Internet is in progress by the IEEE 802.16.

The wireless LAN system such as the conventional IEEE 802.11 provides a data communication system which allows short-range radio communication with reference to stationary access points, which provides no mobility of the subscriber station (SS) but which supports wireless LAN data communication in a local area other than wired LAN data communication.

Meanwhile, a new wireless portable Internet system currently progressed by the IEEE 802.16 working group is designed to support the mobility to the subscriber station and thus provide a seamless data communication service thereto when the subscriber station moves from one cell to another cell.

The mobile communication systems including the above-described wireless portable Internet system have been developed for communication systems which support speech services and high-speed packet data services.

Reported information on the radio channel quality of a link to a subscriber station on the move is very important since the information is used to determine an appropriate adaptive modulation and channel coding (AMC) level for the corresponding link to the subscriber station in the system for supporting high-speed mobility. Since the reported information on the radio channel quality is found to be erroneous, a resource allocated to the link to the subscriber station may be wasted, it is accordingly very important to provide reliable channel quality information (CQI) to a scheduler of the base station.

In order to collect information on the channel quality, the base station selects a predetermined subscriber station for each slot from among a plurality of subscriber stations, transmits packet data thereto, and receives channel quality information on a forward channel from the selected subscriber station to determine transmission parameters such as data rates, channel coding rates, and modulation orders.

In order that the subscriber station reports channel quality information to the base station, when the base station transmits a CQI report message to a plurality of subscriber stations, each subscriber station requests bandwidth for reporting channel quality information. When the bandwidth is allocated, each subscriber station reports a channel quality measurement result to the base station in an additional message format.

FIGs. 1 to 3 show general flowcharts for measuring and reporting channel quality information in a mobile communication system. In FIGs. 1 to 3, the transverse axis stands for the time passage, BS symbolizes the base station, and SS symbolizes the subscriber station.

Referring to FIG. 1, in order to measure the radio channel quality between a base station and a subscriber station, the subscriber station receives a CQI request (REP-REQ) message from the base station and requests a bandwidth for a channel measurement report therefrom (S10 to S13), the base station allocates an uplink resource (UL-MAP) to the subscriber station (S14 and S15), and the subscriber station uses the uplink resource and transmits the channel measurement report (REP-RSP) message to the base station (S16 and S17). The REP-REQ/RSP message is a channel measurement report request/response message from among media access control (MAC) managed messages defined in IEEE 802.16.

However, a delay of a predetermined time occurs because of the request and allocation of the uplink bandwidth until the subscriber station reports the channel measurement information to the base station, since the base station allocates no uplink resource to be used for the channel measurement report in advance when requesting channel quality information from the subscriber station, thereby very probably failing to quickly process the varied channel condition and satisfy the quality of service (QoS) criteria.

FIG. 2 shows a process for the subscriber stations to competitively request a bandwidth from the base station. The respective subscriber stations competitively request a bandwidth for a channel measurement report from the base stations in steps S20 to S23, and when the request has failed, the subscriber stations attempt a competitive bandwidth request again through a backoff process in steps S24 to S27. When the attempt is found to be successful, the base station allocates an uplink resource to the corresponding subscriber station, and the subscriber station transmits a channel measurement report to the base station through the allocated uplink resource in steps S28 to S30. In this case, a delay is generated by the backoff, and the request and allocation of the uplink bandwidth.

FIG. 3 shows a process for a subscriber station to transmit a random code for a bandwidth request to the base station in the general case of requesting and reporting the channel quality information.

When the subscriber station transmits a competitive random code for a bandwidth request to the base station according to the channel quality information provided by the base station in steps S40 to S43, the base station cannot determine from the bandwidth request code whether the subscriber station will transmit bandwidth request information (i.e., an amount of data stored in a transmission buffer of uplink data) or transmit the message for the channel measurement report. Accordingly, the subscriber station may be delayed in transmitting the message for the channel measurement report to the base station even though the subscriber station has successfully transmitted the random code to the base station, and hence, the time delay is inevitable.

As shown in FIG. 3, when the base station allocates a resource for a bandwidth request and the subscriber station transmits a bandwidth request message before the subscriber station transmits the channel measurement report to the base station, the base station must allocate the uplink resource in steps S44 to S49, and hence, a time delay is generated and it is difficult to guarantee the QoS because of the undesired delay.

Also, the base station must transmit a CQI request message to each subscriber station that will generate a channel measurement report. Hence, when transmitting the CQI request message to a plurality of subscriber stations in a frame, the base station respectively transmits the same unicast message (e.g., a basic connection identifier (CID) according to the IEEE 802.16 standard) to the subscriber stations, thereby increasing overheads.

However, the method for the base station to request the channel quality information from a plurality of subscriber stations in the case of one frame may exhaust downlink resources since the base station transmits similar messages to the subscriber stations individually. Further, when the base station transmits the message to the subscriber station by using an inadequate AMC level, in detail, when the base station transmits the CQI request message thereto by using the AMC level determined based on the existing channel status even though the channel has already been degraded, some subscriber stations may fail to receive the CQI request message.

Also, overheads of messages are increased when the respective subscriber stations individually transmit a response message for the channel quality measurement result to the base station.

In addition, the mobile system does not guarantee allocation of uplink resources for transmitting the response message of the channel quality measurement result, and hence, heavy delay may be generated when the subscriber station transmits the response message to the base station. As a result, the subscriber stations may fail to transmit the on-time response message thereto, and the base station may not adaptively process the message following the mobile environment.

[DISCLOSURE]

[TECHNICAL PROBLEM]

It is an advantage of the present invention to provide a method for quickly adapting to the most recent channel state and applying the most efficient modulation and channel coding level when transmitting/receiving data to/from a corresponding subscriber station.

It is another advantage of the present invention to provide an efficient method for minimizing an overhead of an uplink resource and increasing reliability of a CQI report for an REP-RSP.

It is another advantage of the present invention to provide a method for efficiently receiving the CQI by quickly adapting to the channel environment when transmitting/receiving of data to/from a corresponding subscriber station.

It is another advantage of the present invention to provide a method for using CQI values to determine period and frequency of channel quality report, efficiently perform downlink adaptive modulation, and allocate an encoding level and a radio resource.

[TECHNICAL SOLUTION]

In one aspect of the present invention, a method for requesting channel quality information (CQI) in a wireless portable Internet system comprises: a) a base station determining timing of a channel quality information request; b) requesting an automatic repeat request acknowledgement (ARQ-ACK) message of downlink data upon requesting the CQI from a subscriber station; c) allocating a radio resource for the ARQ-ACK message and the channel quality report to the subscriber station; d) receiving information on the ARQ-ACK message and the channel quality report; and e) determining a modulation and coding level of downlink data by extracting the channel quality report information from the ARQ-ACK .

The method further comprises: a-1) determining whether uplink data to be received by the base station exists, after a); b-1) transmitting a piggyback identifier of uplink data to be used to request the CQI to the subscriber station when the uplink data exists; c-1) allocating a radio resource for reporting the CQI to the subscriber station; d-1) receiving the channel quality report information piggybacked on the uplink data; and e-1) extracting the CQI from the uplink data, and determining a modulation and coding level of downlink data based on the reported CQI.

The method further comprises: a-2) determining whether the ARQ-ACK message exists in a-1), when no uplink data to be received by the base station exists; b-2) transmitting an REP_REQ medium access control (MAC) message to the subscriber station when no ARQ-ACK message exists; c-2) allocating the radio resource for reporting the CQI to a dedicated channel; d-2) receiving the REP_REQ MAC message through the dedicated channel; and e-2) determining a modulation and coding level of downlink data based on the reported CQI.

In another aspect of the present invention, a method for reporting channel quality information in a wireless portable Internet system, comprises: a) determining whether transmission of an ARQ-ACK message and a REP-REQ is provided from a base station; b) updating the two values into latest values by measuring the CQI when the transmission is provided; c) acknowledging a radio resource allocated for the ARQ-ACK message and the CQI; and d) transmitting the CQI to a base station while being included in the ARQ-ACK message.

The method further comprises: a-1) determining whether a piggyback identifier for transmitting the CQI is transmitted from the base station; b-1) measuring the CQI and updating the same into the latest values when the piggyback identifier is transmitted; c-1) acknowledging a radio resource allocated for the CQI among the radio resources piggybacked on the uplink data; and d-1) transmitting the CQI piggybacked on the uplink data to the base station.

The method further comprises: a-2) determining whether the REP_REQ MAC message is transmitted from the base station; b-2) measuring the CQI and updating the same into the latest value when the REP_REQ MAC message is transmitted; c-2) acknowledging a radio resource of a dedicated channel allocated for the CQI report; and d-2) transmitting the CQI through the dedicated channel to the base station.

[ADVANTAGEOUS EFFECTS]

CQI information is quickly received without an additional bandwidth request from a subscriber station to determine an AMC level and efficiently transmit downlink data by allocating a CQI channel to the subscriber station by a base station.

In addition, CQI period and frequency are determined based on CQI of the REP-RSP.

[DESCRIPTION OF DRAWINGS]

FIGs. 1 to 3 show general flowcharts for requesting and reporting channel quality information;

FIG. 4 shows a flowchart for requesting and reporting channel quality information according to one exemplary embodiment of the present invention;

FIG. 5 shows a flowchart for requesting and reporting channel quality information according to another exemplary embodiment of the present invention;

FIG. 6 shows a flowchart for requesting and reporting channel quality information according to another exemplary embodiment of the present invention;

FIG. 7 shows a schematic diagram for a wireless portable Internet system;

FIG. 8 shows a hierarchical diagram of a wireless portable Internet system;

FIG. 9 shows a schematic diagram of a connection structure between a base station and a subscriber station in a wireless portable Internet system;

FIG. 10 shows a flowchart for requesting and reporting channel quality information according to an exemplary embodiment of the present invention;

FIG. 11 shows a flowchart for requesting and reporting channel quality information according to an exemplary embodiment of the present invention when the subscriber station has uplink data to be transmitted;

FIG. 12 shows a flowchart for requesting and reporting channel quality information according to an exemplary embodiment of the present invention when the subscriber station has no uplink data to be transmitted; and

FIG. 13 shows uplink and downlink resource allocation structures shown in FIG. 5.

[BEST MODE]

In the following detailed description, only the preferred embodiment of the invention has been shown and described, simply by way of illustration of the best mode contemplated by the inventor(s) of carrying out the invention. As will be known, the invention is capable of modification in various obvious respects, all without departing from the invention. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not restrictive. To clarify the present invention, parts which are not described in the specification are omitted, and parts for which same descriptions are provided have the same reference numerals.

A subsequent method will now be described in order to resolve the above-described problems generated while requesting and reporting the channel quality information in the mobile communication system.

FIG. 4 shows a flowchart for requesting and reporting channel quality information according to an exemplary embodiment of the present invention.

As shown in FIG. 4, the base station (BS) allocates a dedicated channel (a CQI channel) for reporting channel quality information (S101). The CQI channel allocation information is included in uplink radio resource allocation information (referred to as a UL-MAP hereinafter), and is transmitted to the subscriber station (SS).

The base station transmits the REP_REQ message through a basic connection identifier to the subscriber station (S102). The subscriber station measures mean value and standard deviation of the downlink carrier to interference noise ratio (CINR), and updates the given mean value and standard deviation (S103).

The updated CINR mean value and standard deviation is compressed and encoded as a REP_RSP message or a CQI codeword to be transmitted to the base station (S104).

Then, the subscriber station (SS) transmits the REP-RSP through the allocated CQI channel (S105). As noted above, the REP-RSP message includes the latest mean value and standard deviation of the downlink CINR.

The base station (BS) receives the REP-RSP messages, performs scheduling based on the CQI, and applies the scheduling to the downlink MAP information (DL-MAP) (S106).

That is, when the channel quality is degraded in the adaptive modulation and channel coding (AMC), the stronger AMC is used so that the DL-MAP is transmitted to the corresponding subscriber station (S107).

Accordingly, the base station allocates the additional CQI channel to the subscriber station so that the AMC level is determined based on the received CQI before the subscriber station requests the additional bandwidth, thereby quickly and efficiently transmitting the DL-MAP.

Also, the period and frequency can be determined based on the CQI included in the REP-RSP.

FIG. 5 shows a flowchart for requesting and reporting channel quality information according to another exemplary embodiment of the present invention.

In this embodiment, when the downlink data to be transmitted to the subscriber station exists, the base station requests the CQI report. Also, when the downlink data is transmitted to the subscriber station, the base station acknowledges whether the subscriber station successfully receives the CQI, and applies an automatic repeat request (ARQ) when a repetition is needed.

The base station acknowledges the success of the subscriber station receipt thereof and applies an automatic repeat request (ARQ) algorithm as necessary for retransmitting. According to the ARQ algorithm, the subscriber station transmits the ARQ_ACK message of transmitted downlink data so that the base station is provided with acknowledgement of receiving and retransmitting.

The base station transmits the downlink data to the subscriber station, and simultaneously transmits the ARQ_ACK message and subheader for requesting the CQI report (S110).

The subscriber station receives the subheader, measures the mean value and standard deviation, and updates the existing values (S111).

Meanwhile, the base station allocates the uplink resource for transmitting the ARQ-ACK message and CQI message through the UL-MAP (S112). In order to report the channel quality more exactly, the base station can update the CINR mean value and the standard deviation and generates information for reporting the ARQ_ACK message and channel quality information (S113, S114) when allocating the uplink resource.

The subscriber station transmits the ARQ_ACK message and the channel quality information report message through the allocated uplink resource to the base station (S115).

The base station performs scheduling based on the received channel quality information and applies it to the downlink MAP information (DL-MAP) (S116).

When the channel quality is degraded, the downlink data is transmitted to the corresponding subscriber station by a stronger channel modulating and coding method (S117).

According to this embodiment of the invention, when the base station transmits the downlink data and receives the ARQ_ACK message, the base station simultaneously requests the ARQ_ACK message and channel quality information and receives the channel quality information through the radio resource for the ARQ_ACK message, thereby efficiently reporting the CQI.

FIG. 6 shows a flowchart for requesting and reporting channel quality information according to another exemplary embodiment of the present invention;

In this embodiment, when the subscriber station has uplink data to be transmitted to the base station, the subscriber station transmits the uplink data while adding the channel quality report information to the protocol data unit (PDU) of the available uplink data. Such a transmission method is referred to as piggybacking.

The subscriber station transmits a piggyback identifier for reporting the channel quality information using the UL-MAP (S120).

The subscriber station receives the piggyback identifier, measures the CINR mean values and standard deviation, and updates the same as the latest values (S121). The updated mean value and standard deviation are piggybacked on the uplink data PDU to report the CQI (S122).

The CQI is transmitted when the uplink data is transmitted, and off-set information of the CQI is marked in the UL-MAP (S123).

The base station receives the channel quality information, performs scheduling based on the CQI, and applies the scheduling to the downlink link MAP information (DL-MAP) (S124).

When the channel quality is degraded, the downlink data is transmitted to the corresponding subscriber station by using a stronger channel modulating and coding method (S125).

Accordingly, the subscriber station can report the CQI efficiently using the uplink data PDU without additional channel allocation.

A wireless portable Internet system according to the exemplary embodiment of the present invention will be described in more detail.

FIG. 7 shows a schematic diagram for a wireless portable Internet system according to an exemplary embodiment of the present invention.

The wireless portable Internet system includes a subscriber station 100, base stations 200 and 210 for performing radio communication with the subscriber stations routers 300 and 310 connected to the base station through a gateway, and the Internet.

The wireless portable Internet system guarantees mobility and provides seamless data communication services when the subscriber station 100 shown in FIG. 5 moves from a cell covered by a first base station 200 to another cell covered by a second base station 210, supports a handover function, and allocates dynamic IP addresses as the subscriber station moves.

The wireless portable Internet subscriber station 100 and each of the base stations 200 and 210 communicate with each other through the orthogonal frequency division multiple access (OFDMA) method which is resistant against fading generated by multi-paths and has high data rates, and the exemplary embodiment is not restricted to the OFDMA method.

The IEEE 802.16e standard applies the AMC scheme to select an adaptive modulation and coding scheme by means of request/acceptance between the subscriber station 100 and the base stations 200 and 210.

FIG. 8 shows a hierarchical diagram of a wireless portable Internet system.

The IEEE 820.16e wireless portable Internet system is classified into a physical layer L10, and media access control (MAC) layers L21, L22, and L23. The physical layer L10 performs radio communication functions such as modulation/demodulation, coding/decoding, etc. as performed by a normal physical layer.

Meanwhile, the wireless portable Internet system does not have function-specific MAC layers as a wired Internet system, but rather has a single MAC layer in charge of different functions. The MAC layer includes a privacy sublayer L21, a MAC common part sublayer L22, and a service specific convergence sublayer L23.

The service specific convergence sublayer L23 performs payload header suppression and QoS mapping functions in consecutive data communication.

The MAC common part sublayer L22 is the core of the MAC layer which is in charge of system access, bandwidth allocation, connection establishment and maintenance, and QoS control.

The privacy sublayer L21 performs functions of equipment authentication, security key exchange, and encryption. The device authentication is carried on by the privacy sublayer L21, and the user authentication by an upper layer of the MAC (not illustrated).

FIG. 9 shows a schematic diagram of a connection structure between a base station and a subscriber station in the wireless portable Internet system.

A connection is provided between the MAC layers of the subscriber station and the base station. The term "connection C1" as used herein does not refer to a physical connection, but to a logical connection that is defined as a mapping relationship between the MAC peers of the subscriber station and the base station for traffic transmission of one service flow.

Hence, the parameter/message defined on the connection C1 refers to a function executed between the MAC peers. Actually, the parameter/message is processed into a frame, which is transferred through the physical layer and analyzed so as to control the MAC layer to execute the function corresponding to the parameter/message. The MAC message includes various messages for performing request (REQ), response (RSP), and acknowledgment (ACK) for various operations.

FIG. 10 shows a flowchart for requesting and reporting channel quality information according to an exemplary embodiment of the present invention;

The methods for requesting/reporting the channel quality information as shown in FIGs. 4 through 6 will be selectively determined according to the various conditions between the base station and the subscriber station. For example, when there are no uplink/downlink transmission data and available resources, the CQI may be reported using the REP-REQ and REP-RSP as shown in FIG. 4. Also, when there are uplink transmission data and uplink resource allocation, the CQI may be reported by piggybacking the message on the uplink data PDU. Also, when the subscriber station has no uplink transmission data and has the ACK message including retransmission information of the transmitted downlink data without the uplink transmission data, the channel quality information may be transmitted using the corresponding ARQ_ACK message as shown in FIG. 5.

The base station determines timing to request the channel quality report from the predetermined subscriber station (S200), which is controlled according the mean value and standard deviation of the transmitted CINR.

The base station determines the existence of uplink data to be transmitted from a predetermined subscriber station upon necessity of the channel quality report (S210). When there is no uplink data to be transmitted during the predetermined period, the step 220 (S220) is progressed. Alternatively, when there is uplink data, the step 300 (S300) is progressed.

The method for reporting/requesting the channel quality of the (S300) will be described later in detail.

The base station determines the ARQ_ACK message reception for the transmitted downlink data (S220). When the ARQ_ACK message must be received, the step 230 (S230) is progressed, and when there is no ARQ_ACK message to be transmitted during the predetermined period, the step S400 is progressed.

The method for reporting/requesting the channel quality of the step S400 will be described later in detail.

The base station transmits the channel allocation information for reporting the channel quality information for the ARQ_ACK message to the subscriber station. The base station can include sub headers of the ARQ_ACK and CQI request messages in the downlink data, and the resource allocation information for ARQ_ACK and CQI request messages in the UL-MAP, and transmit the same.

The subscriber station provided with the channel quality information report request measures the channel quality information, updates the same, and prepares the CQI report (S240). The CQI may be the mean values and standard deviation of the CINR of the measured downlink channel.

The subscriber station acknowledges the radio resource of the ARQ_ACK message used to the CQI report (S250). The radio resource for reporting the CQI are arranged at the predetermined part of the uplink sub-frame according to the UL-MAP information transmitted from the base station.

The subscriber station includes the CQI in the ARQ_ACK message and transmits the same to the base station (S260). The base station extracts the CQI from the transmitted ARQ_ACK message to thus receive the CQI (S270).

The base station receives the CQI including the mean values or standard deviation of the CINR, determines the AMC level, and performs scheduling based on the received CQI (S280). For example, when the channel quality is degraded, the stronger channel modulating and coding may be applied. Also, when the subscriber station is determined for the radio channel environment to be too variable by a large standard deviation of the CINR, the subscriber station may have resources for the CQI report allocated at the front time slot of the uplink resource.

Also, the channel quality report period and frequency of the step 200 may be controlled according to the CQI. For example, when the radio channel environment is determined to have a small variance by a small standard deviation of the CINR, the base station determines the channel environment to be relatively stable so that the base station may control the channel quality report period and frequency to be low. The base station transmits the modulated and coding downlink burst according to the modulating and coding level determined in step 280 to the subscriber station (S290).

Accordingly, when the base station receives the ARQ-ACK message from the subscriber station, the base station may have the CQI report efficiently without allocation of the additional channel or bandwidth.

FIG. 11 shows a flowchart for requesting and reporting channel quality information according to an exemplary embodiment of the present invention when the subscriber station has uplink data to be transmitted.

When the subscriber station has uplink data to be transmitted at the step S210 of FIG. 10, the step S300 is progressed.

The following method for reporting/requesting the channel quality of the step S300 will be described in detail.

As above-noted, when the subscriber station has uplink data to be transmitted, the base station allocates the piggyback message identifier for the CQI report to the subscriber station (S310). The piggyback message identifier requests the channel quality report and supplies the PDU identifier piggybacked through the UL_MAP to the subscriber station.

When the subscriber station receives the piggyback message identifier, the subscriber station measures the channel quality and updates the same into the latest values (S320). The CQI may be the mean values and/or standard deviation of the CINR of the downlink channel.

When the CQI is updated, the subscriber station uses the piggyback message identifier to acknowledge the piggyback message for the channel quality report and insert the CQI into the uplink data PDU to perform the piggybacking (S330).

The subscriber station includes the CQI in the PDU of the uplink data, and transmits the same to the base station (S340). The base station extracts the CQI from the PDU of the transmitted uplink data to thus receive the CQI (S350).

The base station determines the AMC level and performs scheduling based on the received CQI including the mean values or standard deviation of the CINR (S360). For example, when the channel quality is degraded, the stronger AMC may be applied. Also, when the radio channel environment is determined to be too variable by the large standard deviation of the CINR, the subscriber station may have resources for the CQI report allocated at the front time slot of the uplink resource.

Also, the channel quality report period and frequency of the step 200 may be controlled according to the CQI (S370). For example, when the standard deviation of the CINR of the downlink reported from the subscriber station is less, the base station determines the channel environment to be relative stable because of less variation of the radio condition so that the base station may control the channel quality report period and frequency to be low. The base station transmits bursts generated by modulating and encoding the downlink data according to the modulating and coding level determined in step S360 to the subscriber station (S380).

Accordingly, according to the exemplary embodiment shown in FIG.11, when the subscriber station has the uplink data to be transmitted to the base station, the base station requests CQI through a piggyback identifier, and the subscriber station transmits the CQI along with the PDU of the uplink data corresponding to the piggyback identifier, thereby reporting the CQI efficiently.

FIG. 12 shows a flowchart for requesting and reporting channel quality information according to an exemplary embodiment of the present invention when the subscriber station has no uplink data to be transmitted or need not transmit an ARQ_ACK message.

At the step S220, when the subscriber station has no data to transmit to the base station and it is not necessity to have an ARQ_ACK message for the received data, the step S400 is progressed.

The next method for reporting/requesting the channel quality of the step S400 will be described in detail.

Since the base station and the subscriber station has no data or message to transmit/receive therebetween, the base station allocates the channel and requests the CQI report (S410). The CQI request uses the REP-REQ message, which is the MAC managing message, marks the dedicated channel for CQI (a CQI channel), and transmits the same to the UL-MAP. When the subscriber station receives the REP-REQ, the subscriber station measures the CQI and updates the CQI into the latest values (S420). The CQI includes CINR means values or CINR standard deviation of the downlink channel.

When the CQI is prepared to transmit by updating, the subscriber station conforms the CQI channel for reporting the channel quality (S430), and transmits the CQI through the CQI channel to the base station (S440). The subscriber station, of which the basic CID of the REP-REQ message is known, recognizes the detail resource location to use at the CQI channel designated in the UL-MAP according to the sequence of the identifier.

The base station receives the CQI transmitted through the dedicated CQI channel (S450).

The base station receives such CQI as mean values or standard deviation of the CINR, determines AMC level based on the CQI, and performs scheduling (S460). For example, when the channel quality is degraded, the stronger channel modulating level or coding level may be applied. Also, when the subscriber station is determined for the radio channel environment to be too variable by the large standard deviation of the CINR, the subscriber station may have resources for the CQI report allocated at the front time slot of the uplink resource.

Also, the channel quality report period and frequency of the step (S200) can be controlled based on the CQI (S470). In more detail, when the radio channel environment is determined to have a small variance by the small standard deviation of the CINR, the base station determines the channel environment to be relative stable so that the base station may control the channel quality report period and frequency to be low.

The base station transmits the bursts generated by modulating and coding the downlink data according to the modulating and coding level determined in step (S460) to the corresponding subscriber station (S480).

With the embodiment as shown in FIG.12, reliable channel quality information can be quickly and efficiently reported without delay and the overheads of message transmission can be reduced by the dedicated channel, when the subscriber stations transmit a CQI request message to the base station.

The methods for requesting and reporting the channel quality can be selectively applied according to transmitting/receiving the uplink/downlink data shown in FIGs. 10 to 12. Therefore, the reliable channel quality information can be quickly and efficiently reported by appropriately selecting the one from the above-described three embodiments.

FIG. 13 shows uplink and down link resource allocation structures shown in FIG.5.

In the OFDMA system, a radio resource frame can be realized as a two-dimensional structure including the sub channel in the frequency domain and the symbol in the time domain.

The downlink frame includes UL-MAP information. The UL-MAP includes the channel allocation information for the CQI and the ARQ_ACK message. The burst of the downlink frame may include a REP-REQ.

A REP-RSP is transmitted in response to the REP-REQ message by using the burst of the uplink frame corresponding to the channel allocation information.

The measured channel quality information may be reported to the CQI dedicated channel in a Compressed-REP-RSP message or a CQI Codeword format.

As stated, when the corresponding subscriber station quickly receives and transmits the data corresponding to the variance of the channel environment in a mobile communication system, the most adaptive modulation and channel coding level is applied to increase the transmission amount of the downlink, thereby enhancing the performance.

Although embodiments of the present invention have been described in detail hereinabove in connection with certain exemplary embodiments, it should be understood that the invention is not limited to the disclosed exemplary embodiment, but, on the contrary is intended to cover various modifications and/or equivalent arrangements included within the spirit and scope of the present invention, as defined in the appended claims.

With the structure of the present invention, the subscriber station allocates the resources in advance, which can transmit the channel quality information result upon transmitting the CQI request message so that the delay time (that it takes for the subscriber station to report the channel measurement result) is reduced as much as possible thereby quickly processing the fast changes of the channel environment.

Also, with the structure of the present invention, when the uplink data or the downlink data is provided, the channel quality information can be reported efficiently by using an ARQ_ACK message or uplink data PDU, and the overhead of the uplink resource is minimized.

Also, the frequency and period of the channel quality report may be determined by using the channel quality information values so that the downlink adaptive modulation, coding level, and radio resource allocation may be performed efficiently.

[CLAIMS]

1. A method for requesting channel quality information (CQI) in a wireless portable Internet system, comprising:

a) a base station determining timing of a channel quality information request;

b) requesting an automatic repeat request acknowledgement (ARQ-ACK) message of downlink data upon requesting the CQI from a subscriber station;

c) allocating a radio resource for the ARQ-ACK message and the channel quality report to the subscriber station;

d) receiving information on the ARQ-ACK message and the channel quality report; and

e) determining a modulation and coding level of downlink data by extracting the channel quality report information from the ARQ-ACK .

2. The method for reporting the channel quality information of claim 1, further comprising:

a-1) determining whether uplink data to be received by the base station exists, after a);

b-1) transmitting a piggyback identifier of uplink data to be used to request the CQI to the subscriber station when the uplink data exists;

c-1) allocating a radio resource for reporting the CQI to the subscriber station;

d-1) receiving the channel quality report information piggybacked on the uplink data; and

e-1) extracting the CQI from the uplink data, and determining a modulation and coding level of downlink data based on the reported CQI.

3. The method for reporting the channel quality information of claim 2, further comprising:

a-2) determining whether the ARQ-ACK message exists in a-1), when no uplink data to be received by the base station exists;

b-2) transmitting an REP_REQ medium access control (MAC) message to the subscriber station when no ARQ-ACK message exists;

c-2) allocating the radio resource for reporting the CQI to a dedicated channel;

d-2) receiving the REP_REQ MAC message through the dedicated channel; and

e-2) determining a modulation and coding level of downlink data based on the reported CQI.

4. The method for reporting the channel quality information of one of claims 1 to 3, wherein the CQI is a mean value or standard deviation of a carrier to interference noise ratio (CINR) of the downlink.

5. The method for reporting the channel quality information of one of claims 1 to 3, wherein information on the radio resource allocated for reporting the CQI is transmitted while being included in the UL-MAP of a downlink frame.

6. The method for reporting the channel quality information of one of claims 1 to 3, further comprising:

controlling the period and frequency of the CQI based on the received CQI.

7. The method for reporting the channel quality information of claim 4, further comprising:

allocating a radio resource for reporting the CQI at the front time slot of the uplink resource for the subscriber station having the larger standard deviation of the CINR.

8. A method for reporting channel quality information in a wireless portable Internet system, comprising:

a) determining whether transmission of an ARQ-ACK message and a REP-REQ is provided from a base station;

b) updating the two values into latest values by measuring the CQI when the transmission is provided;

c) acknowledging a radio resource allocated for the ARQ-ACK message and the CQI; and

d) transmitting the CQI to a base station while being included in the ARQ-ACK message.

9. The method for reporting the channel quality information of claim 8, further comprising:

a-1) determining whether a piggyback identifier for transmitting the CQI is transmitted from the base station;

b-1) measuring the CQI and updating the same into the latest values when the piggyback identifier is transmitted;

c-1) acknowledging a radio resource allocated for the CQI among the radio resources piggybacked on the uplink data; and

d-1) transmitting the CQI piggybacked on the uplink data to the base station.

10. The method for reporting the channel quality information of claim 8, further comprising:

a-2) determining whether the REP_REQ MAC message is transmitted from the base station;

b-2) measuring the CQI and updating the same into the latest value when the REP_REQ MAC message is transmitted;

c-2) acknowledging a radio resource of a dedicated channel allocated for the CQI report; and

d-2) transmitting the CQI through the dedicated channel to the base station.

11. The method for reporting the channel quality information of one of claims 8 to 10, wherein the CQI is a mean value or standard deviation of a carrier to interference noise ratio (CINR) of the downlink.

12. The method for reporting the channel quality information of one of claims 8 to 10, wherein the radio resource allocation information for reporting the

CQI transmitted to the base station is included in the UP-MAP of an uplink frame.

13. A method for requesting and reporting channel quality information in a wireless portable Internet system, comprising:

a) a base station determining whether uplink data to be received exists within a predetermined period, and whether an ARQ-ACK message for a transmitted downlink exists;

b) requesting to piggyback the CQI on the uplink data and to transmit the CQI therewith when the uplink data exists;

c) requesting to include the CQI in the ARQ-ACK message and to transmit the CQI therewith when the ARQ_ACK message exists;

d) transmitting the REP-REQ through a channel allocated for CQI when neither the uplink data nor the ARQ-ACK message exists; and

e) reporting the CQI to the base station according to the request of b) to d).

FIG. 1

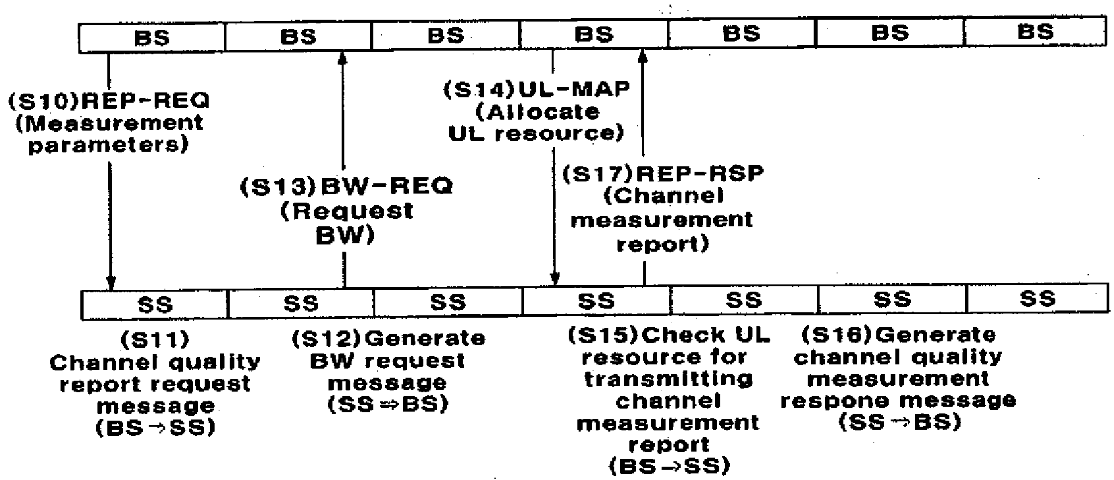

BS
BS
BS
BS
BS
BS
BS
(S10)REP-REQ (Measurement parameters)
(S13)BW-REQ (Request BW)
(S14)UL-MAP (Allocate UL resource)
(S17)REP-RSP (Channel measurement report)
SS
SS
SS
SS
SS
SS
SS
(S11) Channel quality report request message (BS→SS)
(S12)Generate BW request message (SS⇒BS)
(S15)Check UL resource for transmitting channel measurement report (BS→SS)
(S16)Generate channel quality measurement respone message (SS→BS)

FIG. 2

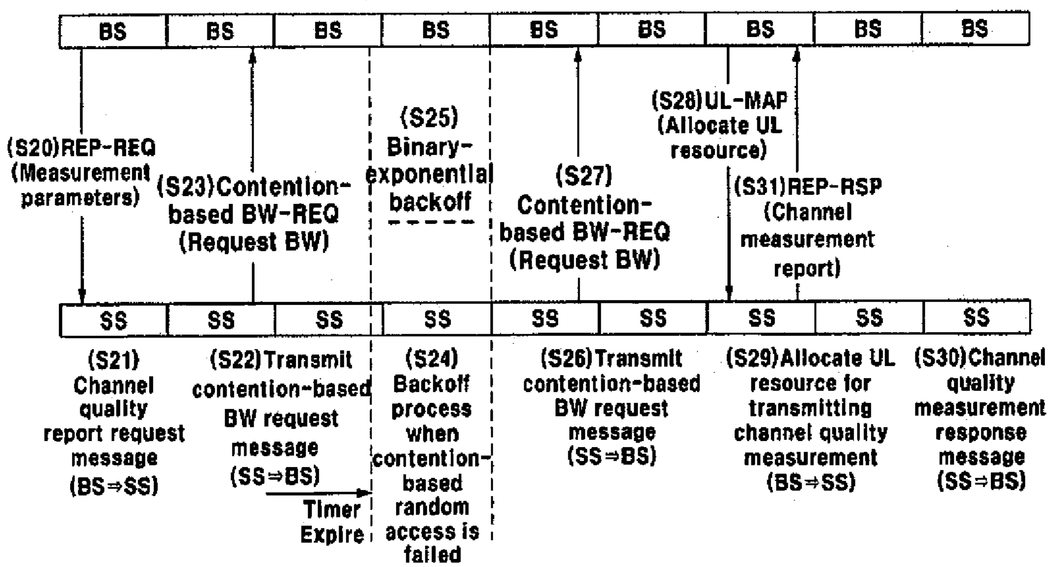

BS
BS
BS
BS
BS
BS
BS
BS
BS
(S20)REP-REQ (Measurement parameters)
(S23)Contention-based BW-REQ (Request BW)
(S25) Binary-exponential backoff
(S27) Contention-based BW-REQ (Request BW)
(S28)UL-MAP (Allocate UL resource)
(S31)REP-RSP (Channel measurement report)
SS
SS
SS
SS
SS
SS
SS
SS
SS
(S21) Channel quality report request message (BS⇒SS)
(S22)Transmit contention-based BW request message (SS⇒BS)
Timer Expire
(S24) Backoff process when contention-based random access is failed
(S26)Transmit contention-based BW request message (SS⇒BS)
(S29)Allocate UL resource for transmitting channel quality measurement (BS⇒SS)
(S30)Channel quality measurement response message (SS⇒BS)

FIG. 3

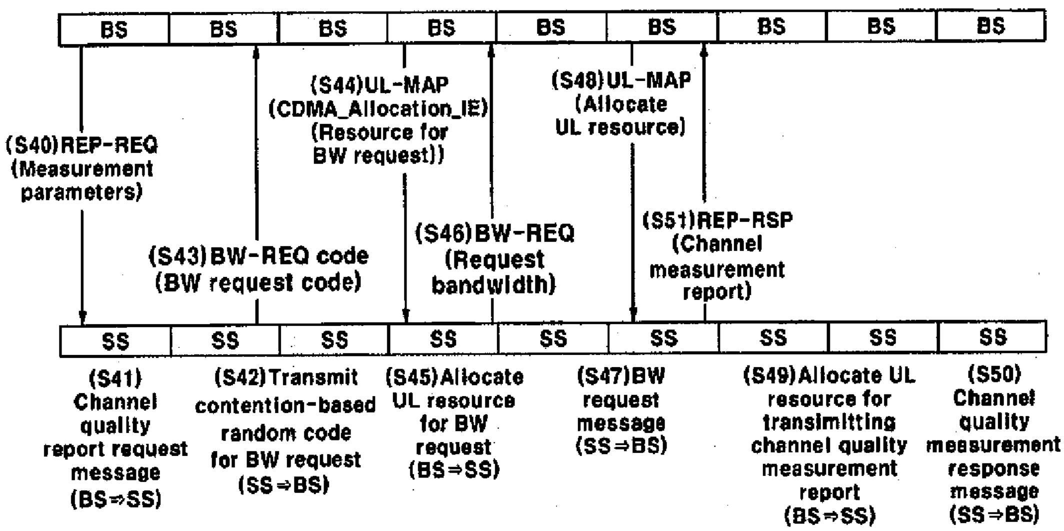

BS
SS
(S40)REP-REQ (Measurement parameters)
(S43)BW-REQ code (BW request code)
(S44)UL-MAP (CDMA_Allocation_IE) (Resource for BW request))
(S46)BW-REQ (Request bandwidth)
(S48)UL-MAP (Allocate UL resource)
(S51)REP-RSP (Channel measurement report)
(S41) Channel quality report request message (BS⇒SS)
(S42)Transmit contention-based random code for BW request (SS⇒BS)
(S45)Allocate UL resource for BW request (BS⇒SS)
(S47)BW request message (SS⇒BS)
(S49)Allocate UL resource for transimitting channel quality measurement report (BS⇒SS)
(S50) Channel quality measurement response message (SS⇒BS)

FIG. 4

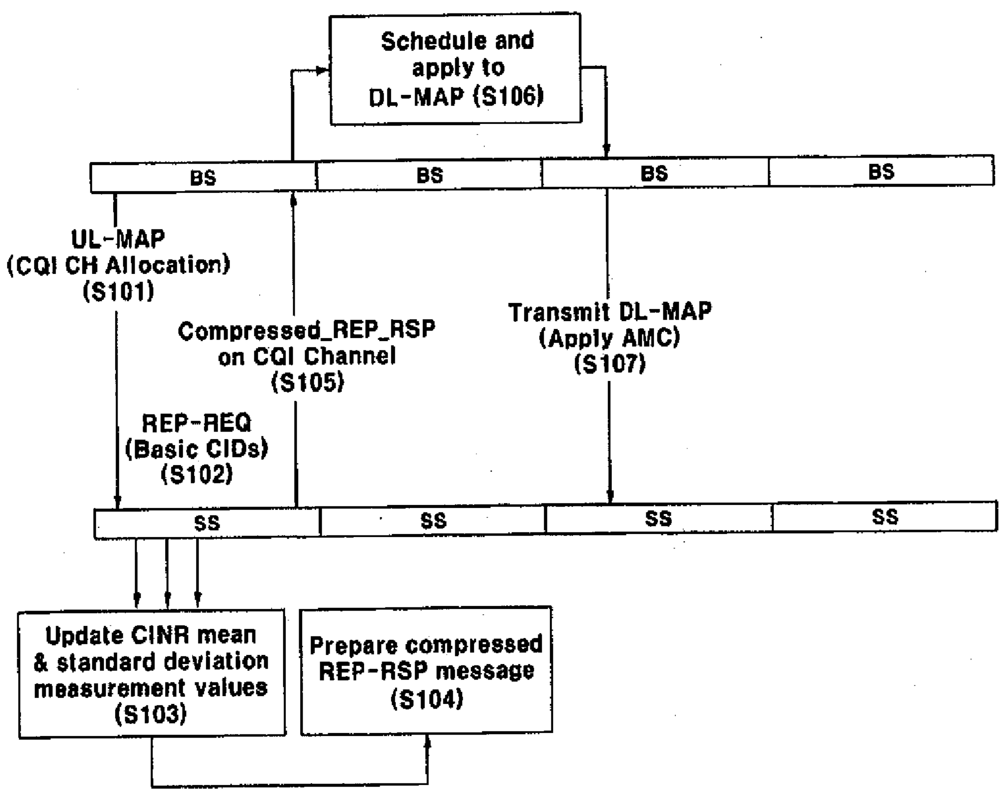

Schedule and apply to DL-MAP (S106)
BS
BS
BS
BS
UL-MAP (CQI CH Allocation) (S101)
Compressed_REP_RSP on CQI Channel (S105)
Transmit DL-MAP (Apply AMC) (S107)
REP-REQ (Basic CIDs) (S102)
SS
SS
SS
SS
Update CINR mean & standard deviation measurement values (S103)
Prepare compressed REP-RSP message (S104)

FIG. 5

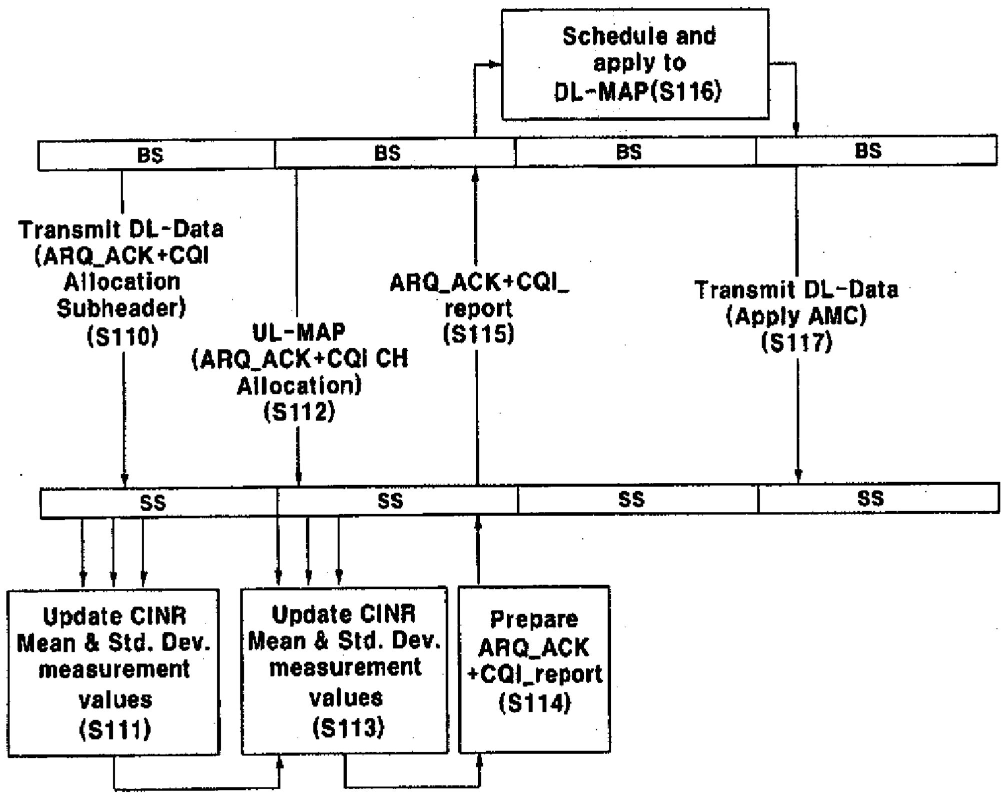

Schedule and apply to DL-MAP(S116)
BS
BS
BS
BS
Transmit DL-Data (ARQ_ACK+CQI Allocation Subheader) (S110)
UL-MAP (ARQ_ACK+CQI CH Allocation) (S112)
ARQ_ACK+CQI_ report (S115)
Transmit DL-Data (Apply AMC) (S117)
SS
SS
SS
SS
Update CINR Mean & Std. Dev. measurement values (S111)
Update CINR Mean & Std. Dev. measurement values (S113)
Prepare ARQ_ACK +CQI_report (S114)

FIG. 6

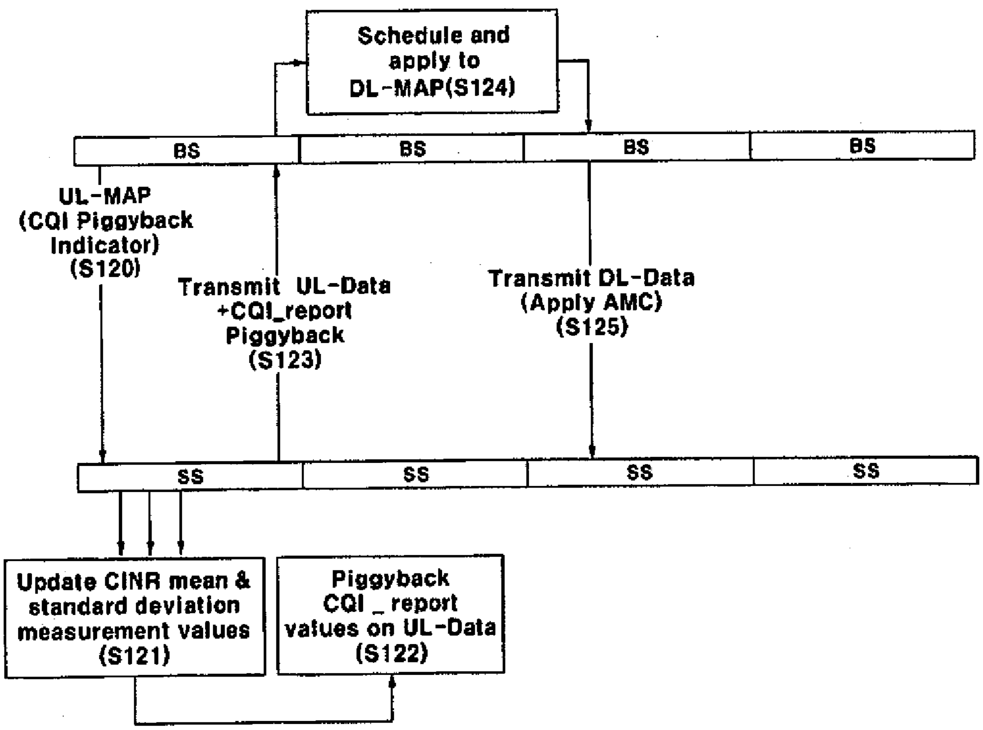

Schedule and
apply to
DL-MAP(S124)
BS
BS
BS
BS
UL-MAP
(CQI Piggyback
Indicator)
(S120)
Transmit UL-Data
+CQI_report
Piggyback
(S123)
Transmit DL-Data
(Apply AMC)
(S125)
SS
SS
SS
SS
Update CINR mean &
standard deviation
measurement values
(S121)
Piggyback
CQI _ report
values on UL-Data
(S122)

FIG. 7

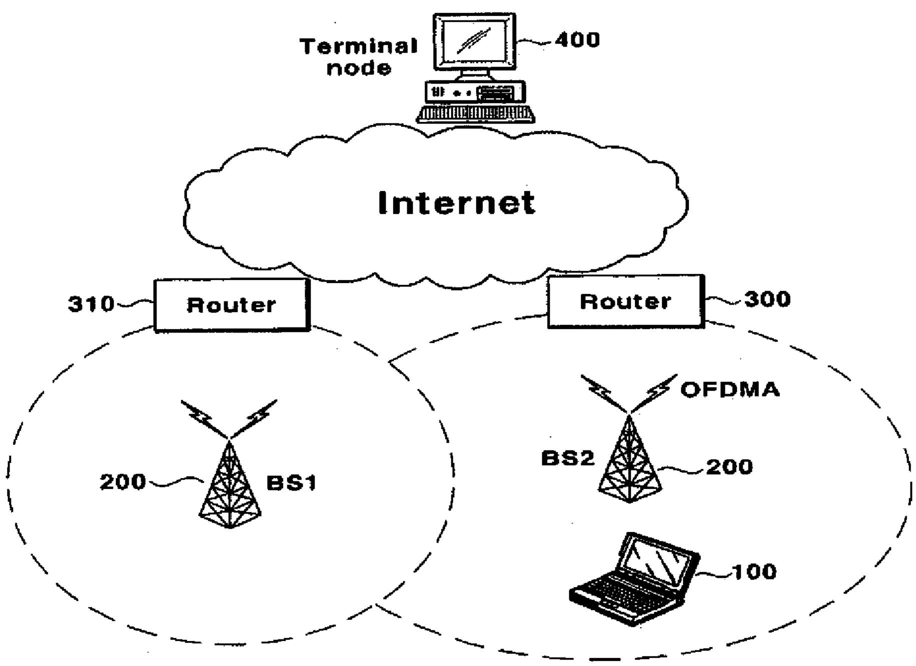

Terminal node
400
Internet
310
Router
Router
300
OFDMA
200
BS1
BS2
200
100

FIG. 8

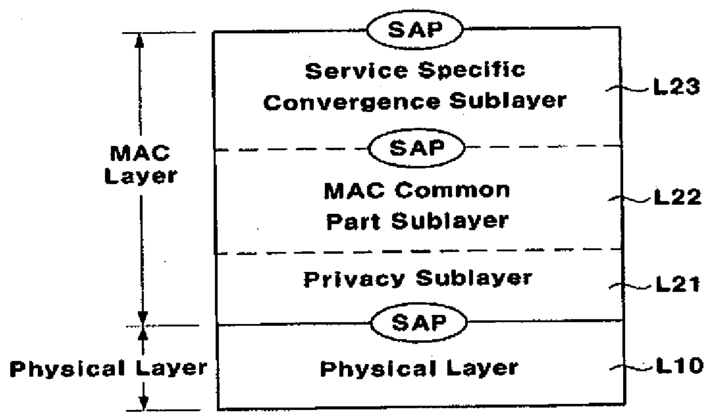

SAP
Service Specific Convergence Sublayer
L23
MAC Layer
SAP
MAC Common Part Sublayer
L22
Privacy Sublayer
L21
SAP
Physical Layer
Physical Layer
L10

FIG. 9

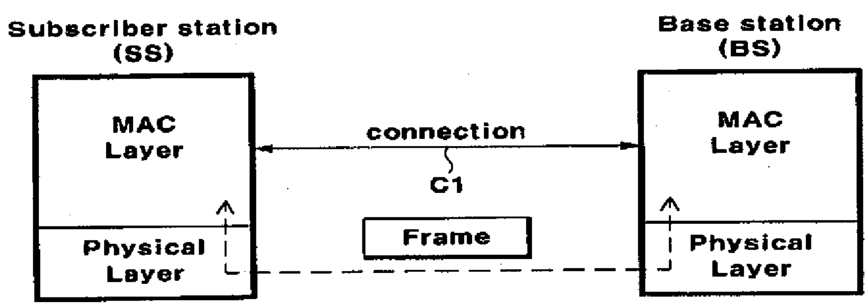

Subscriber station
(SS)
MAC
Layer
Physical
Layer
connection
C1
Frame
Base station
(BS)
MAC
Layer
Physical
Layer

FIG. 10

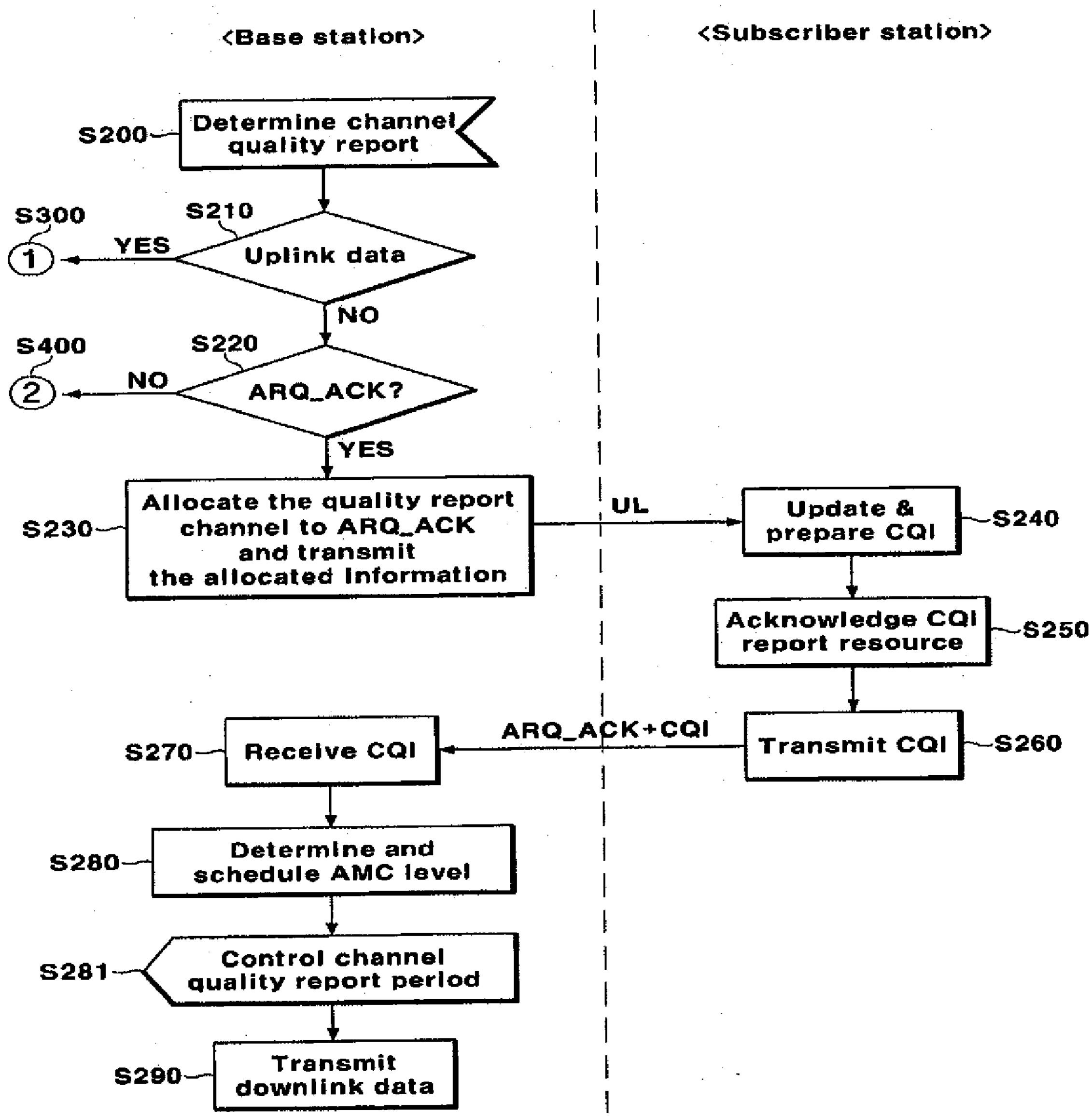

<Base station>
<Subscriber station>
S200
Determine channel quality report
S300
S210
YES
Uplink data
1
NO
S400
S220
NO
ARQ_ACK?
2
YES
S230
Allocate the quality report channel to ARQ_ACK and transmit the allocated information
UL
Update & prepare CQI
S240
Acknowledge CQI report resource
S250
S270
Receive CQI
ARQ_ACK+CQI
Transmit CQI
S260
S280
Determine and schedule AMC level
S281
Control channel quality report period
S290
Transmit downlink data

FIG. 11

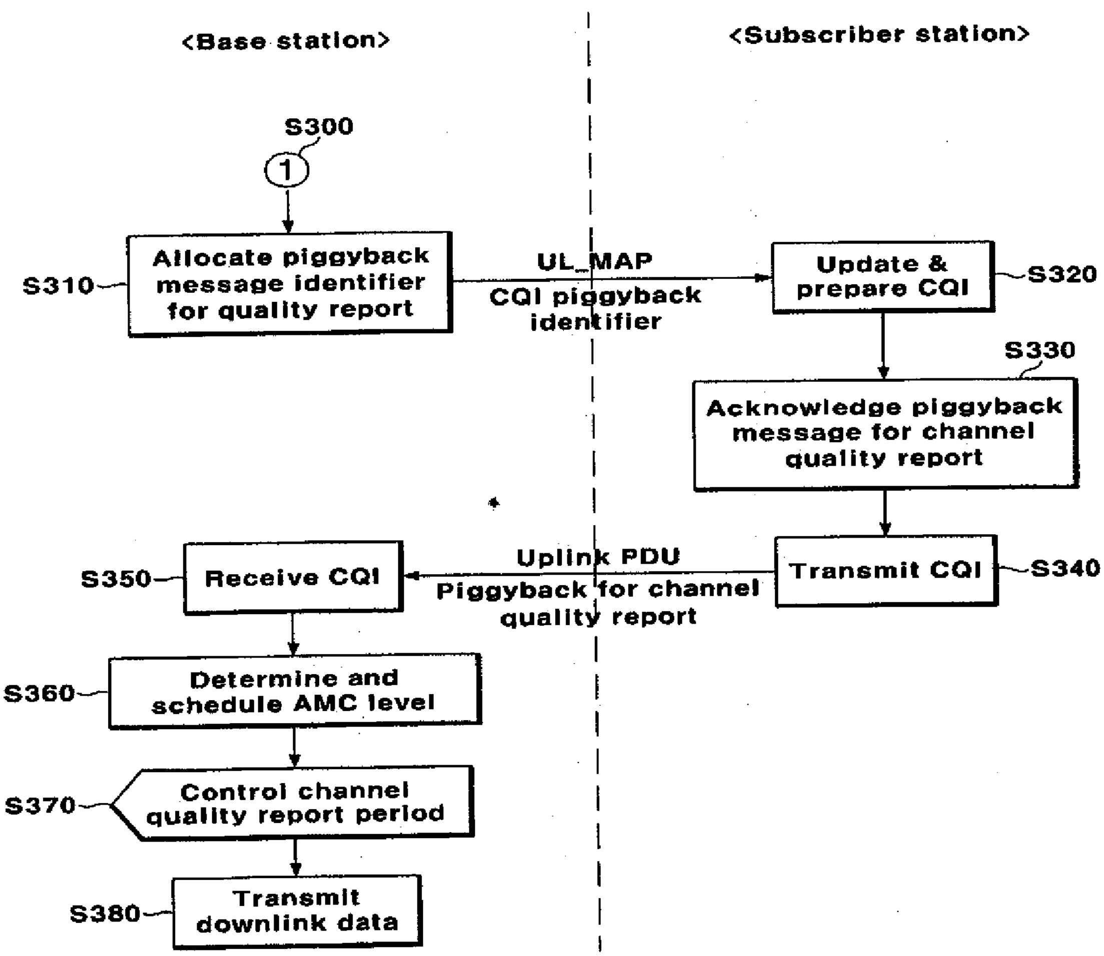
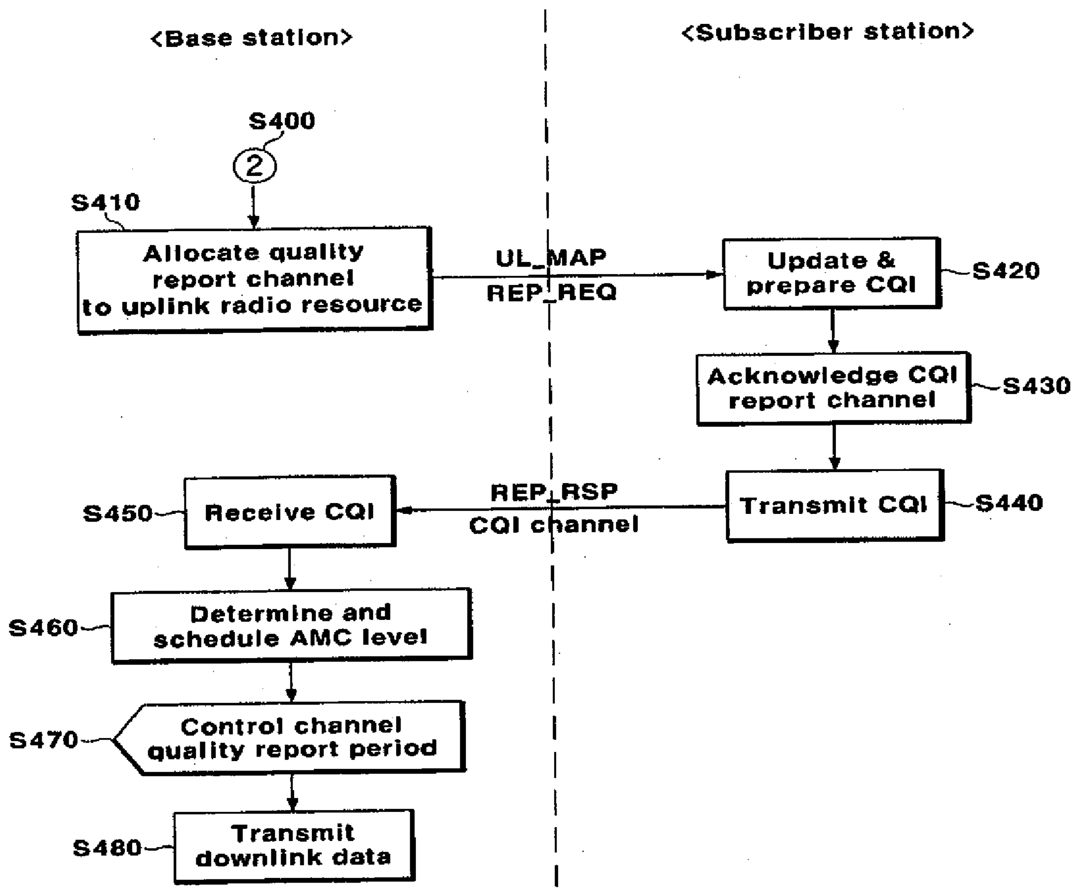
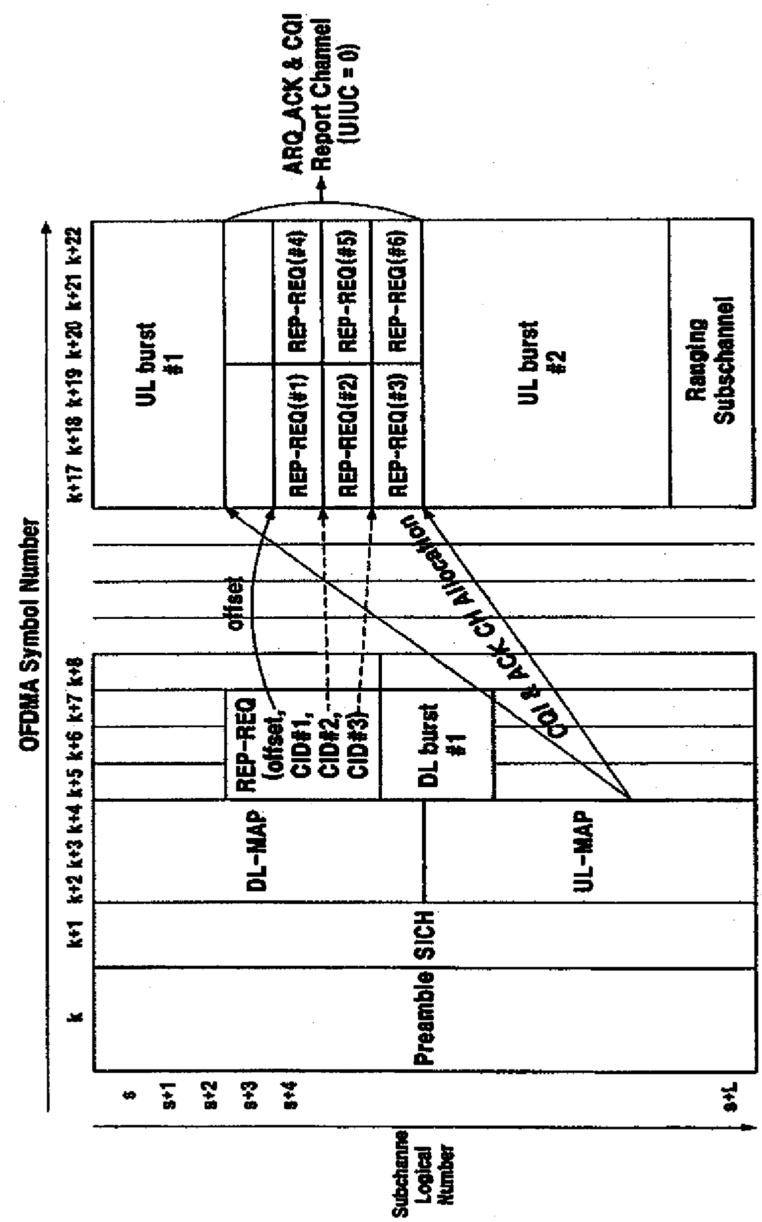

<Base station>
<Subscriber station>
S300
1
S310
Allocate piggyback message identifier for quality report
UL_MAP
CQI piggyback identifier
Update & prepare CQI
S320
S330
Acknowledge piggyback message for channel quality report
Transmit CQI
S340
Uplink PDU
Piggyback for channel quality report
S350
Receive CQI
S360
Determine and schedule AMC level
S370
Control channel quality report period
S380
Transmit downlink data

FIG. 12



<Base station>
<Subscriber station>
S400
2
S410
Allocate quality report channel to uplink radio resource
UL_MAP
REP_REQ
Update & prepare CQI
S420
Acknowledge CQI report channel
S430
Transmit CQI
S440
REP_RSP
CQI channel
S450
Receive CQI
S460
Determine and schedule AMC level
S470
Control channel quality report period
S480
Transmit downlink data

FIG. 13


OFDMA Symbol Number
k
k+1
k+2 k+3 k+4 k+5 k+6 k+7 k+8
k+17 k+18 k+19 k+20 k+21 k+22
Subchannel Logical Number
s
s+1
s+2
s+3
s+4
s+L
Preamble
SICH
DL-MAP
UL-MAP
REP-REQ (offset, CID#1, CID#2, CID#3)
DL burst #1
offset
CQI & ACK CH Allocation
UL burst #1
REP-REQ(#1)
REP-REQ(#2)
REP-REQ(#3)
REP-REQ(#4)
REP-REQ(#5)
REP-REQ(#6)
UL burst #2
Ranging Subschannel
ARQ_ACK & CQI Report Channel (UIUC = 0)

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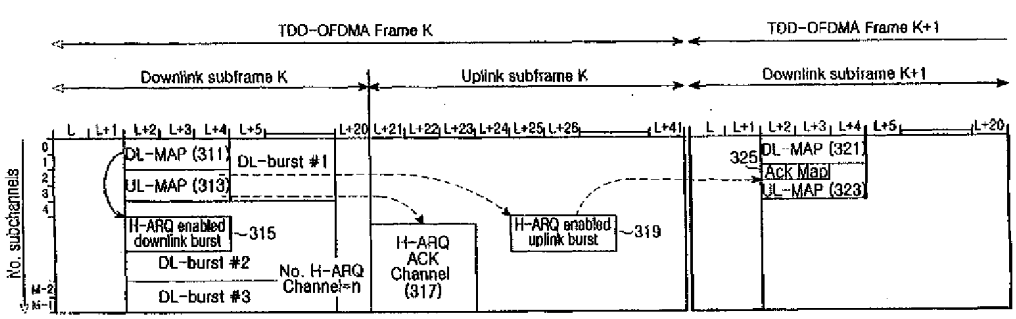
[Continued on next page]

(54) Title: METHOD FOR OPERATION OF HARQ IN A BROADBAND WIRELESS ACCESS COMMUNICATION SYSTEM



(57) Abstract: A method supporting a Hybrid Automatic Repeat Request (H-ARQ) between a subscriber station and a base station in a broadband wireless access communication system including. The method comprises the steps of: transmitting at least one H-ARQ enabled uplink burst from the subscriber station to the base station; generating ACK or NACK information according to the received H-ARQ enabled uplink burst at the base station; mapping the generated ACK or NACK information to a bitmap at the base station; transmitting the bitmap through a downlink information from the base station to the subscriber station.

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METHOD FOR OPERATION OF HARQ IN A BROADBAND WIRELESS ACCESS COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a method for operating a Hybrid Automatic Repeat Request (HARQ) scheme in a broadband wireless access communication system and, more particularly, to a method for operating an uplink/downlink transmit response for effective utilization of a HARQ scheme.

2. Description of the Related Art

In a 4th generation (4G) communication system, which is the next generation communication system, research has been actively pursued to provide users with services having various qualities of service (QoS) at a high transmission speed of 100 Mbps. The current third generation (3G) communication system supports a transmit speed of about 384 kbps in an outdoor environment having relatively bad channel conditions and a transmit speed of a maximal 2 Mbps in an indoor environment having relatively good channel conditions

A wireless Local Area Network (LAN) communication system and a wireless Metropolitan Area Network (MAN) communication system generally support transmission speeds of 20 to 50 Mbps. Because the wireless MAN communication system has a wide service coverage and supports a high transmission speed, it is suitable for supporting a high speed communication service. However, the wireless MAN system does not accommodate the mobility of a user, i.e., a subscriber station (SS), nor does it perform a handover according to the high speed movement of the SS. The wireless MAN system is a broadband wireless access communication system having a wider service area and supporting a higher transmission speed than the wireless LAN system.

Accordingly, in a current 4G communication system, a new type of communication system ensuring mobility and QoS for the wireless LAN system and the wireless MAN system supporting relatively high transmission speeds is currently being developed to support a high speed service to be provided by the 4G communication system. In this context, many studies are being conducted on using an Orthogonal Frequency Division Multiplexing (OFDM) scheme for high-speed data transmission over wired/wireless channels in the 4G mobile communication system. The OFDM scheme, which transmits data using multiple carriers, is a special type of a Multiple Carrier Modulation (MCM) scheme in which a serial symbol sequence is converted into parallel symbol sequences and the parallel symbol sequences are modulated with a plurality of mutually orthogonal subcarriers (or subcarrier channels) before being transmitted.

The Orthogonal Frequency Division Multiple Access (OFDMA) scheme is a Multiple Access scheme based on the OFDM scheme. In the OFDMA scheme, subcarriers in one OFDM symbol are distributed to a plurality of users (or SSs). Communication systems using the OFDMA scheme include an Institute of Electrical and Electronics Engineers (IEEE) 802.16a communication system and an IEEE 802.16e communication system. The IEEE 802.16 communication systems utilize the OFDM/OFDMA scheme in order to support a broadband transmit network for a physical channel of the wireless MAN system. Further, the IEEE 802.16 communication systems are broadband wireless access communication systems using a Time Division Duplex (TDD)-OFDMA scheme. Therefore, in the IEEE 802.16 communication systems, because the OFDM/OFDMA scheme is applied to the wireless MAN system, a physical channel signal can be transmitted using a plurality of sub-carriers, thereby achieving data transmission of high speed and high quality.

The OFDMA scheme can be defined by a two-dimensional access scheme, which is a combination of the Time Division Access (TDA) technology and Frequency Division Access (FDA) technology. Therefore, in data transmission using the OFDMA scheme, each OFDMA symbol is distributed to sub-carriers and transmitted through predetermined sub-channels. Herein, the sub-channel is a channel including a plurality of sub-carriers. In a communication system using the OFDMA scheme (OFDMA communication system), predetermined number of sub-carriers according to system conditions are included in one sub-channel.

FIG. 1 schematically illustrates a frame structure of a conventional TDD-OFDMA communication system. Referring to FIG. 1, the frame used in the TDD-OFDMA communication system is divided between downlink (DL) 149 and uplink (UL) 153, according to the time unit. In the frame, a protection time interval named 'Transmit/receive Transition Gap (TTG) 151' is arranged at a time interval for transition from the downlink 149 to the uplink 153 and a protection time interval named 'Receive/transmit Transition Gap (RTG) 155' is arranged at a time interval for transition from the uplink 153 to the next downlink. In FIG. 1, the horizontal axis represents the OFDM symbol number 145 of the OFDMA symbols and the vertical axis represents the sub-channel logical number 147 of the multiple sub-channels.

As illustrated in FIG. 1, one OFDMA frame includes a plurality of OFDMA symbols (for example, 12 OFDMA symbols). Also, one OFDMA symbol includes a plurality of sub-channels (for example, L sub-channels).

In the IEEE 802.16 communication system described above, all sub-carriers (especially, data sub-carriers) are distributed to all frequency bands, in order to obtain the frequency diversity gain. Further, in the IEEE 802.16 communication system, during the transmit/receive time interval, ranging is performed in order to adjust time offset and frequency offset, and adjust the transmit power.

Referring to the downlink 149, a preamble 111 for synch acquisition is located at the k-th OFDMA symbol, and broadcast data information such as a Frame Control Header (FCH) 113, a downlink MAP (DL-MAP) 115, and an uplink MAP (UL-MAP) 117, which must be broadcast to the subscriber stations, is located at the (k+1)-th or (k+2)-th OFDMA symbol. The FCH 113 includes two sub-channels to transfer basic information about the sub-channel, the ranging and the modulation scheme, etc. Downlink bursts (DL bursts) 121, 123, 125, 127, and 129 are located at the OFDMA symbols from the (k+2)-th OFDMA symbol to the (k+8)-th OFDMA symbol, except for the UL-MAP located at the (k+2)-th OFDMA symbol.

Referring to the uplink 153, preambles 131, 133, and 135 are located at the (k+9)-th OFDMA symbol and uplink bursts (UL bursts) 137, 139, and 141 are located at the OFDMA symbols from the (k+10)-th OFDMA symbol to the (k+12)-th OFDMA symbol. Further, a ranging sub-channel 143 is located at the OFDMA symbols from the (k+9)-th OFDMA symbol to the (k+12)-th OFDMA symbol.

In the IEEE 802.16 communication system, the transition from the downlink to the uplink is performed during the TTG 151. Further, the transition from the uplink to the downlink is performed during the RTG 155. Further, after the TTG 151 and the RTG 155, separate preamble fields 111, 131, 133, and 135 may be allocated to acquire synch between the transmitter and the receiver.

According to the frame structure of the IEEE 802.16 communication system, the downlink frame 149 includes a preamble field 111, an FCH field 113, a DL-MAP field 115, UL-MAP fields 117 and 119, and a plurality of DL burst fields (including a DL burst #1 field 123, a DL burst #2 field 125, a DL burst #3 field 121, a DL burst #4 field 127, and a DL burst #5 field 129).

The preamble field 111 is a field for transmitting a preamble sequence, which is a synch signal for synch acquisition for the transmit/receive time interval. Further, the FCH field 113 includes two sub-channels to transfer basic information about the sub-channel, the ranging, the modulation scheme, etc. The DL-MAP field 115 is a field for transmitting the DL-MAP message. The UL-MAP fields 117 and 119 are fields for transmitting the UL-MAP messages. Here, the DL-MAP message includes Information Elements (IEs) as shown in Table 1 below.

Table 1

Syntax	Size	Notes
DL-MAP_IE() {		
DIUC	4 bits	
if(DIUC==15) {		
Extended DIUC dependent IE	variable	See 802.16a/16e OFDMA PHY Specifications
} else {		
if(INC_CID==1) {		The DL-MAP starts with INC_CID=0. INC_CID is toggled between 0 and 1 by the CID_SWITCH_IE () (See 802.16a/16e OFDMA PHY Specifications)
N_CID	8 bits	Number of CIDs assigned for this IE
for(n=0;n<N_CID;n++) {		
CID	16 bits	
}		
}		
OFDMA Symbol Offset	10 bits	
Subchannel Offset	5 bits	
Boosting	3 bits	000: normal (not boosted) 001: +6 dB 010: -6 dB 011: +9 dB 100: +3 dB 101: -3 dB 110: -9 dB 111: -12 dB
No. OFDMA Symbols	9 bits	
No. Subchannels	5 bits	
}		
}		

As shown in Table 1, a DIUC (Downlink Interval Usage Code) represents the object of a currently transmitted message and the modulation scheme in which the currently transmitted message is modulated before being transmitted. A CID (connection Identifier) represents the CID of each subscriber station corresponding to the DIUC.

OFDMA Symbol Offset represents the offset of a symbol resource allocated to each DL burst. Subchannel Offset represents the offset of a sub-channel resource allocated to each DL burst. Boosting represents a power value increased in the transmit power. 'No. OFDMA Symbols' represents the number of allocated OFDMA symbols. 'No. Subchannels represents the number of allocated sub-channels.

As noted from Table 1, the downlink information of the IEEE 802.16 communication system is expressed in combination with information about each subscriber station according to the DIUC. Therefore, each subscriber station can analyze the data targeting the subscriber station itself, only after demodulating the entire DL-MAP message.

The UL-MAP message includes Information Elements (IEs) as shown in Table 2 below.

Table 2

Syntax	Size	Notes
UL-MAP_IE() {		
CID	16 bits	
UIUC	4 bits	
if(UIUC==12) {		
OFDMA Symbol Offset	10 bits	
Subchannel Offset	6 bits	
No. OFDMA Symbols	8 bits	
No. Subchannels	5 bits	
Ranging Method	3 bits	000: Initial Ranging over two symbols 001: Initial Ranging over four symbols 010: BW Request/Periodic Ranging over one sysbol 011: BW Request/Periodic Ranging over three symbols 100~111: reserved
} else if(UIUC==14) {		
CDMA_Allocation_IE ()	52 bits	
} else if(DIUC==15) {		
Extended DIUC dependent IE	variable	See 802.16a/16e OFDMA PHY Specifications
} else {		
OFDMA Symbol Offset	10 bits	
Subchannel Offset	5 bits	
No. OFDMA Symbols	9 bits	
No. Subchannels	5 bits	
Mini-subchannel index	3 bits	000: no mini-subchannels used 001: starting with mini-subchannel 1 010: starting with mini-subchannel 2 011: starting with mini-subchannel 3 100: starting with mini-subchannel 4 101: starting with mini-subchannel 5 110, 111: reserved
}		
}		

As shown in Table 2, a CID (connection Identifier) represents the CID of each corresponding subscriber station and an UIUC (Uplink Interval Usage Code) represents the object of the message to be transmitted by the corresponding subscriber station and the modulation scheme in which the message is modulated before being transmitted. The other information elements are similar to those in Table 1, so description of them will be omitted here.

According to the frame structure of the IEEE 802.16 communication system as described above, the uplink frame 153 includes a ranging sub-channel field 143, a plurality of preamble fields 131, 133, and 135, and a plurality of UL burst fields (a UL burst #1 field 137, a UL burst #2 field 139, and a UL burst #3 field 141).

The ranging sub-channel field 143 is a field for transmitting ranging sub-channels for the ranging, and the preamble fields 131, 133, and 135 are fields for transmitting preamble sequences, i.e. synch signals for synch acquisition for the transmit/receive time interval.

According to the prior art as described above, each subscriber station (SS) cannot be identified by the bursts transmitted from the base station (BS) to the SS but can be identified by the bursts transmitted from the SS to the BS. Accordingly, the prior art described above is not proper for use of a Hybrid Automatic Repeat Request (HARQ) scheme in order to increase the transmission throughput when high speed transmission is required in a digital communication system. Therefore, in the prior art, transmission efficiency may be degraded due to errors in the wireless data transmission.

Further, the IEs, as described above, must be transmitted to all SSs through the MAP message by the most robust modulation scheme, such that they can be delivered to an entire cell area covered by the BS. However, as noted from the above discussion, the IEs are inefficiently included in the MAP message, that is, control data of an over burdensome size in the high speed data transmission system must be maintained. Such inefficient control data decreases the proportion of the actual data traffic in the entire traffic.

SUMMARY OF THE INVENTION

Accordingly, the present invention has been designed to solve the above and other problems occurring in the prior art. An object of the present invention is to provide a method for operating an uplink/downlink transmission response for efficient utilization of the HARQ scheme in a broadband wireless access communication system.

It is another object of the present invention to provide an operation method of an ACK channel for supporting HARQ, transmitting a downlink HARQ enabled burst result report field through an uplink map, and transmitting an uplink HARQ enabled burst result in the form of bitmap.

In order to accomplish the above and other objects, there is provided a method supporting a Hybrid Automatic Repeat Request (H-ARQ) between a subscriber station and a base station in a broadband wireless access communication system including. The method comprises the steps of transmitting at least one H-ARQ enabled uplink burst from the subscriber station to the base station; generating ACK or NACK information according to the received H-ARQ enabled uplink burst at the base station; mapping the generated ACK or NACK information to a bitmap at the base station; transmitting the bitmap through a downlink information from the base station to the subscriber station.

In accordance with another aspect of the present invention, there is provided a method supporting a Hybrid Automatic Repeat Request (H-ARQ) between a subscriber station and a base station in a broadband wireless access communication system including. The method comprises the steps of: generating a downlink information indicating a H-ARQ ACK region and at least one H-ARQ enabled downlink burst at the base station; transmitting the downlink information from the base station to the subscriber station; generating ACK or NACK information according to the received H-ARQ enabled downlink burst at the subscriber station; transmitting the generated ACK or NACK information through the H-ARQ ACK region from the subscriber station to the base station.

In accordance with another aspect of the present invention, there is provided a method for operating a Hybrid Automatic Repeat Request (HARQ) scheme for a downlink by a subscriber station in a broadband wireless access communication system including the subscriber station and a base station. The method comprises the steps of: determining the type of HARQ enabled downlink burst being transmitted by analyzing an information element corresponding to a connection identifier of the subscriber station, after receiving a downlink MAP message belonging to a corresponding frame; when the HARQ enabled downlink burst being transmitted is a new burst, confirming transmission of the new burst and information of the HARQ enabled downlink burst, and receiving the HARQ enabled downlink burst in a downlink data region; when the HARQ enabled downlink burst being transmitted is a retransmitted burst, confirming retransmission of an already transmitted burst and information of the HARQ enabled downlink burst, and receiving the HARQ enabled downlink burst in a downlink data region; determining if the received HARQ enabled downlink burst has an error; and transmitting one of an acknowledgement (ACK) message and a negative acknowledgement (NACK) message through a sub-channel in accordance with the determining for the error.

In accordance with another aspect of the present invention, there is provided a method for operating a Hybrid Automatic Repeat Request (HARQ) scheme for an uplink by a base station in a broadband wireless access communication system. The method comprises the steps of: determining at least one subscriber station to which a base station will transmit a HARQ enabled burst through a corresponding uplink frame; determining information of the HARQ enabled burst of the at least one subscriber station; determining a type of the HARQ enabled burst by analyzing an information element corresponding to the determined subscriber station; when the HARQ enabled burst being transmitted is a new burst, preparing an uplink MAP message to be transmitted to the subscriber station, preparing an information element corresponding to the uplink MAP message, and receiving the HARQ enabled burst targeting the base station in an uplink data region; when the HARQ enabled burst being transmitted is a retransmitted burst, preparing an Incremental Redundancy (IR) scheme, preparing the uplink MAP message to be transmitted to the subscriber station, preparing an information element corresponding to the uplink MAP message, and receiving the HARQ enabled burst targeting the base station in the uplink data region; determining if the received HARQ enabled burst has an error; preparing one of an ACK message and a NACK message in a form of bitmap, in accordance with a result of the determining; and transmitting the one of the ACK message and the NACK message.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features, and advantages of the present invention will be more apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 schematically illustrates a frame structure of a conventional TDD-OFDMA communication system;

FIG. 2 schematically illustrates a frame structure including a dedicated uplink control channel of a TDD-OFDMA communication system according to the present invention;

FIG. 3 is a view for illustrating a method for operation of HARQ ACK/NACK of a TDD-OFDMA communication system according to an embodiment of the present invention;

FIG. 4 is a flowchart of a process for operation of downlink HARQ in a HARQ ACK/NACK operation method according to the present invention; and

FIG. 5 is a flowchart of a process for operation of uplink HARQ in a HARQ ACK/NACK operation method according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Preferred embodiments of the present invention will be described in detail herein below with reference to the accompanying drawings. In the following description, a detailed description of known functions and configurations incorporated herein will be omitted when it may obscure the subject matter of the present invention.

The present invention proposes a new TDD-OFDMA frame structure for a TDD-OFDMA communication system (an OFDMA communication system using a TDD scheme). More specifically, the present invention proposes an uplink/downlink transmission control method, in which an ACK channel for supporting the HARQ scheme is newly constituted and an uplink HARQ enabled burst result is transmitted as a bitmap through an uplink map, so the method can efficiently use the HARQ scheme.

The method of the present invention reduces the size of the entire MAP because the ACK/NACK information is transmitted in the form of bitmap. Further, such reduction in the size of the entire MAP reduces the control data in a system intended to perform high speed data transmission (for example, the TDD-

OFDMA communication system). Moreover, such a reduction can increase the proportion of the actual data traffic in the entire traffic, thereby improving transmission efficiency.

The present invention discloses a method for transmitting/receiving uplink/downlink data for high speed data transmission in a broadband wireless access system including an SS and a BS providing service to the SS. In the system according to the present invention, in high speed data transmission between the BS and the SS, control information for HARQ is carried through HARQ_Control IE in the burst information of each SS in the DL-MAP message and the UL-MAP message broadcast to each SS from the BS, and ACK/NACK information for the data which the BS has received from the SS is carried through HARQ_ACK_BITMAP IE in the UL-MAP of the BS.

Further, in the system according to the present invention, the channel through which the SS can transmit the ACK/NACK information for the data that the SS has received from the BS is determined according to an ACK/NACK information transfer scheme. Therefore, the present invention enables efficient use of the HARQ scheme, rapid and exact transmission of ACK/NACK for the uplink/downlink data, and an efficiency increase thereof.

FIG. 2 schematically illustrates a frame structure including a dedicated uplink control channel of a TDD-OFDMA communication system according to the present invention. The present invention proposes a new common control information channel, that is, a System Information Channel (SICH), in order to overcome the problems due to the transmission of the SS information in the form of messages such as the DL-MAP message and the UL-MAP message in the downlink frame in the conventional IEEE 802.16 communication system.

In FIG. 2, the horizontal axis represents the OFDMA symbol number and the vertical axis represents the sub-channel number. Further, one OFDMA frame includes a plurality of OFDMA symbols and one OFDMA symbol includes a plurality of sub-channels. Also, one sub-channel includes a plurality of sub-carriers distributed over all frequency bands.

Referring to FIG. 2, reference numeral 211 designates a downlink preamble (DL preamble), and the OFDMA frame structure does not include an uplink preamble. Reference numeral 213 designates the SICH to which the OFDMA symbol is exclusively allocated. The SICH contains system information such as the frame number, BS identifier (ID), etc.

Reference numeral 215 designates three OFDMA symbols exclusively allocated to an Uplink Control Channel (UCC), which includes a ranging channel, a Channel Quality Indicator Channel (CQI-CH) for reporting the wireless state, and an ACK channel for HARQ.

Further, the SICH includes an Uplink Control Channel Indicator (UCCI) representing if the MAP includes a UCC_Region IE containing region information of the UCC. As described above, the UCC region 215 of FIG. 2 includes three divided regions.

Table 3 shows the structure of the UCC_Region IE.

Table 3

Syntex	Size	Notes
UCC_Region_IE() {		This IE exists only if UCCI bit is 1
Ranging Channel Region	2 bits	
HARQ ACK Channel Region	6 bits	
}		

Referring Table 3, the UCC_Region IE includes a Ranging Channel Region representing the size of the ranging channel and a HARQ ACK Channel Region representing the size of the ACK channel for HARQ. The CQI-CH can be calculated from the size of the ranging channel and the size of the ACK channel. When the SS receives the information about the UCC region as described above, the SS can utilize the UCC region according to its object.

The HARQ function control is performed by a HARQ_Control IE among information elements of bursts allocated to each SS. Table 4 below shows the structure of the HARQ_Control IE.

Table 4

Syntex	Size	Notes
HARQ_Control_IE() {		In DL/UL-MAP
SPID	2 bits	Subpacket ID
ACID	2 bits	ARQ Connection ID
Continuation	1 bit	
}		

Referring Table 4, it is noted that the HARQ_Control IE includes five bits in total. In Table 4, 'SPID' represents a sub-packet identifier, which is used to identify each sub-packet generated during application of the HARQ according to an Incremental Redundancy (IR) scheme. However, the characteristic and the operation of the IR scheme have been widely known to the public, so detailed description thereof will be omitted here.

In the TDD-OFDMA communication system, because the TDD-OFDMA communication system includes three sub-packets, the SPID can be expressed by two bits.

ACID represents a connection identifier used in order to effectively indicate transmission delay generated during the application of the HARQ. Usually, it is difficult to process without delay the ACK/NACK for the HARQ-applied data even in a system capable of transmitting data at high speed for both the uplink and the downlink. Therefore, it is difficult to regard an ACK/NACK carried by a specific frame as relating to the data having been transmitted by the specific frame, so such an identifier is necessary. In the TDD-OFDMA communication system, the ACID can be expressed by two bits, because the maximum delay of the ACK/NACK is considered as being about three frames.

'Continuation' is a field representing if a new HARQ enabled burst is being transmitted or an already transmitted HARQ enabled burst is being retransmitted. 'Continuation' is used to detect errors in the transmission of the ACK/NACK of the HARQ type, thereby improving the reliability.

FIG. 3 illustrates a method for operation of HARQ ACK/NACK of a

TDD-OFDMA communication system according to an embodiment of the present invention. Referring to FIG. 3, the DL-MAP 311 in the K-th frame expresses the location and the size of a HARQ enabled downlink burst 315 (a downlink burst transmitted at the K-th frame from the BS to the SS). Further, in transmitting the DL-MAP 311, control information of the HARQ enabled downlink burst is carried by the HARQ_Control IE as defined in Table 4.

The UL-MAP 313 in the K-th frame expresses the location and the size of an HARQ enabled uplink burst 319 (an uplink burst transmitted at the K-th frame from the SS to the BS). In transmitting the UL-MAP 313 also, control information of the transmitted HARQ enabled uplink burst is carried by the HARQ_Control IE as defined in Table 4.

In the UL-MAP 313, a channel for carrying the ACK/NACK information for the HARQ enabled downlink burst 315 transmitted at or before the K-th frame from the BS to the SS may be arranged in the UCC region 317.

In arranging the channel for carrying the ACK/NACK information, the number of HARQ enabled downlink bursts is counted, the ordinal number of the HARQ enabled downlink burst 315 is checked, a HARQ ACK channel is arranged and occupied in the UCC region 317, and the ACK/NACK information is then transmitted. For example, if the HARQ enabled downlink burst 315 is transmitted at the m-th time in the downlink data region, the ACK/NACK information for the HARQ enabled downlink burst 315 is transmitted through the m-th HARQ ACK channel.

The ACK/NACK information of the HARQ enabled uplink burst 319 transmitted from the SS to the BS is expressed as a bitmap (ACK MAP) 325 in the UL-MAP message 323 broadcast at the (K+1)-th frame or after the (K+1)-th frame to the SSs by the BS.

Further, information of the bit to which the ACK/NACK information for the SS corresponds in the bitmap 325 is controlled in the same way as the method of transmitting the downlink ACK/NACK information described above. That is, the number of HARQ enabled uplink bursts is counted, the ordinal number of the

HARQ enabled uplink burst 319 is checked, one bit in the bitmap 325 of the UL-MAP message 323 is occupied, and the ACK/NACK information is then transmitted. For example, if the HARQ enabled uplink burst 319 is transmitted at the n-th time in the uplink data region, the ACK/NACK information for the HARQ enabled uplink burst 319 is transmitted through the n-th bit.

The IEs included in the bitmap 325 are shown in Table 5 below.

Table 5

Syntex	Size	Notes
HARQ_ACK_BITMAP_IE() {		In UL-MAP
Length of ACK bitmap	4 bits	8×(n+1) bitmap, n=0~15
ACK bitmap	variable	The ACK bit-map field is a variable length field
}		

In Table 5, 'Length of ACK bitmap' represents the length of the HARQ ACK bitmap. 'ACK bitmap' expresses a variable length.

As described above, the HARQ_ACK_BITMAP IE is transmitted according to the most robust modulation scheme by the UL-MAP message broadcast from the BS to all SSs. Therefore, in order to achieve efficient transmission in a system including variable SSs, it is more efficient to use a bitmap having a variable length than to use a bitmap having a fixed length.

Further, by using the bitmap in transmitting the ACK/NACK information, the size of the entire MAP can be largely reduced as described above. Therefore, use of the bitmap can reduce the size of the control data in a high speed data transmission system such as the TDD-OFDMA communication system. That is, use of the bitmap can increase the proportion of the actual data traffic in the entire traffic, thereby improving the transmission efficiency.

FIG. 4 is a flowchart of a process for operation of a downlink HARQ in a HARQ ACK/NACK operation method according to the present invention. More specifically, FIG. 4 illustrates an operation of an SS for the downlink in a process of operating the HARQ ACK/NACK.

Referring to FIG. 4, the SS confirms the DL-MAP in the corresponding frame currently assigned to the SS and then analyzes the HARQ_Control IE corresponding to the CID of the SS in step 411. Based on the analysis of the HARQ_Control IE, the SS confirms the continuation field in the HARQ_Control IE in step 413. When the continuation field has a value of '0', the SS confirms that current transmission is transmission of a new HARQ enabled downlink burst and then checks information including the location, size, and sequence of the HARQ enabled downlink burst in step 415.

After checking the HARQ enabled downlink burst information, the SS receives the HARQ enabled downlink burst forwarded to the SS in a downlink data region in step 417. The SS checks whether the received HARQ enabled downlink burst has an error in steps 419 and 421.

When the HARQ enabled downlink burst has no error the SS codes the ACK information in step 423. However, when the HARQ enabled downlink burst has an error the SS codes the NACK information in step 451.

After coding the ACK or NACK information, the SS transmits the coded signal through the sub-channel (ACK-CH) allocated to the SS in the uplink UCC region of the frame in step 425.

As a result of the confirmation of the continuation field in the HARQ_Control IE in step 413, when the continuation field has a value of '1', the SS confirms that current transmission is a retransmission of an already transmitted HARQ enabled downlink burst and then prepares the Incremental Redundancy (IR) scheme in step 431. After preparing the IR scheme, the SS confirms information including the location, size, and sequence of the HARQ enabled downlink burst in step 433. Thereafter, the SS receives the HARQ enabled downlink burst targeting the SS itself and applies the IR scheme by combining the already received sub-packet and the burst in step 435.

Hereinafter, an operation of the SS for the downlink in the HARQ ACK/NACK operation process of the TDD-OFDMA communication system having the above-described construction will be described.

In step 411, the SS confirms the DL-MAP in the corresponding frame and then analyzes the HARQ_Control IE corresponding to the CID of the SS. In step 413, the SS refers to the value of the continuation field in the HARQ_Control IE and determines if the current transmission is transmission of a new HARQ enabled downlink burst or retransmission of an already transmitted HARQ enabled downlink burst. The continuation field is (shown in Table 4) used for determining if the current transmission is transmission of a new HARQ enabled downlink burst or retransmission of an already transmitted HARQ enabled downlink burst, and is used in order to detect an error in the ACK/NACK transmission of the HARQ scheme, thereby improving the reliability.

When the continuation field has a value of '0', that is, when the current transmission is transmission of a new HARQ enabled downlink burst, the SS proceeds to step 415. In step 415, the SS confirms that the transmitted burst is a new HARQ enabled downlink burst and then checks information including the location, size, and sequence of the HARQ enabled downlink burst by analyzing the DL-MAP IE.

In step 417, the SS receives the HARQ enabled downlink burst forwarded to the SS itself in a downlink data region. In steps 419 and 421, the SS determines if the received HARQ enabled downlink burst has an error. Here, in determining if the received HARQ enabled downlink burst has an error, a Cyclic Redundancy Check (CRC) scheme is utilized. The CRC scheme uses cyclic binary codes in order to detect errors during usual data transmission. According to the CRC scheme, the determination of a transmission error is based on whether, when a transmitter-side has divided data into blocks and then transmitted the blocks together with a cyclic code attached after each block, which is obtained through a special calculation using a binary polynomial, a receiver-side obtains the same cyclic code by the same calculation method.

When the continuation field has a value of '1', that is, when the current transmission is retransmission of an already transmitted HARQ enabled downlink burst, the SS proceeds to step 431. In step 431, the SS confirms that current transmission is retransmission of an already transmitted HARQ enabled downlink burst and then prepares the IR scheme. In step 433, the SS confirms the location, size, and sequence of the HARQ enabled downlink burst by analyzing the DL-MAP IE and then proceeds to step 435.

In step 435, the SS receives the HARQ enabled downlink burst targeting the SS and applies the IR scheme by combining the already received sub-packet and the HARQ enabled downlink burst.

In steps 419 and 421, the SS determines if the received HARQ enabled downlink burst has an error. When the received HARQ enabled downlink burst has no error, the SS proceeds to step 423. In step 423, the SS prepares an ACK message by coding ACK information in accordance with the received HARQ enabled downlink burst.

When the received HARQ enabled downlink burst has an error, the SS proceeds to step 451.In step 451, the SS prepares a NACK message by coding NACK information in accordance with the HARQ enabled downlink burst error.

Finally, in step 425, the SS transmits the message (prepared through the ACK/NACK coding in step 423 or 451) through a sub-channel (ACK-CH) allocated to the SS in an uplink UCC region of the corresponding frame or a frame one or two frame-delayed after the corresponding frame.

FIG. 5 is a flowchart illustrating a process for operation of an uplink HARQ in a HARQ ACK/NACK operation method according to the present invention. More specifically, FIG. 5 illustrates an operation of a BS for the uplink in a process of operating the HARQ ACK/NACK.

Referring to FIG. 5, the BS determines the location, size, and sequence of the bursts of the SSs in step 511 and then checks the value of the continuation field in step 513.

When the continuation field has a value of '0', the BS confirms that current transmission is transmission of a new HARQ enabled uplink burst and then prepares a UL-MAP to be transmitted to the SS and a corresponding HARQ_Control IE in step 515. Thereafter, the BS receives the HARQ enabled uplink burst of the SS in step 517 and checks whether the received HARQ enabled uplink burst has an error in steps 519 and 521.

When the received HARQ enabled uplink burst has no error the BS prepares the ACK information in step 523. However, when the received HARQ enabled uplink burst has an error the BS prepares the NACK information in step 551. Thereafter, the BS prepares a bitmap to carry the prepared ACK/NACK message through the UL-MAP in step 525 and transmits the bitmap through the UL-MAP in step 527.

When the continuation field has a value of '1', the BS confirms that current transmission is retransmission of an already transmitted HARQ enabled uplink burst and then prepares an IR scheme in step 531. Thereafter, the BS prepares the UL-MAP to be transmitted to the SS and prepares a corresponding HARQ_Control IE in step 533. The BS receives the burst targeting the BS and applies the IR scheme by combining the already received sub-packet and the burst in step 535.

Hereinafter, an operation of the BS for the downlink in the HARQ ACK/NACK operation process of the TDD-OFDMA communication system having the above-described construction will be given.

In step 511, the BS determines SSs to which the BS will transmit the HARQ enabled uplink bursts through a corresponding uplink frame and then determines the location, size, and sequence of the bursts of the SSs. In step 513, the BS checks the value of the continuation field, thereby determining if the HARQ enabled uplink burst to be received is a retransmitted HARQ enabled uplink burst. The continuation field (shown in Table 4) is used for determining if the current transmission is transmission of a new HARQ enabled uplink burst or retransmission of an already transmitted HARQ enabled uplink burst, and is used to detect an error in the ACK/NACK transmission of the HARQ scheme, thereby improving the reliability.

When the continuation field has a value of '0', that is, when the current transmission is transmission of a new HARQ enabled uplink burst, the BS proceeds to step 515. In step 515, the BS prepares a UL-MAP to be transmitted to the SS and a corresponding HARQ_Control IE. In step 517, the BS receives the HARQ enabled uplink burst targeting the BS in the uplink data region. In steps 519 and 521 the BS determines if the received HARQ enabled uplink burst has an error. Here, in determining if the received HARQ enabled uplink burst has an error, the BS uses the CRC scheme as described above with reference to FIG. 4.

When the continuation field has a value of '1', that is, when the current transmission is retransmission of an already transmitted HARQ enabled uplink burst, the BS proceeds to step 531. In step 531, the BS confirms that current transmission is a retransmission of an already transmitted HARQ enabled uplink burst and then prepares an IR scheme. In step 533, the BS prepares the UL-MAP to be transmitted to the SS and prepares a corresponding HARQ_Control IE.

In step 535, the BS receives the burst targeting the BS in the uplink data region and applies the IR scheme by combining the already received sub-packet and the burst. .

In steps 519 and 521, the BS determines if the received HARQ enabled uplink burst has an error. When the received HARQ enabled uplink burst has no error, the BS proceeds to step 523. In step 523, the BS prepares an ACK message corresponding to the received HARQ enabled uplink burst.

When the received HARQ has an error, the BS proceeds to step 551. In step 551, the BS prepares a NACK message corresponding to the HARQ enabled uplink burst error.

Thereafter, in step 525, the BS prepares a bitmap, which includes the ACK/NACK information prepared in step 523 or step 551 and will be transmitted through a UL-MAP of the next frame or a after frame one or two frame-delayed. Finally, In step 527, the BS transmits the bitmap through the UL-MAP of the corresponding frame.

According to a method for operating an HARQ scheme in a broadband wireless access communication system of the present invention, the ACK/NACK information is transferred by a bitmap. As a result, the size of the control data can be reduced in a high speed data transmission system such as the TDD-OFDMA communication system.

Further, the reduction above can increase the proportion of the actual data traffic in the entire traffic, thereby improving the transmission efficiency.

Moreover, the present invention proposes an method for efficient use of the HARQ scheme in order to increase the transmission efficiency in uplink/downlink high speed data transmission. The proposed method achieves rapid and exact control of the ACK/NACK information, thereby achieving exact transmission and reception of only the necessary information together with reduction of the MAP message.

While the present invention has been shown and described with reference to certain preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the appended claims.

WHAT IS CLAIMED IS:

1. A method supporting a Hybrid Automatic Repeat Request (H-ARQ) between a subscriber station and a base station in a broadband wireless access communication system including, the method comprising the steps of:

transmitting at least one H-ARQ enabled uplink burst from the subscriber station to the base station;

generating ACK or NACK information according to the received H-ARQ enabled uplink burst at the base station;

mapping the generated ACK or NACK information to a bitmap at the base station;

transmitting the bitmap through a downlink information from the base station to the subscriber station.

2. The method as claimed in claim 1, wherein a bit position in the bitmap is determined by the order of the H-ARQ enabled uplink bursts.

3. The method as claimed in claim 1, wherein the broadband wireless access communication system is TDD(Time Division Duplex)-OFDMA(Orthogonal Frequency Division Multiple Access) system.

4. The method as claimed in claim 1, wherein a size of the bit map is variable according to the number of H-ARQ enabled uplink bursts.

5. The method as claimed in claim 1, wherein the downlink information is a downlink broadcasting message.

6. A method supporting a Hybrid Automatic Repeat Request (H-ARQ) between a subscriber station and a base station in a broadband wireless access communication system including, the method comprising the steps of:

generating a downlink information indicating a H-ARQ ACK region and at least one H-ARQ enabled downlink burst at the base station;

transmitting the downlink information from the base station to the subscriber station;

generating ACK or NACK information according to the received H-ARQ enabled downlink burst at the subscriber station;

transmitting the generated ACK or NACK information through the H-ARQ ACK region from the subscriber station to the base station.

7. The method as claimed in claim 6, wherein the downlink information is a downlink broadcasting message.

8. The method as claimed in claim 6, wherein the H-ARQ ACK region is a H-ARQ ACK channel.

9. The method as claimed in claim 6, wherein the broadband wireless access communication system is TDD(Time Division Duplex)-OFDMA(Orthogonal Frequency Division Multiple Access) system.

10. A method for operating a Hybrid Automatic Repeat Request (HARQ) scheme for a downlink by a subscriber station in a broadband wireless access communication system including the subscriber station and a base station, the method comprising the steps of:

determining the type of HARQ enabled downlink burst being transmitted by analyzing an information element corresponding to a connection identifier of the subscriber station, after receiving a downlink MAP message belonging to a corresponding frame;

when the HARQ enabled downlink burst being transmitted is a new burst, confirming transmission of the new burst and information of the HARQ enabled downlink burst, and receiving the HARQ enabled downlink burst in a downlink data region;

when the HARQ enabled downlink burst being transmitted is a retransmitted burst, confirming retransmission of an already transmitted burst and information of the HARQ enabled downlink burst, and receiving the HARQ enabled downlink burst in a downlink data region;

determining if the received HARQ enabled downlink burst has an error; and

transmitting one of an acknowledgement (ACK) message and a negative acknowledgement (NACK) message through a sub-channel in accordance with the determining for the error.

11. The method as claimed in claim 10, wherein, when the HARQ enabled downlink burst being transmitted is the retransmitted burst, the method further comprises the steps of:

preparing an Incremental Redundancy (IR) scheme;

confirming the information of the HARQ enabled downlink burst by analyzing the downlink MAP information element;

receiving the HARQ enabled downlink burst in the downlink data region; and

applying the IR scheme by combining an already received sub-packet and the HARQ enabled downlink burst.

12. The method as claimed in claim 10, wherein the downlink MAP message includes information about a location and a size of the HARQ enabled downlink burst in a predetermined frame, the HARQ enabled downlink burst being a downlink burst transmitted from the base station to the subscriber station.

13. The method as claimed in claim 10, wherein, the step of determining the type of HARQ enabled downlink burst being transmitted is performed by confirming a value of a continuation field included in the information element.

14. The method as claimed in claim 10, wherein the step of transmitting one of the ACK message and the NACK message comprises the steps of:

when the received HARQ enabled downlink burst has no error, transmitting the ACK message through a sub-channel allocated to the subscriber station, the ACK message being obtained by coding ACK information; and

when the received HARQ enabled downlink burst has an error, transmitting the NACK message through the sub-channel allocated to the subscriber station, the NACK message being obtained by coding NACK information.

15. The method as claimed in claim 10, wherein the one of the ACK message and the NACK message is transmitted through a sub-channel allocated to the subscriber station in an uplink control channel region of a corresponding

frame.

16. The method as claimed in claim 10, wherein the one of the ACK message and the NACK message is transmitted through a sub-channel allocated to the subscriber station in an uplink control channel region of a frame after a corresponding frame.

17. The method as claimed in claim 10, wherein, in transmitting the one of the ACK message and the NACK message, a number of HARQ enabled downlink bursts are counted, a location of the HARQ enabled downlink burst is determined, a HARQ ACK channel is appointed in an uplink control channel region, and one of ACK information and NACK information is then transmitted through the HARQ ACK channel.

18. The method as claimed in claim 10, wherein the HARQ enabled downlink burst and one of ACK information and NACK information for the HARQ enabled downlink burst are transmitted through a HARQ ACK channel at a same position in the downlink data region.

19. The method as claimed in claim 10, wherein the sub-channel is an ACK channel.

20. A method for operating a Hybrid Automatic Repeat Request (HARQ) scheme for an uplink by a base station in a broadband wireless access communication system, the method comprising the steps of:

determining at least one subscriber station to which a base station will transmit a HARQ enabled burst through a corresponding uplink frame;

determining information of the HARQ enabled burst of the at least one subscriber station;

determining a type of the HARQ enabled burst by analyzing an information element corresponding to the determined subscriber station;

when the HARQ enabled burst being transmitted is a new burst, preparing an uplink MAP message to be transmitted to the subscriber station, preparing an information element corresponding to the uplink MAP message, and receiving the HARQ enabled burst targeting the base station in an uplink data region;

when the HARQ enabled burst being transmitted is a retransmitted burst, preparing an Incremental Redundancy (IR) scheme, preparing the uplink MAP message to be transmitted to the subscriber station, preparing an information element corresponding to the uplink MAP message, and receiving the HARQ enabled burst targeting the base station in the uplink data region;

determining if the received HARQ enabled burst has an error;

preparing one of an ACK message and a NACK message in a form of bitmap, in accordance with a result of the determining; and

transmitting the one of the ACK message and the NACK message.

21. The method as claimed in claim 20, wherein, when the HARQ enabled burst being transmitted is the retransmitted burst, the method further comprises the steps of:

confirming retransmission of an already transmitted burst and preparing an Incremental Redundancy (IR) scheme;

preparing an uplink MAP message to be transmitted to the subscriber station and preparing an information element corresponding to the uplink MAP message;

receiving the HARQ enabled burst targeting the base station itself in the uplink data region; and

applying the IR scheme by combining an already received sub-packet and the HARQ enabled burst.

22. The method as claimed in claim 20, wherein the uplink MAP message in a corresponding frame includes information about a location and a size of the HARQ enabled burst in the corresponding frame, the HARQ enabled burst being an uplink burst transmitted from the subscriber station to the base station.

23. The method as claimed in claim 20, wherein the uplink MAP message appoints a channel in the uplink control channel region, such that one of ACK information and NACK information for the HARQ enabled burst from the base station to the subscriber station can be transmitted through the channel by at least the corresponding frame.

24. The method as claimed in claim 23, wherein, in appointing the channel through which the one of the ACK information and the NACK information can be transmitted, a number of uplink HARQ enabled bursts are counted, a location of the HARQ enabled burst is determined, one bit is appointed in the bitmap of the uplink MAP message, and the one of the ACK information and the NACK information is then transmitted by said one bit.

25. The method as claimed in claim 20, wherein, the step of determining the type of the HARQ enabled burst being transmitted is performed by confirming a value of a continuation field included in the information element.

26. The method as claimed in claim 20, wherein the step of transmitting the one of the ACK message and the NACK message comprises the steps of:

when the received HARQ enabled burst has no error, preparing ACK information, performing HARQ bitmap coding for the prepared ACK information, and transmitting the coded ACK information in a form of a bitmap through the uplink MAP message in the corresponding frame; and

when the received HARQ enabled burst has an error, preparing NACK information, performing HARQ bitmap coding for the prepared NACK information, and transmitting the coded NACK information in a form of a bitmap through the uplink MAP message in the corresponding frame.

27. The method as claimed in claim 20, wherein the one of the ACK message and the NACK message is transmitted in a form of a bitmap through an uplink MAP message of a frame after the corresponding frame.

28. The method as claimed in claim 20, wherein the HARQ enabled burst and one of ACK information and NACK information for the HARQ enabled burst are transmitted through a HARQ ACK channel at a same position in the uplink data region.

29. The method as claimed in claim 20, wherein one of ACK information and NACK information for the HARQ enabled burst transmitted from the subscriber station to the base station is expressed in a form of a bitmap

in an uplink MAP message broadcasted from the base station to the subscriber station at a frame after the corresponding frame.

30. The method as claimed in claim 20, wherein the bitmap includes a field representing a fixed length and a field representing a variable length of a transmitted bitmap.

FIG.1

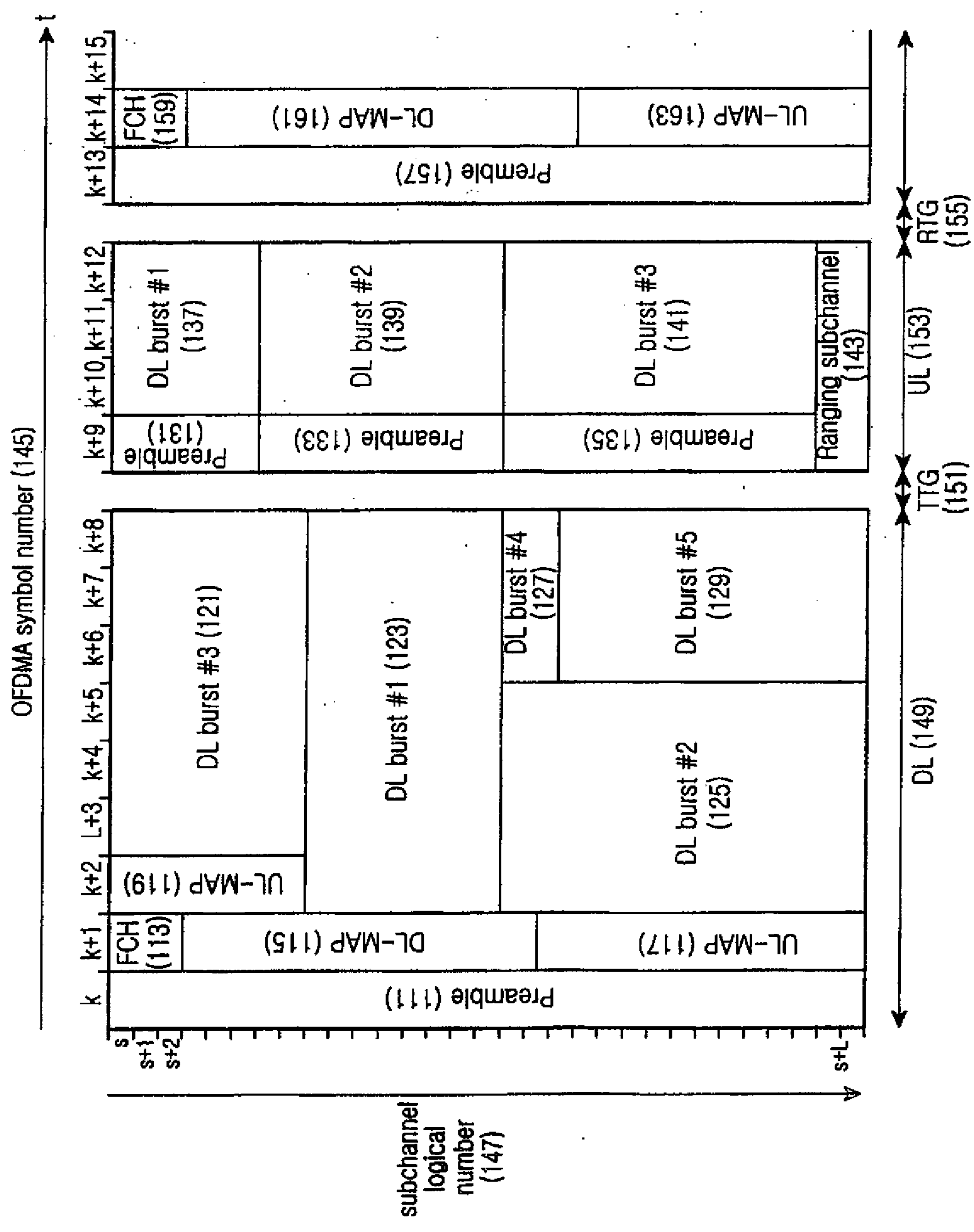
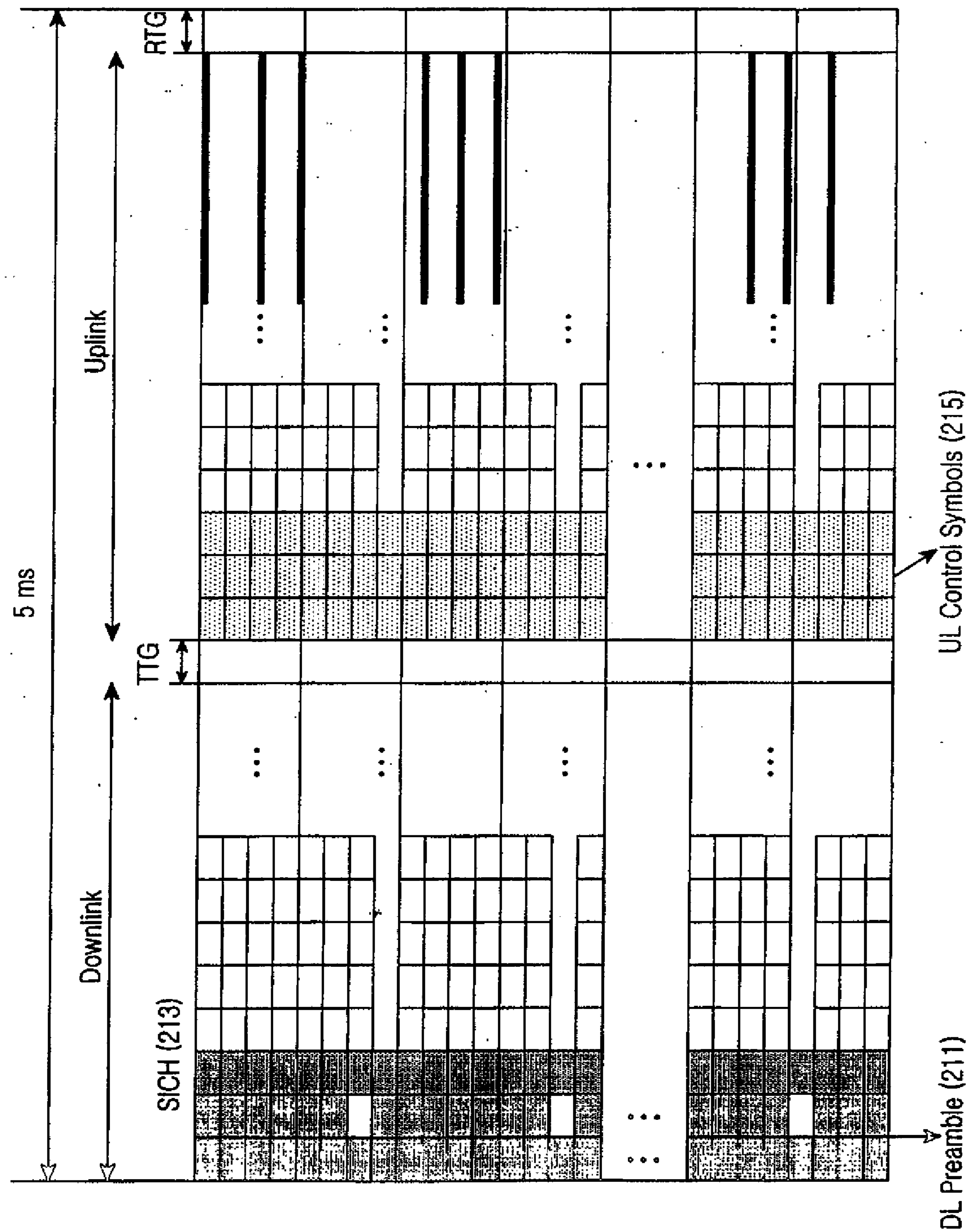

OFDMA symbol number (145)
t
k
k+1
k+2
L+3
k+4
k+5
k+6
k+7
k+8
k+9
k+10
k+11
k+12
k+13
k+14
k+15
Preamble (111)
FCH (113)
DL-MAP (115)
UL-MAP (117)
UL-MAP (119)
DL burst #3 (121)
DL burst #1 (123)
DL burst #2 (125)
DL burst #4 (127)
DL burst #5 (129)
Preamble (131)
Preamble (133)
Preamble (135)
DL burst #1 (137)
DL burst #2 (139)
DL burst #3 (141)
Ranging subchannel (143)
Premble (157)
FCH (159)
DL-MAP (161)
UL-MAP (163)
DL (149)
TTG (151)
UL (153)
RTG (155)
s
s+1
s+2
s+L
subchannel logical number (147)

FIG.2


5 ms
Uplink
Downlink
RTG
TTG
SICH (213)
UL Control Symbols (215)
DL Preamble (211)

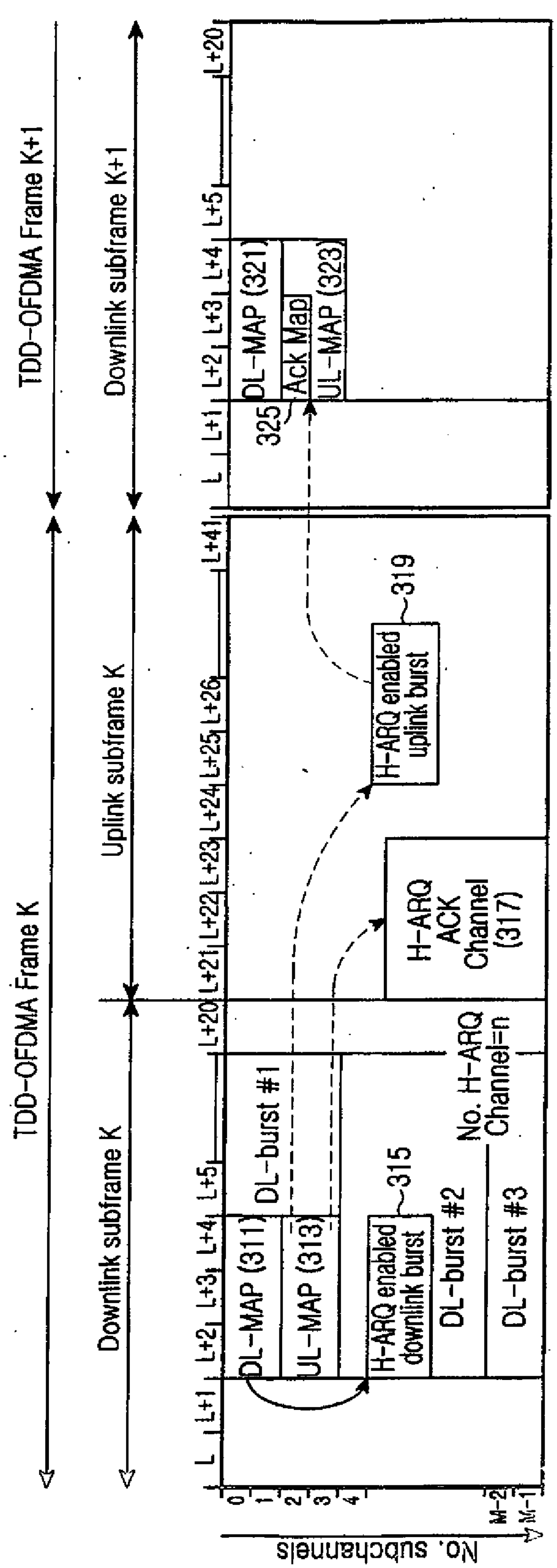

TDD-OFDMA Frame K
TDD-OFDMA Frame K+1
Downlink subframe K
Uplink subframe K
Downlink subframe K+1
No. subchannels
L
L+1
L+2
L+3
L+4
L+5
L+20
L+21
L+22
L+23
L+24
L+25
L+26
L+41
DL-MAP (311)
UL-MAP (313)
H-ARQ enabled downlink burst
315
DL-burst #1
DL-burst #2
DL-burst #3
No. H-ARQ Channel=n
H-ARQ ACK Channel (317)
H-ARQ enabled uplink burst
319
DL-MAP (321)
Ack Map
UL-MAP (323)
325

FIG.3

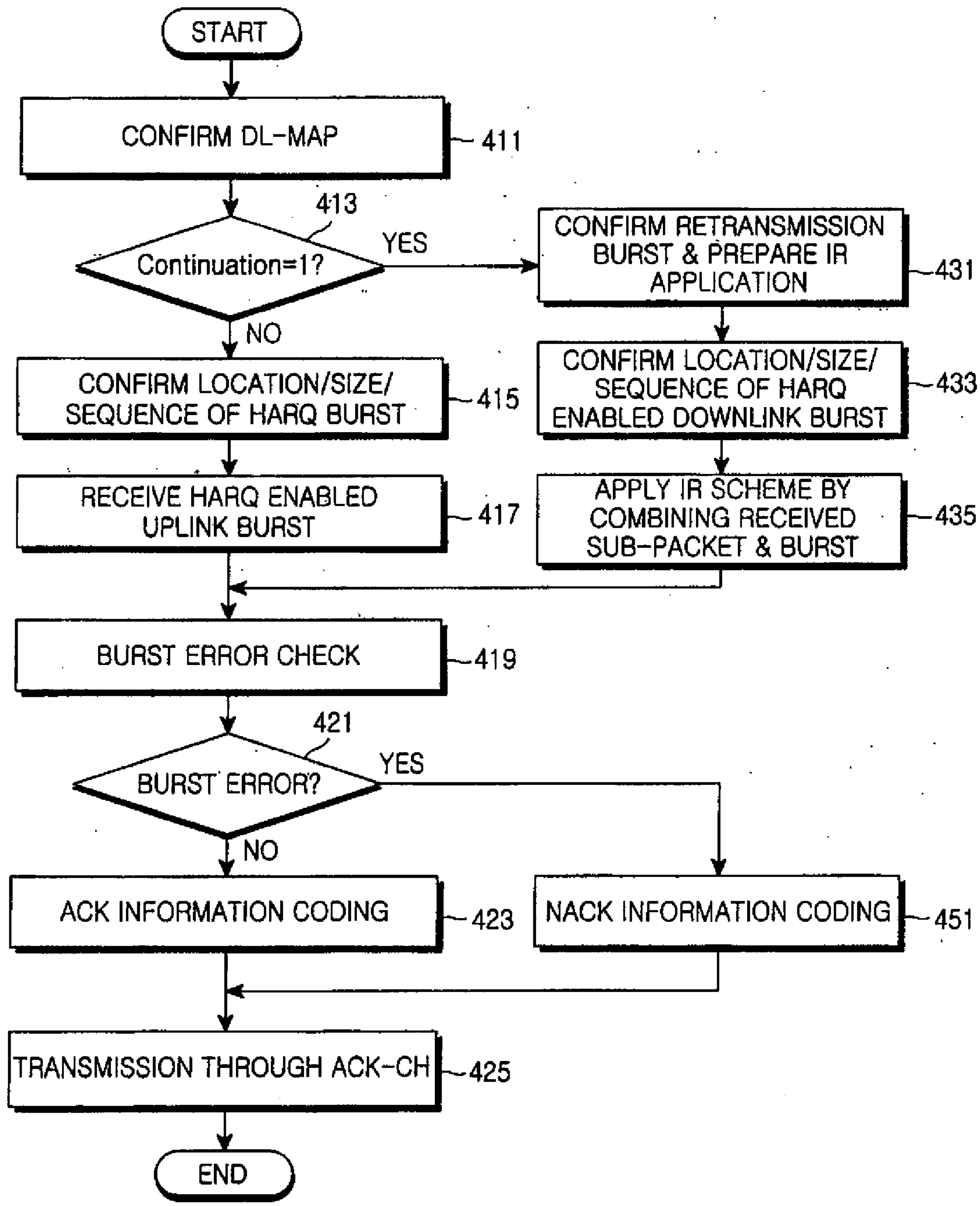

START
CONFIRM DL-MAP
411
413
Continuation=1?
YES
CONFIRM RETRANSMISSION BURST & PREPARE IR APPLICATION
431
NO
CONFIRM LOCATION/SIZE/ SEQUENCE OF HARQ BURST
415
CONFIRM LOCATION/SIZE/ SEQUENCE OF HARQ ENABLED DOWNLINK BURST
433
RECEIVE HARQ ENABLED UPLINK BURST
417
APPLY IR SCHEME BY COMBINING RECEIVED SUB-PACKET & BURST
435
BURST ERROR CHECK
419
421
BURST ERROR?
YES
NO
ACK INFORMATION CODING
423
NACK INFORMATION CODING
451
TRANSMISSION THROUGH ACK-CH
425
END

FIG.4

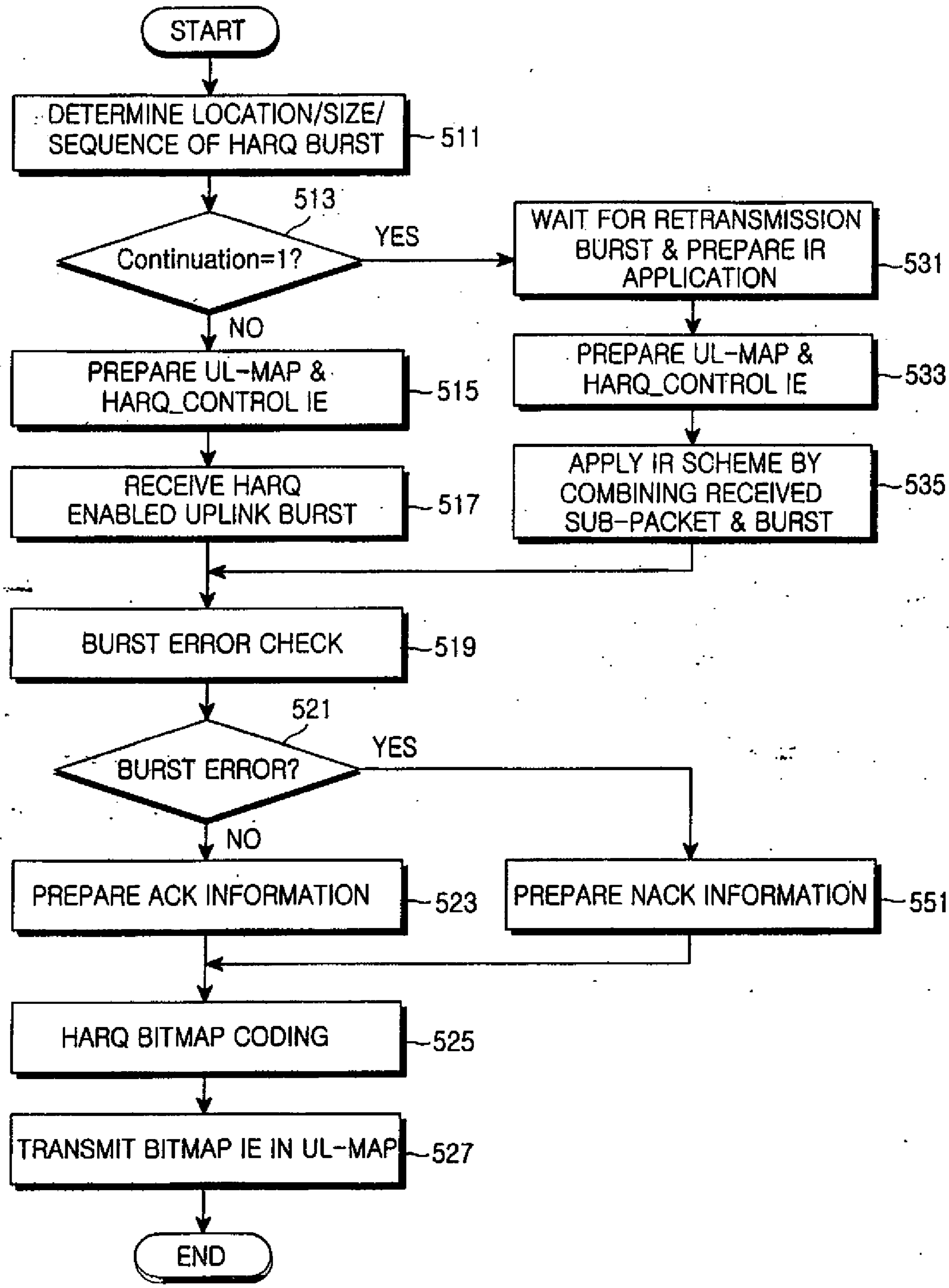

START
DETERMINE LOCATION/SIZE/ SEQUENCE OF HARQ BURST
511
513
Continuation=1?
YES
NO
WAIT FOR RETRANSMISSION BURST & PREPARE IR APPLICATION
531
PREPARE UL-MAP & HARQ_CONTROL IE
515
PREPARE UL-MAP & HARQ_CONTROL IE
533
RECEIVE HARQ ENABLED UPLINK BURST
517
APPLY IR SCHEME BY COMBINING RECEIVED SUB-PACKET & BURST
535
BURST ERROR CHECK
519
521
BURST ERROR?
YES
NO
PREPARE ACK INFORMATION
523
PREPARE NACK INFORMATION
551
HARQ BITMAP CODING
525
TRANSMIT BITMAP IE IN UL-MAP
527
END

FIG.5

Electronic Acknowledgement Receipt

EFS ID:	4507769
Application Number:	12159841
International Application Number:	
Confirmation Number:	3203
Title of Invention:	METHOD OF TRANSMITTING/RECEIVING A PAGING MESSAGE IN A WIRELESS COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Young Dae Lee
Customer Number:	35884
Filer:	Puya Partow-Navid/Adrian Lee
Filer Authorized By:	Puya Partow-Navid
Attorney Docket Number:	2101-3515
Receipt Date:	22-DEC-2008
Filing Date:	
Time Stamp:	19:45:52
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Filed (SB/08)	IDS.pdf	608779 de568a77d34cbcdcd6e513deb1180ac965d80afc	no	5

Warnings:

Information:

2	NPL Documents	3GPP-AdHocMeeting-R1-060034.pdf	250685 7cb8904ea77de15e8694a2af60f05406ea336dff	no	6
Warnings:					
Information:					
3	NPL Documents	3GPP-Meeting49-R2-052985.pdf	161822 d3f096c1e3e9f7aabc261f8b9c42c1e0ec79c451	no	3
Warnings:					
Information:					
4	NPL Documents	3GPP-TSG-R1-061712.pdf	165505 ef2b0e2f1ad920fb0edcd120f9693a8088c60234	no	3
Warnings:					
Information:					
5	NPL Documents	3GPP-TSG-RAN-R2-060106.pdf	379953 f212970a2e9f4eb4cef3d5cec5da5ab90f944b93	no	4
Warnings:					
Information:					
6	NPL Documents	3GPP-TSG-RAN-R2-061012.pdf	276184 038f031bdf92d98c2805a5a932bbbfea0548d997	no	3
Warnings:					
Information:					
7	NPL Documents	Common-Channel-Soft-handoff.pdf	1152990 976c4746ddfb11017874d6649dcc7d9fa9f6fcfe	no	14
Warnings:					
Information:					
8	NPL Documents	npl1.pdf	530946 6fc8ddf272c4cca22ac8f68b3b6271eb7ef4c372	no	9
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Information:					
9	NPL Documents	npl2.pdf	456670 43b59a8d0f9cfa3f1b44c039f2b6b82370a2ddad	no	6
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Information:					
10	Foreign Reference	WO0247417.pdf	766008 eabdd94f14901f8c2d3564b22f98999214de8224	no	18
Warnings:					
Information:					

11	Foreign Reference	WO03007636.pdf	943992 77d42e234f4b773514f960ecdca88d73d75bd202	no	24
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12	Foreign Reference	WO03017691.pdf	1759480 125db7d608097ae5bbcd0410a9fd179016894b6a	no	44
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14	Foreign Reference	WO03056723.pdf	1307348 b02aefdb5169d9dc51dfce15db7da3ad30812c74	no	26
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Information:					
15	Foreign Reference	WO2005074312.pdf	1312997 e03ecd2c49be6f8a5485c6ad587e89f7615f062c	no	47
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Warnings:					
Information:					
			Total Files Size (in bytes):	12111681	

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National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	12159841
	Filing Date	
	First Named Inventor	Young Lee
	Art Unit	2617
	Examiner Name	
	Attorney Docket Number	2101-3515

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	1	WO1999/063713	WO		1999-12-09	TANTIVY COMMUNICATIONS		☐
	2	EP1599063	EP		2005-11-23	SAMSUNG ELECTRONICS		☐
	3	WO2004/034656	WO		2004-04-22	GOLDEN BRIDGE TECHNOLOGY, INC.		☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	12159841
	Filing Date	
	First Named Inventor	Young Lee
	Art Unit	2617
	Examiner Name	
	Attorney Docket Number	2101-3515

	4	WO2002/039760	WO		2002-05-16	NOKIA		☐
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	12159841
	Filing Date	
	First Named Inventor	Young Lee
	Art Unit	2617
	Examiner Name	
	Attorney Docket Number	2101-3515

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☐ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Puya Partow-Navid/	Date (YYYY-MM-DD)	2008-12-19
Name/Print	Puya Partow-Navid	Registration Number	59,657

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(19) Europäisches Patentamt
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(12) EUROPEAN PATENT APPLICATION

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(30) Priority: 19.05.2004 KR 2004035729

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80538 München (DE)

(54) **Method and apparatus for scheduling enhanced uplink dedicated channels in a mobile communication system**

(57) An apparatus and method are provided for performing scheduling in a Node B for data transmission of a user equipment (UE) in a mobile communication system supporting an enhanced uplink dedicated channel (E-DCH). The Node B receives, from a radio network controller (RNC), scheduling assistance information for an uplink service to be provided from the UE. The Node B estimates a data amount for the uplink service on the basis of the scheduling assistance information in each scheduling period. The Node B schedules data transmission for the uplink service according to the estimated data amount.

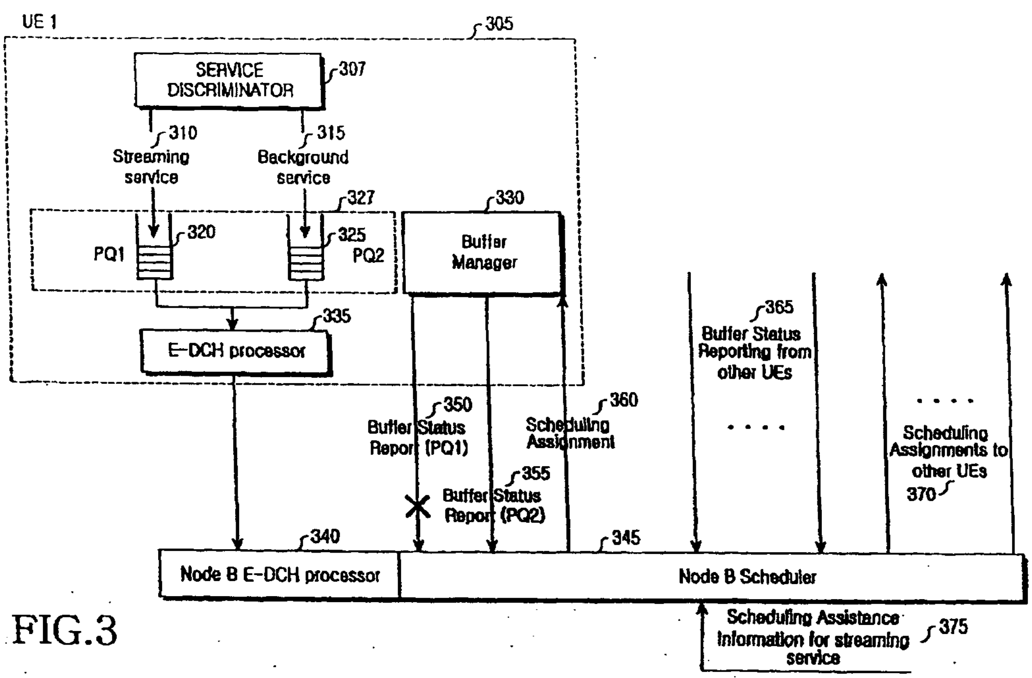

FIG.3

EP 1 599 063 A1

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Description

BACKGROUND OF THE INVENTION

Field of the Invention:

[0001] The present invention relates generally to an asynchronous wideband code division multiple access (WCDMA) communication system. More particularly, the present invention relates to a scheduling method and apparatus for supporting an enhanced uplink dedicated channel (E-DCH).

Description of the Related Art:

[0002] A universal mobile telecommunication service (UMTS) system serving as the third generation mobile communication system uses wideband code division multiple access (WCDMA) based on a global system for mobile communications (GSM) serving as a European mobile communication system and general packet radio services (GPRS). The UMTS system performs packet-based transmission of text, digitized voice, video, and multimedia at data rates up to 2 megabits per second (Mbps) that offers a consistent set of services to mobile computer and phone users no matter where they are located in the world. In UMTS, a packet-switched connection using a packet protocol such as an Internet Protocol (IP) uses a virtual connection that is always available to any other end point in the network.

[0003] In uplink (UL) communications from a user equipment (UE) to a Node B, the UMTS system uses an enhanced uplink dedicated channel (E-DCH) to improve the performance of packet transmission. The E-DCH supports technologies such as adaptive modulation and coding (AMC), hybrid automatic retransmission request (HARQ), Node B control scheduling, and others in order to support stable high-speed data transmission.

[0004] The AMC determines modulation and coding schemes of a data channel according to channel states between a Node-B and a UE, and improves resource use efficiency. A combination of the modulation and coding schemes is referred to as a modulation and coding scheme (MCS). Various MCS levels can be defined by supportable modulation and coding schemes. The AMC adaptively changes an MCS level according to channel states between a Node-B and a UE, and improves resource use efficiency.

[0005] The HARQ is a scheme for re-transmitting a packet to compensate for an erroneous packet when an error occurs in an initially transmitted data packet. The HARQ scheme is divided into a chase combining (CC) scheme for re-transmitting a packet with the same format as that of the initially transmitted data packet when an error occurs, and an incremental redundancy (IR) scheme for re-transmitting a packet with a format different from that of the initially transmitted data packet when an error occurs.

[0006] According to the Node B control scheduling, a Node B determines uplink data transmission and an upper limit of a data rate when multiple UEs transmit data using the E-DCH, and sends information to the UEs through a scheduling command. The UEs refer to the scheduling command, and determine a data rate of an uplink E-DCH.

[0007] FIG. 1 illustrates uplink packet transmission through the E-DCH in the conventional wireless communication system. In FIG. 1, reference numeral 100 denotes a Node B for supporting the E-DCH, and reference numerals 101, 102, 103, and 104 denote UEs using the E-DCH. As illustrated in FIG. 1, the UEs 101 to 104 transmit data to the Node B 100 through E-DCHs 111, 112, 113, and 114, respectively.

[0008] Using a data buffer status, requested data rate, or channel status information of the UEs 101 to 104, the Node B 100 provides each UE with information indicating if E-DCH data transmission is possible, or performs a scheduling operation for controlling an E-DCH data rate. To improve the overall performance of the system, the scheduling operation assigns relatively low data rates to the UEs 103 and 104 that are far away from the Node B 100 such that a noise rise value measured by the Node B 100 does not exceed a target value. However, the scheduling operation assigns relatively high data rates to the UEs 101 and 102 close to the Node B 100.

[0009] FIG. 2 is a call flow diagram illustrating a transmission and reception procedure through the conventional E-DCH.

[0010] Referring to FIG. 2, the Node B and the UE establish the E-DCH in step 202. Step 202 includes a process for sending messages through a dedicated channel. When the E-DCH has been established, the UE notifies the Node B of scheduling information in step 204. The scheduling information includes UE transmission power information for an uplink channel, remaining UE transmission power information, information about an amount of transmission data accumulated in a buffer of the UE, and others.

[0011] When receiving the scheduling information from a plurality ofUEs currently performing communication, the Node B monitors scheduling information of the UEs to schedule data transmission of the UEs in step 206. In step 208, the Node B determines whether to allow the UE to transmit an uplink packet, and sends a scheduling assignment command to the UE. The scheduling assignment command includes information about an allowed data rate and allowed transmission timing, and others. In step 210, the UE determines the amount of radio resources to be assigned to the

E-DCH using the scheduling assignment command. In steps 212 and 214, the UE transmits uplink (UL) packet data through the E-DCH and simultaneously sends, to the Node B, radio resource assignment information including a transport format resource indicator (TFRI) necessary to demodulate the E-DCH. In step 214, the UE selects an MCS level by considering radio resources assigned by the Node B and a channel state, and transmits the UL packet data using the MCS level.

[0012] In step 216, the Node B determines if an error is present in the TFRI and/or the packet data. In step 218, the Node B sends non-acknowledge (NACK) information to the UE through an NACK channel when an error is present, and sends acknowledge (ACK) information to the UE through an ACK channel when no error is present. When the ACK information is sent, the packet data transmission is completed, and the UE transmits new user data through the E-DCH. However, when the NACK information is sent, the UE re-transmits the same packet data through the E-DCH.

[0013] Representative services capable of being provided through the E-DCH are a streaming service, interactive service, and background service. The streaming service is a quasi-realtime service sensitive to delay, and corresponds to, for example, video streaming. In this streaming service, data is generated regularly, but the utility value of the data is lost when the data is delayed for a predetermined time. The interactive service is not sensitive to delay, but a user is inconvenienced when data transmission or reception is delayed for a relatively long time. For example, a web browsing service corresponds to the interactive service. In this interactive service, data is irregularly generated, and the utility value of the data is not lost due to delay. The background service is not sensitive to delay as in a file transfer protocol (FTP), and does not have a serious problem even though data transmission or reception is delayed for a relatively long time. In this background service, data is irregularly generated, but the utility value of the data is not lost due to delay.

[0014] Because data generation is irregular and not predicted in the case of the interactive or background service, a method for reporting a buffer status to the Node B is useful whenever data is generated. However, because data is regularly generated in the streaming service, the method for reporting a buffer status to the Node B whenever data is generated is inefficient.

[0015] For example, in the case of a service in which video is coded according to the H.263 standard which is incorporated herein by reference, 128 75-byte packets are generated per second. Alternatively, in the case of a service in which voice is coded at a 12.2 kbps adaptive multi-rate, 50 32-byte packets are generated per second. In the case where data is generated regularly, an operation for reporting a buffer state whenever data is generated is an important factor causing radio resources to be wasted.

SUMMARY OF THE INVENTION

[0016] It is, therefore, an aspect of the present invention to prevent the inefficient use of radio resources due to buffer status reporting by suitably selecting buffer state reporting according to a type of service in a user equipment (UE).

[0017] It is another aspect of the present invention to exactly estimate uplink data generation without buffer status reporting of a user equipment (UE) by providing advance information about regularly generated data from a radio network controller (RNC) to a Node B scheduler.

[0018] It is yet another aspect of the present invention to efficiently provide a service sensitive to delay by sending a scheduling assignment command before the utility value of data is lost.

[0019] The above and other aspects of the present invention can be achieved by a method for performing scheduling in a Node B for data transmission of a user equipment (UE) in a mobile communication system supporting an enhanced uplink dedicated channel (E-DCH). The method comprises the steps of receiving, from a radio network controller (RNC), scheduling assistance information for an uplink service to be provided from the UE; estimating a data amount for the uplink service on a basis of the scheduling assistance information in each scheduling period; and scheduling data transmission for the uplink service according to the estimated data amount.

[0020] The above and other aspects of the present invention can also be achieved by an apparatus for performing scheduling in a Node B for data transmission of a user equipment (UE) in a mobile communication system supporting an enhanced uplink dedicated channel (E-DCH). The apparatus comprises a Node B scheduler for receiving, from a radio network controller (RNC), scheduling assistance information for an uplink service to be provided from the UE, estimating a data amount for the uplink service on a basis of the scheduling assistance information in each scheduling period, and scheduling data transmission for the uplink service using the estimated data amount; and an E-DCH processor.

[0021] The above and other aspects of the present invention can also be achieved by a scheduling method for transmitting data according to a scheduling operation of a Node B in a mobile communication system supporting an enhanced uplink dedicated channel (E-DCH). The scheduling method comprises the steps of receiving a radio bearer setup message from a radio network controller (RNC) and establishing radio bearers for the E-DCH according to configuration information included in the radio bearer setup message; examining indication information associated with a buffer status report for at least one uplink service included in the configuration information; and limiting buffer status reporting for an uplink service not requiring the buffer status report, and performing buffer status reporting for an uplink service requiring the buffer status report according to a result of the examination.

[0022] The above and other aspects of the present invention can also be achieved by an apparatus for performing scheduling in a user equipment (UE) for transmitting data according to a scheduling operation of a Node B in a mobile communication system supporting an enhanced uplink dedicated channel (E-DCH). The apparatus comprises a service discriminator for detecting and outputting data according to uplink services to be used by a user; a buffer for storing service data output from the service discriminator; a buffer manager for determining if a buffer status report must be sent according to a buffer status and types of the uplink services, sending the buffer status report according to a result of the determination, and receiving a scheduling assignment command; and an E-DCH processor for transmitting data stored in the buffer to the Node B through the E-DCH in response to the scheduling assignment command.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The above and other aspects and advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 illustrates uplink packet transmission in a conventional mobile communication system;
FIG. 2 is a call flow diagram illustrating a transmission and reception procedure through a conventional enhanced uplink dedicated channel (E-DCH);
FIG. 3 is a block diagram illustrating the operation between a Node B and a user equipment (UE) in accordance with an embodiment of the present invention;
FIG. 4 is a call flow diagram illustrating control signal flows between a Node B and a UE in accordance with an embodiment of the present invention;
FIG. 5 is a flow chart illustrating the operation of the UE in accordance with an embodiment of the present invention; and
FIG. 6 is a flow chart illustrating the operation of the Node B in accordance with an embodiment of the present invention.

[0024] Throughout the drawings, the same or similar elements are denoted by the same reference numerals.

DETAILED DESCRIPTION OF EXEMPLARY PREFERRED EMBODIMENTS

[0025] Embodiments of the present invention will now be described in detail herein below with reference to the accompanying drawings. In the following description, a detailed description of known functions and configurations incorporated herein will be omitted for conciseness. It is to be understood that the phraseology and terminology used herein are for the purpose of description and should not be regarded as limiting.

[0026] First, interfaces between a user equipment (UE) and a Node B in a wideband code division multiple access (WCDMA) system to which the present invention is applied will be described.

[0027] An interface between the UE and a wireless communication network is referred to as a Uu interface. The Uu interface is divided into a control plane used to exchange a control signal and a user plane used to transmit data.

[0028] The control plane comprises a radio resource control (RRC) layer, a radio link control (RLC) layer, a media access control (MAC) layer, and a physical (PHY) layer. The user plane comprises a packet data convergence protocol (PDCP) layer, a broadcast/multicast control (BMC) layer, an RLC layer, a MAC layer, and a PHY layer. The PHY layer is located in each Node B or cell, and the MAC layer, the RRC layer, and others are located in a radio network controller (RNC).

[0029] The PHY layer provides an information transmission service using the radio transfer technology, and corresponds to the first layer of an open system interconnection (OSI) model. Transport channels are connected between the PHY and MAC layers. The transport channels are defined by a scheme for processing specific data in the PHY layer. The transport format of the transport channels is referred to as TF. The transport format of a PHY layer mapped to a plurality of transport channels is indicated by a TFC indicator (TFCI) indicating one of transport format combinations (TFCs).

[0030] The MAC and RLC layer are connected through logical channels. The MAC layer receives data through a logical channel from the RLC layer, and delivers the received data to the PHY layer through a suitable transport channel. Moreover, the MAC layer receives data through a transport channel from the PHY layer, and delivers the received data to the RLC layer through a suitable logical channel. Moreover, the MAC layer inserts additional information into data delivered through a logical or transport channel, or interprets inserted information to take a suitable operation and controls a random access operation. In the MAC layer, an entity relating to a dedicated service is referred to as a MAC-d entity, and an entity relating to a common service is referred to as a MAC-c entity. In relation to an embodiment of the present invention, an entity responsible for controlling the E-DCH and transmitting data through the E-DCH is referred to as a MAC-e entity.

[0031] The RLC layer is responsible for establishing and releasing a logical channel. The RLC layer can operate in one of three operating modes an acknowledged mode (AM), unacknowledged mode (UM), and transparent mode (TM). These three operating modes provide different functions. Conventionally, the RLC layer is responsible for dividing or assembling a service data unit (SDU) received from a higher layer to a suitable size, and an error correction function.

[0032] The PDCP layer is located in a higher level of the RLC layer on the user plane. The PDCP layer is responsible for compressing or decompressing a header of Internet protocol (IP) packet data, and a lossless transfer function in a state in which a RNC providing a service to a specific UE is changed.

[0033] Characteristics of a transport channel connected between PHY and higher layers are defined by the TF prescribing processing schemes such as convolutional channel encoding, interleaving, and service-specific rate matching.

[0034] As described above, the E-DCH used for a WCDMA communication system supports adaptive modulation and coding (AMC), hybrid automatic retransmission request (HARQ), Node B control scheduling, and others. UEs send, to the Node B, scheduling information such as a UE buffer status, a UE power status, and the like such that all available resources of the Node B are assigned to selected optimal terminals at each time interval, and Node B control scheduling is efficiently performed.

[0035] The UEs for providing a plurality of services through the E-DCHs configure a plurality of priority queues (PQs) therefor, and temporarily store service data in the PQs. Then, the UEs report, to the Node B, an amount of data stored in each PQ. The Node B performs scheduling on the basis of reporting of the UEs.

[0036] FIG. 3 illustrates the operation between the Node B and the UE in accordance with an embodiment of the present invention.

[0037] UE-1 305 transmits streaming service data 310 and background service data 315 detected and output by a service discriminator 307 using an E-DCH processor 335. The streaming service data 310 is stored in PQ-1 320 within a buffer 327 before being transmitted through the E-DCH, and the background service data 315 is stored in PQ-2 325 within the buffer 327. A buffer manager 330 monitors the statuses of PQ-1 320 and PQ-2 325. Because the streaming service data 310 is regularly input to PQ-1 320, the buffer manager 330 does not report the buffer status for PQ-1 320.

[0038] The buffer manager 330 determines that service data not requiring buffer status reporting is stored in PQ-1 320. Even when the buffer status for PQ-1 320 is varied, the buffer manager 330 does not send a buffer status report 350. Alternatively, the buffer manager 330 determines that service data requiring buffer status reporting is stored in PQ-2 325. When the buffer status for PQ-2 325 is varied, the buffer manager 330 sends a buffer status report 355.

[0039] For example, the buffer manager 330 sends the buffer status report 355 when new data is stored in PQ-2 325 or a data amount of PQ-2 325 exceeds a threshold value.

[0040] Similarly, a Node B scheduler 345 receives buffer status reporting 365 from other UEs.

[0041] The Node B scheduler 345 assigns radio resources to the UEs on the basis of the buffer status reports 355 and 365 received from the UEs including the UE 305, and scheduling assistance information 375 for a streaming service. Information about the assigned radio resources is sent to corresponding UEs through scheduling assignment commands 360 and 370.

[0042] Specifically, the Node B scheduler 345 receives, from a radio network controller (RNC) (not illustrated), the scheduling assistance information 375 comprising information about regular data generation in PQ-1 320 of LTE-1 305 and information about how to schedule data of PQ-1 320. For example, when data of an amount value E is generated from PQ-1 320 of UE-1 305 in a period D, the scheduling assistance information may include information indicating that transmission resources capable of transmitting the data of the amount value E in the period D must be assigned for PQ-1 320. Accordingly, the scheduler 345 estimates a data amount of PQ-1 320 through the scheduling assistance information 375.

[0043] The scheduler 345 determines basic radio resources to be assigned to transmit data of PQ-1 320 using the estimated data amount of PQ-1 320, and determines radio resources to be assigned to transmit data stored in PQ-2 325 on the basis of the buffer state report 350 sent from UE-1 305. The scheduling assignment command 360 to be sent to UE-1 305 comprises information about a sum of radio resources determined for PQ-1 320 and PQ-2 325.

[0044] The UE 305 to which the radio resources are assigned through the scheduling assignment command 360 sends data stored in the PQs 320 and 325 to the E-DCH processor 335. The E-DCH processor 335 transmits data through the E-DCH. An E-DCH processor 340 of the Node B delivers the data received through the E-DCH to the RNC. The E-DCH processors 335 and 340 are associated with PHY layer implementation, and are not directly associated with the present invention. Accordingly, a detailed description of these E-DCH processors 335 and 340 is omitted.

[0045] For the above-described streaming service, the Node B estimates an amount of streaming service data from scheduling assistance information. The RNC determines the scheduling assistance information on the basis of quality of service (QoS) parameters of radio bearers (RBs) for providing the streaming service. The scheduling assistance information is assistance information necessary to perform scheduling such that the utility value of generated data is not lost as a data generation status is reported to the scheduler in the streaming service. For example, the scheduling assistance information includes information about a data amount (hereinafter, referred to as Data_Amount) and a repetition period (hereinafter, referred to as Repetition_Period).

[0046] Data_Amount indicates an amount of streaming data generated for Repetition_Period. Repetition_Period is a period for maintaining the utility value of the streaming data.

[0047] If the Node B has received, from the UE, the scheduling assistance information for an E-DCH service, it assigns, to the UE, transmission resources capable of transmitting data of Data_Amount in Repetition_Period.

[0048] Data_Amount depends upon a guaranteed bit rate (GBR) and Repetition_Period as in the following.

Data_Amount = [GBR + retransmission margin] * Repetition_Period

[0049] Here, the GBR indicates a bandwidth to be provided at any time for the streaming service or interactive service.

[0050] The retransmission margin indicates an amount of data according to retransmission of the RLC. For example, because one RLC packet data unit (PDU) out of 100 RLC packet data units (PDUs) is retransmitted when a block error rate (BER) of the PHY layer is 0.01, the retransmission margin becomes 0.01. The GBR indicates a bandwidth to be always guaranteed for a corresponding service, and is defined in the form of bits per second (bps).

[0051] Repetition_Period is determined by a transfer delay. The transfer delay is a parameter determined by delay sensitivity of a corresponding service. Repetition_Period is a maximum delay value for a service data unit (SDU) input to a corresponding RB endurable within a Universal Mobile Telecommunications Service (UMTS) Terrestrial Radio Access Network (UTRAN), and is given in milliseconds. In other words, when data does not reach a destination within an allowed transfer delay time, the utility value of the data is lost. In this case, a transmitting side releases the data transmission. The transfer delay and the GBR are defined only for the streaming service.

[0052] Repetition_Period indicates a time interval until the utility value of data is lost after one packet reaches a PQ. That is, because the packet must be transmitted within Repetition_Period, the Node B scheduler schedules the packet within Repetition_Period. However, the Node B scheduler cannot track all individual packet generation statuses. In other words, the UE reports packet arrival whenever a packet arrives at a PQ, but it is almost impossible for the Node B scheduler to schedule all packets within Repetition_Period on the basis of the packet arrival report. When it is taken into account that data is regularly generated in the streaming service, the Node B scheduler can approximate an amount of data generated in each Repetition_Period. The GBR indicates an amount of data per second in the streaming service, and the amount of data generated in each Repetition_Period is a value obtained by multiplying the GBR with Repeition_Period. When the obtained value is added to an amount of retransmission data, Data_Amount to be transmitted in the streaming service is computed. That is, data of Data_Amount is generated in Repetition_Period for the streaming service, and the Node B scheduler determines that Data_Amount must be scheduled in each Repetition_Period.

[0053] Repetition_Period is affected by operating mode of the RLC layer. If the streaming service does not support retransmission in the RLC layer, Repetition_Period has a value close to a transfer delay. Alternatively, if the streaming service supports two retransmissions, Repetition_Period is a half of the transfer delay.

[0054] FIG. 4 is a ladder diagram illustrating control signal flow between a Node B and a UE in accordance with an embodiment of the present invention.

[0055] In step 405, the RNC determines whether to establish two RBs of RB x and RB y with the UE using the E-DCH. The RBs are established to provide a specific service. The RBs comprise a packet data convergence protocol (PDCP) entity and a radio link control (RLC) entity configured suitably to provide the service. The streaming service is provided through RB x, and the background or interactive service is provided through RB y. The RNC sets PQs for RB x and RB y. For example, PQ z is set for RB x, and PQ w is set for RB y. Conventionally, because the streaming service and the background service are assigned different priorities, different PQs are assigned for RB x and RB y. Upon determining scheduling assignment information to be applied to PQ z mapped to the streaming service on the basis of a GBR and transfer delay of the streaming service, the RNC sends an E-DCH setup message to the Node B in step 410. The message includes E-DCH configuration information for RB x and RB y, and PQ z and PQ w configuration information, and further includes scheduling assignment information.

[0056] In step 415, the RNC sends, to the UE, a message comprising the configuration information of the E-DCH for RB x and RB y. The message may be, for example, a RB setup message. The RB setup message comprises indication information (RB x : BRR = off) for limiting buffer status reporting for RB x of the streaming service, and indication information (RB y : BRR = on) for enabling buffer status reporting for RB y of the background or interactive service.

[0057] That is, buffer status reporting required (BRR) for RB x is set to 'off', and a BRR for RB y is set to 'on'. The RB setup message comprises mapping information (RB x : PQ z and RB y : PQ w) between RBs and PQs. The RB setup message may comprise GBR information in place of BRR information. For example, the RB setup message may comprise GBR information as indication information (RB x) for limiting buffer status reporting for RB x of the streaming service, and may not comprise GBR information as indication information (RB y : GBR = y kbps) for enabling buffer status reporting for RB y of the background or interactive service.

[0058] When the GBR is used in indication information for enabling buffer status reporting, the UE can determine buffer status reporting according to a predetermined condition. For example, if an amount of generated RB data included in the GBR information is less than the GBR, the buffer status is not reported. Otherwise, a difference between the GBR and generated buffer data may be reported.

[0059] The present invention supports both a BRR signaling method and a GBR signaling method to control the above-described buffer status reporting, but only the BRR signaling method will be described for convenience.

[0060] Scheduling assistance information for the streaming service is sent to the Node B, and the UE is notified of the presence of the buffer status reporting. When an E-DCH is established between the Node B and the UE, they initiate E-DCH communication. Even when the UE generates data for a RB not requiring buffer status reporting as in the streaming service, it does not notify the Node B of the data generation. The Node B estimates the buffer status for PQ z by taking into account data generation corresponding to Data_Amount in each Repetition_Period in the UE according to the scheduling assistance information received from the RNC. When buffer state reporting is not received from the UE, the Node B assigns, to the UE, radio resources associated with the estimated Data_Amount in step 420.

[0061] In step 425, when the UE generates data of an amount 'a' for RB y requiring a buffer status report as in the interactive or background service, the data is stored in PQ w, and reports the buffer status for PQ w.

[0062] In step 430, the Node B assigns, to the UE, transmission resources capable of transmitting all data based on the estimated Data_Amount for PQ z and the data amount 'a' reported for PQ w.

[0063] Similarly, in step 435, when the UE sends a buffer status report of 'PQ w = b', the Node B assigns, to the UE, transmission resources capable of transmitting all data based on the estimated Data_Amount and the data amount 'b' reported for PQ w in step 440.

[0064] FIG. 5 is a flow chart illustrating the operation of the UE in accordance with an embodiment of the present invention.

[0065] In step 505, the UE receives an RB setup message. The message comprises RB configuration information (RLC configuration information, BRR information, and others) and E-DCH configuration information.

[0066] In step 510, the UE establishes RBs according to the configuration information. In this case, two layer entities such as PDCP and RLC are established, and a suitable transport channel is connected. In an embodiment of the present invention, the transport channel is an E-DCH. The UE establishes the E-DCH according to the setup message. In this case, an E-DCH processor is established, and various physical channels are established.

[0067] In step 515, the UE examines a BRR of the established RB, or examines the presence of a GBR of the established RB. If the BRR is off or the GBR is included, the UE proceeds to step 520. However, if the BRR is on or the GBR is not included, the UE proceeds to step 525.

[0068] If the BRR is off, the UE applies Buffer Status Reporting Method 1 for an RB. Buffer Status Reporting Method 1 is applied for RBs to which scheduling assignment information is set.

Buffer Status Reporting Method 1

[0069]

Alternative 1: No buffer status reporting is performed for a corresponding RB.

Alternative 2: If untransmitted data is still present until the utility value of the data associated with a corresponding RB is lost and discarded, buffer status reporting is performed. Otherwise, no buffer status reporting is performed.

Alternative 3: Buffer status reporting is performed if an amount of data associated with a corresponding RB exceeds a GBR. Otherwise, no buffer status reporting is performed.

[0070] If the BRR is on, the UE applies Buffer Status Reporting Method 2 for the corresponding RB in step 525. Buffer Status Reporting Method 2 is applied for RBs to which scheduling assistance information is not set.

Buffer Status Reporting Method 2

[0071] When data is generated from a corresponding RB and a predetermined condition is satisfied, the UE performs buffer status reporting. The predetermined condition is aimed to prevent excessively frequent buffer status reporting. For example, the predetermined condition can use a threshold value associated with an amount of data stored in a buffer for an RB, and others.

[0072] FIG. 6 is a flow chart illustrating the operation of the Node B in accordance with an embodiment of the present invention.

[0073] In step 605, the Node B receives an E-DCH setup message associated with the UE. The E-DCH setup message comprises configuration information of various physical channels associated with an E-DCH, and others. In step

610, the Node B establishes the E-DCH with the UE according to the setup message. In step 615, the Node B determines if the message comprises scheduling assistance information. If the message includes the scheduling assistance information, the Node B proceeds to step 620. Otherwise, the Node B proceeds to step 625.

[0074] In step 620, when the scheduling assistance information is set, the Node B assigns radio transmission resources capable of transmitting data of an amount estimated from the scheduling assistance information and a buffer status report received from the UE. Streaming data of Data_Amount is generated in each Repetition_Period, regardless of data reported through the buffer status report from the UE, because the streaming data is sensitive to delay. That is, when a buffer status report is not received from the UE, the Node B basically assigns radio resources of Data_Amount in each Repetition_Period in step 620. When the buffer status report is present, the Node B assigns additional transmission resources on the basis of the buffer status report. In step 625, when the scheduling assistance information is not set, the Node B assigns transmission resources on the basis of the buffer status report from the UE.

[0075] As is apparent from the above description, the present invention has a number of advantages.

[0076] For example, the present invention can reduce transmission resources according to a buffer status report between a user equipment (UE) and a Node B. Moreover, the present invention can smoothly provide a service by scheduling data of a streaming service sensitive to delay before the utility value of data is lost.

[0077] Although embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions, and substitutions are possible, without departing from the scope of the present invention. Therefore, the present invention is not limited to the above-described embodiments, but is defined by the following claims, along with their full scope of equivalents.

Claims

1. A method for scheduling, in a Node B, data transmission of a user equipment (UE) in a mobile communication system supporting an enhanced uplink dedicated channel (E-DCH), comprising the steps of:

   receiving, from a radio network controller (RNC), scheduling information for an uplink service to be provided from the UE;
   estimating a data amount for the uplink service based on the scheduling information in each scheduling period; and
   scheduling the data transmission for the uplink service according to the estimated data amount.

2. The method of claim 1, wherein the uplink service is a streaming service whose data is generated regularly.

3. The method of claim 1, wherein the scheduling information comprises information about a predetermined repetition period and an amount of data to be generated for the predetermined repetition period.

4. The method of claim 1, wherein the scheduling step comprises the step of:

   assigning radio resources capable of transmitting all data based on a data amount included in information of a buffer status report and the estimated data amount, when the buffer status report is received from the UE.

5. An apparatus for scheduling, in a Node B, data transmission of a user equipment (UE) in a mobile communication system supporting an enhanced uplink dedicated channel (E-DCH), comprising:

   a Node B scheduler for receiving, from a radio network controller (RNC), scheduling information for an uplink service to be provided from the UE, estimating a data amount for the uplink service based on the scheduling information in each scheduling period, and scheduling the data transmission for the uplink service using the estimated data amount; and
   an E-DCH processor for performing the data transmission for the uplink service according to the scheduling result.

6. The apparatus of claim 5, wherein the uplink service is a streaming service whose data is generated regularly.

7. The apparatus of claim 5, wherein the scheduling information comprises information about a predetermined repetition period and an amount of data to be generated for the predetermined repetition period.

8. The apparatus of claim 5, wherein the Node B scheduler assigns radio resources capable of transmitting all data

based on a data amount included in information of a buffer status report and the estimated data amount, when the buffer status report is received from the UE.

9. A method for reporting a buffer status in a user equipment(UE) in a mobile communication system supporting an enhanced uplink dedicated channel (E-DCH), comprising the steps of:

receiving a control message from a radio network controller (RNC) and establishing radio bearers according to configuration information included in the control message;
examining information associated with a buffer status report for at least one service included in the configuration information; and
limiting the buffer status reporting for the service not requiring the buffer status report, and performing buffer status reporting for the service requiring the buffer status report according to a result of the examination.

10. The scheduling method of claim 9, further comprising the steps of:

determining a streaming service whose data is regularly generated as the service that does not require the buffer status report; and
determining a background service whose data is not regularly generated as the service that requires the buffer status report.

11. The scheduling method of claim 9, wherein the examining step comprises the step of:

determining if the buffer status report is required according to 'on' setup information of buffer status reporting required (BRR) included in the indication information or guaranteed bit rate (GBR) information.

12. The scheduling method of claim 9, wherein the step of performing the buffer status reporting comprises the step of:

sending the buffer status report to the Node B, wherein the buffer status report comprises information about an amount of data for at least one different service rather than a streaming service whose data is generated regularly.

13. The scheduling method of claim 12, wherein the step of performing the buffer status reporting comprises the step of:

sending, to the Node B, the buffer status report comprising information about the amount of data for the at least one different service, when new data for the at least one different service is generated or the amount of data for the at least one different service exceeds a threshold value.

14. The scheduling method of claim 9, further comprising the step of:

sending, to the Node B, the buffer status report comprising information about an amount of data to be transmitted for the at least one uplink service, when untransmitted data is still present until a utility value of the data for the at least one uplink service not requiring the buffer status report is lost and discarded.

15. An apparatus for scheduling, in a user equipment (UE), data transmission in a mobile communication system supporting an enhanced uplink dedicated channel (E-DCH), comprising:

a buffer for storing service data output;
a buffer manager for determining if a buffer status report must be sent according to a buffer status and types of services, sending the buffer status report according to a result of the determination, and receiving a scheduling assignment command; and
an E-DCH processor for transmitting data stored in the buffer to the Node B in response to the scheduling assignment command.

16. The apparatus of claim 15, wherein the service discriminator detects streaming service data regularly generated and service data irregularly generated.

17. The apparatus of claim 15, wherein the buffer manager receives, from a radio network controller (RNC), information indicating if the buffer status report for an uplink service is required.

18. The apparatus of claim 17, wherein the buffer manager examines indication information indicating if the buffer status report for an uplink service is required, limits buffer status reporting for an uplink service if the buffer status report is not required, and performs buffer status reporting for an uplink service if the buffer status report is required.

19. The apparatus of claim 18, wherein the buffer manager determines if the buffer status report is required according to 'on' setup information of buffer status reporting required (BRR) included in the indication information or guaranteed bit rate (GBR) information.

20. The apparatus of claim 15, wherein the buffer manager sends the buffer status report to the Node B, wherein the buffer status report comprises information about an amount of data for at least one different service rather than a streaming service whose data is generated regularly.

21. The apparatus of claim 20, wherein the buffer manager sends, to the Node B, the buffer status report comprising information about the amount of data for the at least one different service, when new data for the at least one different service is generated or the amount of data for the at least one different service exceeds a threshold value.

22. The apparatus of claim 15, wherein the buffer manager sends, to the Node B, the buffer status report comprising information about an amount of data to be transmitted for an uplink service, when untransmitted data is still present until a utility value of the data for the uplink service not requiring the buffer status report is lost and discarded.

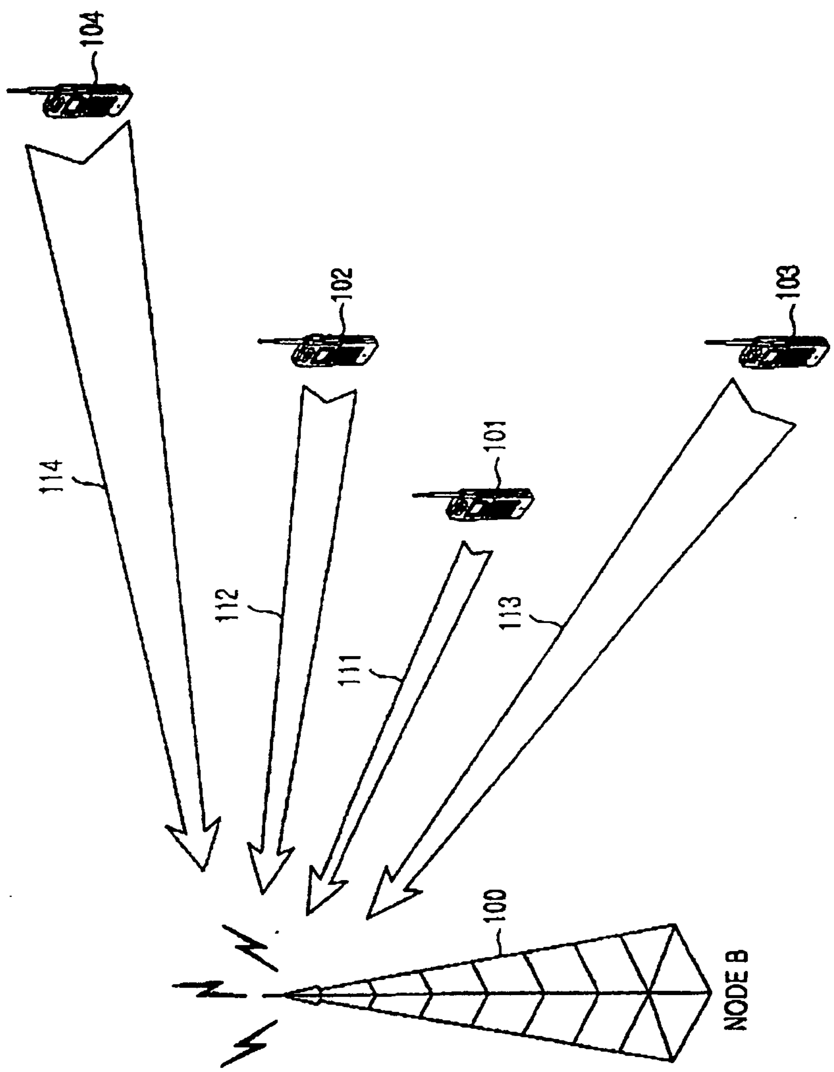

FIG.1

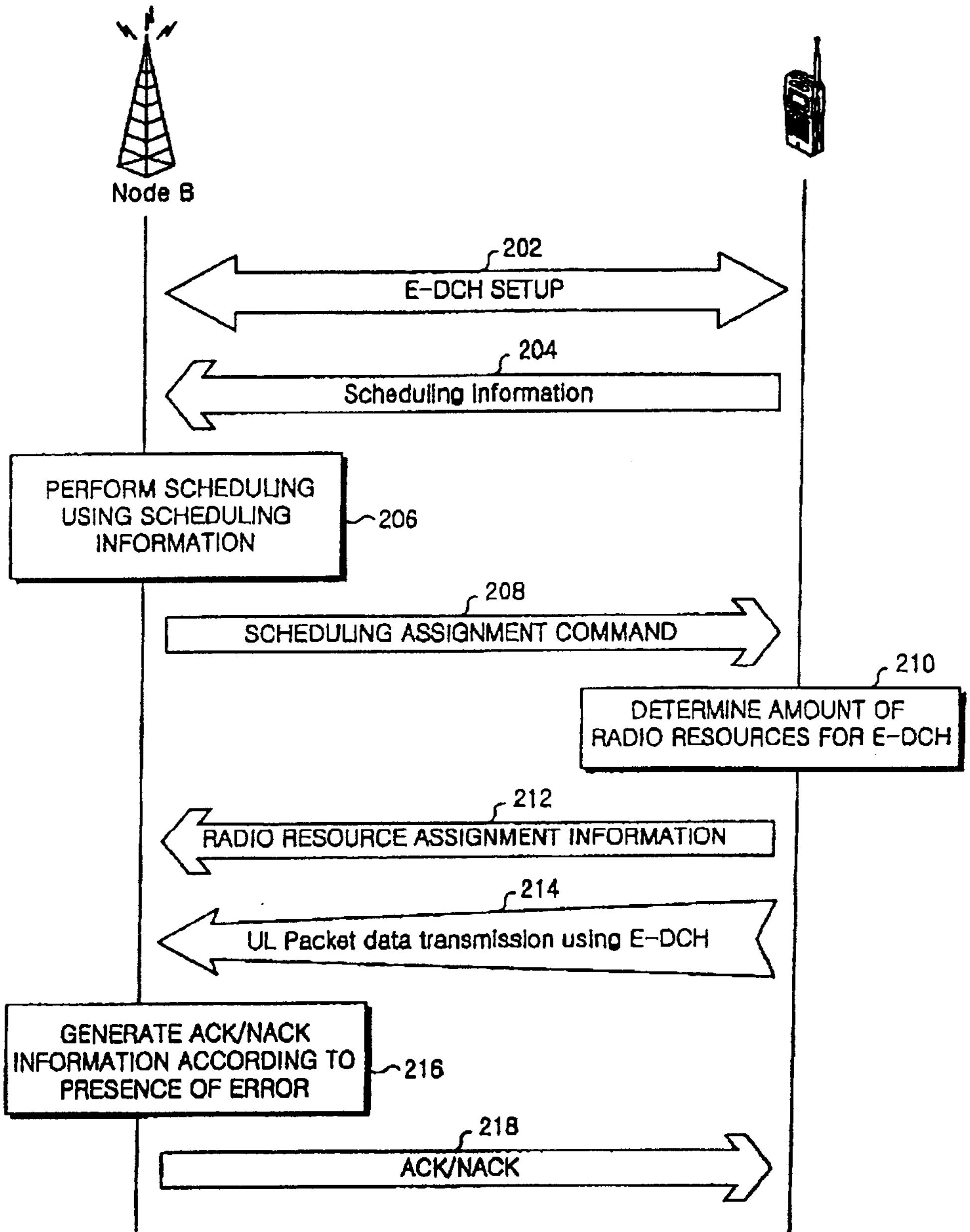
Node B
202
E-DCH SETUP
204
Scheduling Information
PERFORM SCHEDULING USING SCHEDULING INFORMATION
206
208
SCHEDULING ASSIGNMENT COMMAND
210
DETERMINE AMOUNT OF RADIO RESOURCES FOR E-DCH
212
RADIO RESOURCE ASSIGNMENT INFORMATION
214
UL Packet data transmission using E-DCH
GENERATE ACK/NACK INFORMATION ACCORDING TO PRESENCE OF ERROR
216
218
ACK/NACK

FIG.2

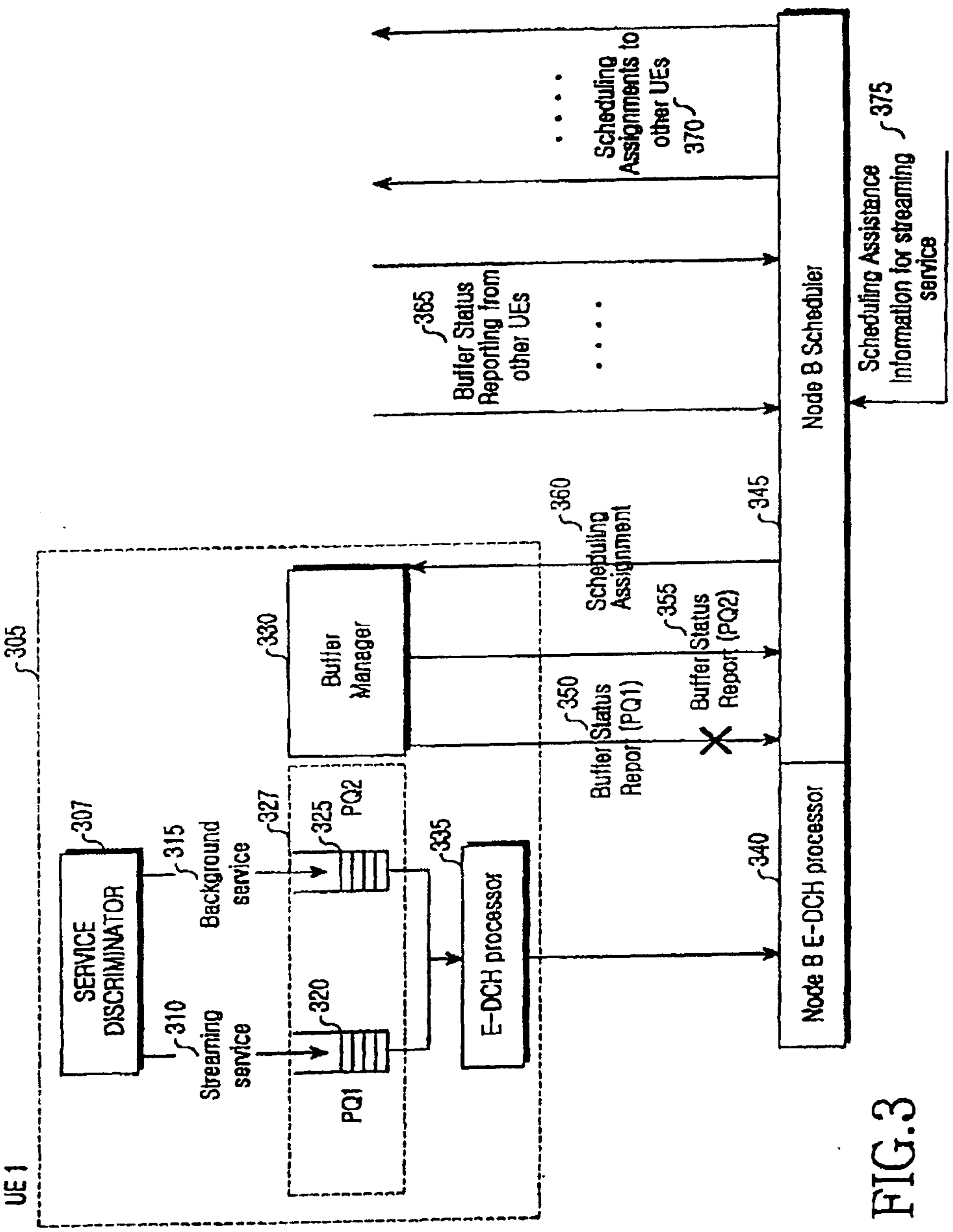
UE 1
305
SERVICE DISCRIMINATOR
307
310
Streaming service
315
Background service
327
320
325
PQ1
PQ2
330
Buffer Manager
335
E-DCH processor
350
Buffer Status Report (PQ1)
355
Buffer Status Report (PQ2)
360
Scheduling Assignment
345
340
Node B E-DCH processor
Node B Scheduler
365
Buffer Status Reporting from other UEs
Scheduling Assignments to other UEs
370
375
Scheduling Assistance Information for streaming service

FIG.3

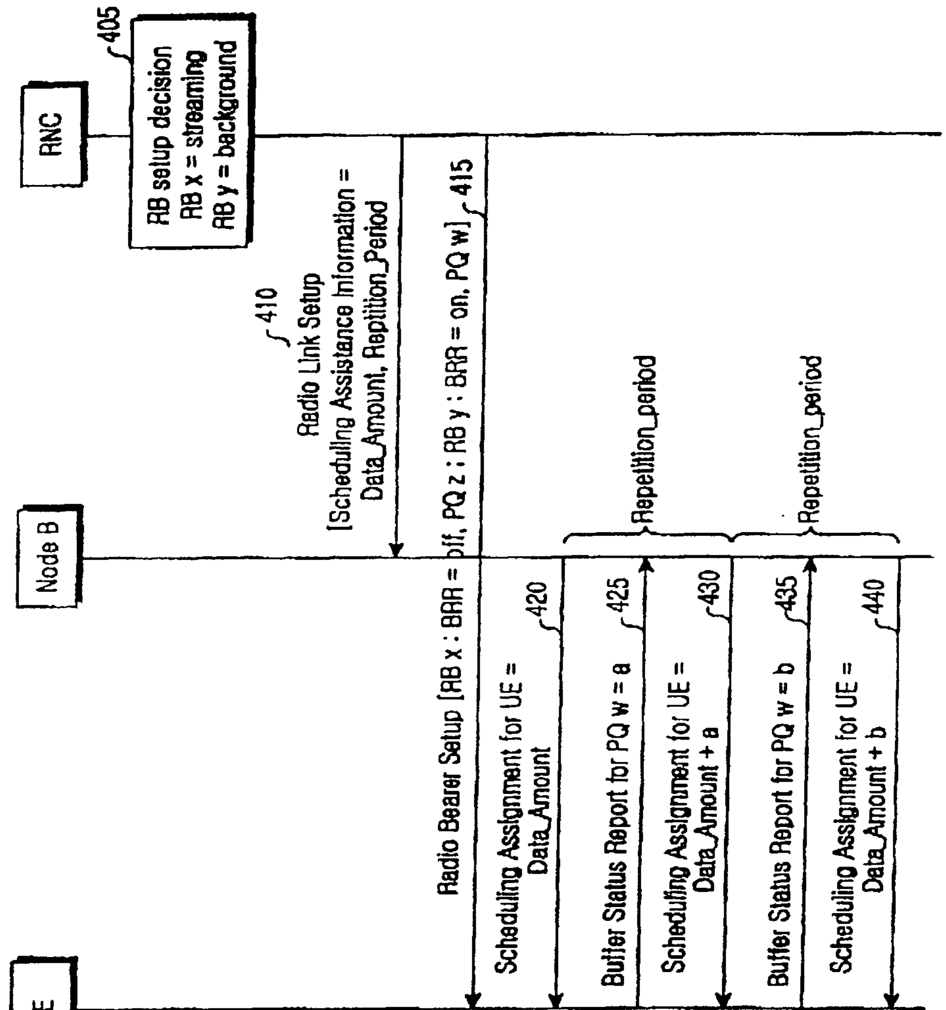
UE
Node B
RNC
405
RB setup decision
RB x = streaming
RB y = background
410
Radio Link Setup
[Scheduling Assistance Information =
Data_Amount, Reptition_Period
Radio Bearer Setup [RB x : BRR = off, PQ z ; RB y : BRR = on, PQ w]
415
Scheduling Assignment for UE =
Data_Amount
420
Buffer Status Report for PQ w = a
425
Scheduling Assignment for UE =
Data_Amount + a
430
Repetition_period
Buffer Status Report for PQ w = b
435
Scheduling Assignment for UE =
Data_Amount + b
440
Repetition_period

FIG.4

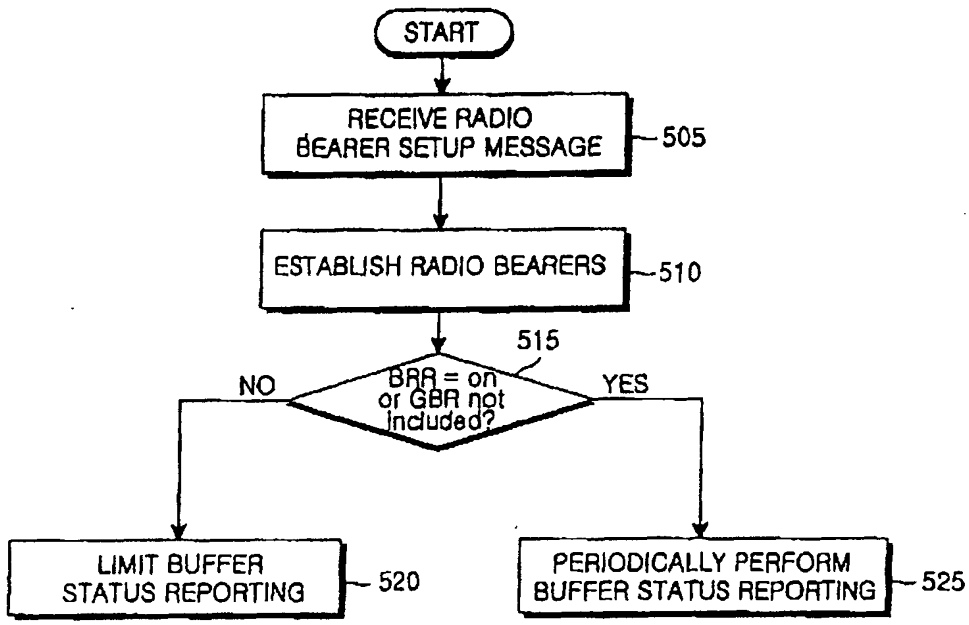
START
RECEIVE RADIO BEARER SETUP MESSAGE
505
ESTABLISH RADIO BEARERS
510
515
BRR = on or GBR not included?
NO
YES
LIMIT BUFFER STATUS REPORTING
520
PERIODICALLY PERFORM BUFFER STATUS REPORTING
525

FIG.5

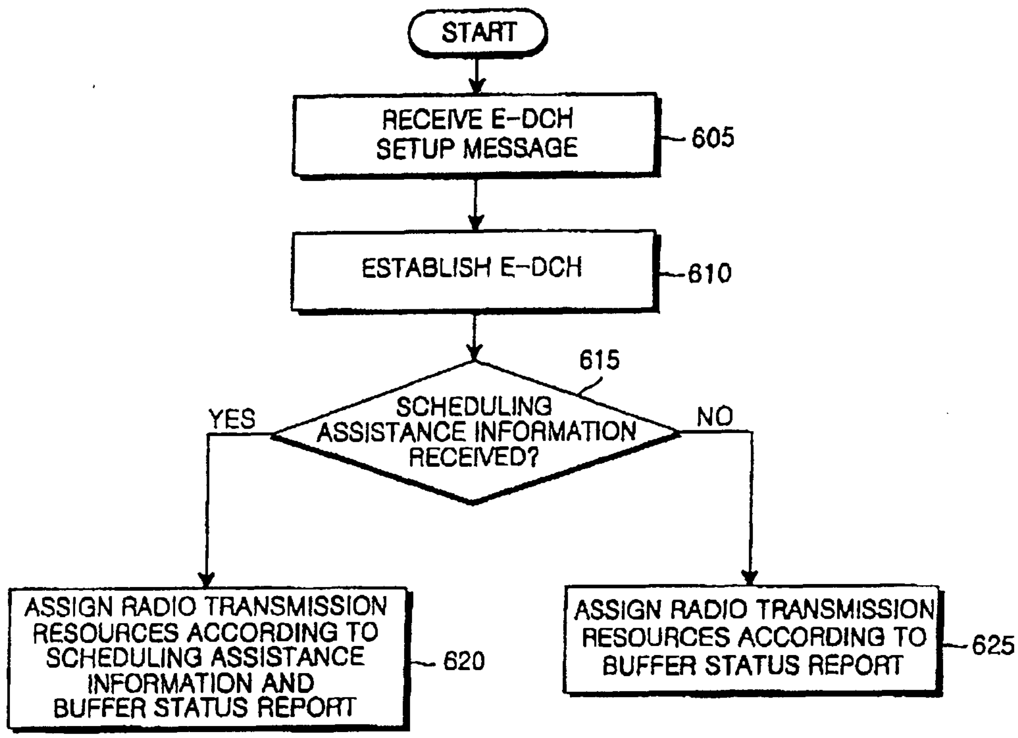
START
RECEIVE E-DCH SETUP MESSAGE
605
ESTABLISH E-DCH
610
615
SCHEDULING ASSISTANCE INFORMATION RECEIVED?
YES
NO
ASSIGN RADIO TRANSMISSION RESOURCES ACCORDING TO SCHEDULING ASSISTANCE INFORMATION AND BUFFER STATUS REPORT
620
ASSIGN RADIO TRANSMISSION RESOURCES ACCORDING TO BUFFER STATUS REPORT
625

FIG.6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 01 0890

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	3GPP: "3GPP TR 25.896 v6.0.0 (2004-03) 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Feasibility Study for Enhanced Uplink for UTRA FDD (Release 6)"[Online] March 2004 (2004-03), page 1,2,16-26, XP002342959 Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Specs/html-info/25896.htm> [retrieved on 2005-08-31] * page 16, line 38 - page 18, line 33 * * page 20, line 1 - page 22, line 34 * * page 24, lines 4-29 *	1-22	H04Q7/38
A	3GPP: "3GPP TS 23.107 v6.1.0 (2004-03) 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Quality of Service (QoS) concept and architecture (Release 6)"[Online] March 2004 (2004-03), page 1-41, XP002342960 Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Specs/html-info/23107.htm> [retrieved on 2005-08-31] * page 14, line 8 - page 17, line 30 * * page 20, line 22 - page 26, line 21 *	1-22	TECHNICAL FIELDS SEARCHED (Int.Cl.7): H04Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Berlin	31 August 2005	Alonso Maleta, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

2

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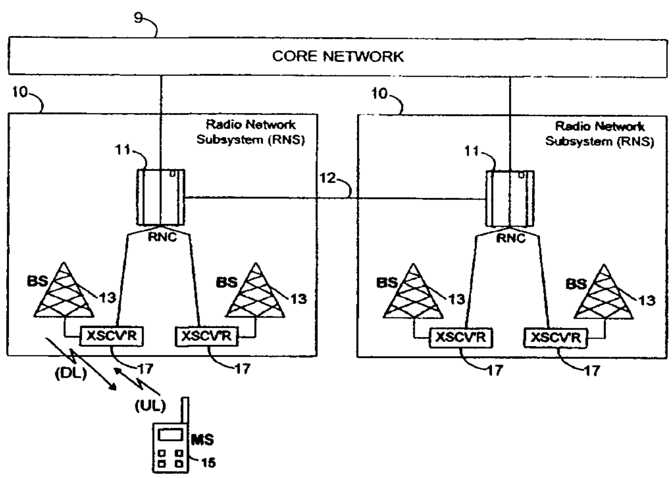
(54) Title: ENHANCED UPLINK PACKET TRANSFER



(57) Abstract: An enhanced spread-spectrum uplink technique provides more efficient packet transfer in a wireless network. A mobile station requests to utilize an uplink channel, typically, a physical dedicated channel. If the network will grant access, a base station sends back a channel-request-granted message, which specifies a transmission start time and length. The base station starts related downlink transmissions at the start time, and at a time thereafter, the mobile station starts sending packet data over the uplink physical dedicated channel. After a transmission of no more that the specified length, the mobile station ceases its uplink transmission on the dedicated channel, and the base station and/or the mobile station can immediately release one or more channel resources. The grant message and/or the subsequent signaling communications from the base station may also specify a modulation scheme and a channelization code for the uplink channel.

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ENHANCED UPLINK PACKET TRANSFER

Related Applications

[0001] This application claims the benefit of U.S. Provisional Application No. 60/416,256 Filed October 7, 2003 entitled "Enhanced Uplink Packet Transfer Method," the disclosure of which is entirely incorporated herein by reference.

Technical Field

[0002] The present subject matter relates to techniques and equipment for wireless spread-spectrum communications, and more particularly for implementation in code-division-multiple-access (CDMA) cellular, packet-switched communication systems. In a spread-spectrum system, comprising a plurality of base stations and a plurality of remote stations, the subject matter particularly relates to techniques and/or equipment for enhancing the performance of one or more of the dedicated uplink packet channels.

Background

[0003] Recent developments in wireless communications technologies have allowed expansion of service offerings from the original voice telephone service model to include a number of services supporting packet data communications, including for broadband applications. As customers become increasingly familiar with data services offered through landline networks, they are increasingly demanding comparable data communications in the wireless domain, for example to maintain service while mobile subscribers roam freely or to provide remote service in locations where wireless loops are preferable to landline subscriber loops. A number of technologies support packet data communications in the wireless domain.

[0004] Under the currently proposed W-CDMA technical specification, there is a dedicated transport channel, the Dedicated Channel (DCH), which can be either a downlink or an uplink transport channel. The DCH is the channel of choice in services where long delays cannot be tolerated, e.g. for low delay constrained packet services and services which require longer than 640 ms packet transmission times. The DCH is also the preferred channel for certain network protocol methods, like TCP/IP, which operate much more efficiently under small packet delays rather than long ones.

[0005] However, the current uplink DCH, as with any circuit-switched packet channel, requires a lot of overhead resources. As shown in Fig. 17, under the current uplink DCH method, once a link is set up between a user j and the base station, the communication will require an associated uplink physical dedicated channel (Associated UL-PDCH) and an associated downlink physical dedicated channel (Associated DL-PDCH) for closed-loop power control. When communications for the user j start on these two associated channels, there is a period of time when the base station is still attempting to lock in on the Associated UL-PDCH from user j, during which no data can be transferred to the base station yet. This period of time is called the set-up time. The length of this delay is indeterminate and varies depending on how long it takes for the base station to lock onto the Associated UP-PDCH. After the data is sent from user j to the base station, there is again a period of time called the inactivity time before the two associated channels are released. Also, under the current uplink DCH method, while the data is power-controlled, it does not adapt its modulation, coding and channelization code according to the quality of the link, resulting in additional wastage.

[0006] Hence a need exists for a technique to deal with these deficiencies in the current uplink DCH.

<u>Summary</u>

[0007] The concepts disclosed herein alleviate the above noted problems with the current uplink DCH. The concepts and improvements described herein can also be generalized and applied to similar channels in other packet-switched communication systems.

[0008] The techniques and network equipment discussed here introduce an uplink transmission method for a more efficient packet transfer. Hence a general objective is to remove the inefficiencies associated with the current UL DCH method.

[0009] Another objective is to provide a fast mechanism to control the modulation, coding and/or the channelization code of data transmission based on the quality of the link

[0010] A further objective is to provide a fast mechanism to facilitate the base station in detecting the Associated UL-PDCH and therefore shortening the set-up time.

[0011] A further objective is to reduce the power of the Associated UL-PDCH and Associated DL-PDCH when no data is being transferred to the base station.

[0012] A further objective of the invention is to have the network node, typically the base station, make all the decisions of assigning and de-assigning uplink packet communication resources via the MAC controller residing in the network.

[0013] The uplink methodology provides an improvement to a code-division-multiple-access (CDMA) system employing spread-spectrum modulation. The CDMA system typically has a radio network controller (RNC) and a plurality of base stations, which serve a plurality of mobile or remote stations. Each base station (BS) has a BS-spread-spectrum transmitter and a BS-spread-spectrum receiver. Each mobile station (MS) has an MS-spread-spectrum transmitter and an MS-spread-spectrum receiver.

[0014] The concepts disclosed herein relate to methods of operations as well as base and mobile stations, for implementing the enhanced uplink. For example, from an overall perspective, the communications involve signaling and data communications exchanged between a base station and a mobile station. The MS-spread-spectrum transmitter of the one mobile station transmits a spread-spectrum signal, signifying a request to utilize an uplink channel. This request signal is received at the BS-spread-spectrum receiver, and processed to determine whether or not to grant the requested access. If access is to be granted, the BS-spread-spectrum transmitter sends a spread spectrum signal comprising a channel-request-granted message for the one mobile station. This channel-request-granted message contains a transmission start time parameter and specifies a transmission length. At the start time, the base station begins downlink signaling transmissions to the mobile station. A time after receiving the downlink signaling transmissions, at the mobile station, the MS spread-spectrum transmitter will start sending a spread spectrum signal containing packet data over the uplink channel. The mobile station will transmit packet data of no more than the specified length.

[0015] In several examples, the request-granted message and/or the subsequent control signaling transmissions may include one or more of Hybrid-ARQ (Automatic Repeat reQuest) information, data identifying an uplink modulation scheme, and an uplink channelization code related to an uplink physical dedicated channel assigned for use by the one mobile station.

[0016] Additional objects, advantages and novel features of the examples will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following and the accompanying drawings or may be learned by production or operation of the examples. The objects and advantages of the present subject matter may be realized and attained by means of the methodologies, instrumentalities and combinations particularly pointed out in the appended claims.

Brief Description of the Drawings

[0017] The drawing figures depict one or more implementations in accord with the present concepts, by way of example only, not by way of limitations. In the drawing figures, like reference numerals refer to the same or similar elements.

[0018] Fig. 1 is a functional block diagram of a simplified CDMA Terrestrial Radio Access network architecture, capable of implementing the enhanced uplink communications.

[0019] Fig. 2 is a basic enhanced uplink dedicated packet channel signal flow diagram.

[0020] Fig. 3 is a basic enhanced uplink dedicated packet channel signal flow diagram where a PDCH is used to carry all signaling and control information.

[0021] Fig. 4 is an enhanced uplink dedicated packet channel signal flow diagram showing transmission from the base station for multiple users.

[0022] Fig. 5 is an uplink dedicated packet channel signal flow diagram with a channel acquire message.

[0023] Fig. 6 is an uplink dedicated packet channel signal flow diagram with immediate release.

[0024] Fig. 7 is an uplink dedicated packet channel signal flow diagram with an uplink preamble.

[0025] Fig. 8 is an uplink dedicated packet channel signal flow diagram with a channel release message.

[0026] Fig. 9 is an enhanced uplink dedicated packet channel signal flow diagram with multiple data packet transfer.

[0027] Fig. 9a is an enhanced uplink dedicated packet channel signal flow diagram with multiple data packet transfer via different radio links.

[0028] Fig. 10 is an uplink dedicated packet channel signal flow diagram with a channel power reduction message.

[0029] Fig. 11 is an uplink dedicated packet channel signal flow diagram with channel power resumption requested by mobile station.

[0030] Fig. 12 is an uplink dedicated packet channel signal flow diagram with channel power resumption requested by base station

[0031] Fig. 13 is an uplink dedicated packet channel signal flow diagram with a channel power reduction and power resumption with gating as the reduction mode.

[0032] Fig. 14 is an uplink dedicated packet channel signal flow diagram with modified CPCH access procedure.

[0033] Fig. 15 is a functional block diagram of a spread spectrum remote or mobile station transceiver.

[0034] Fig. 16 is a functional block diagram of a spread spectrum base station transceiver.

[0035] Fig. 17 is a signal flow diagram illustrating an existing uplink dedicated packet channel.

Detailed Description

[0036] The various concepts disclosed herein relate to networks, components and methods of operation thereof for providing an enhanced uplink channel capability, for wireless packet data communications. Reference now is made in detail to the examples illustrated in the accompanying drawings and discussed below. In understanding of these concepts, it may be helpful first to briefly consider the architecture of an exemplary network.

[0037] Fig. 1 illustrates one simplified example of a mobile wireless communication system, that may implement the enhanced dedicated uplink communications, for example, in the form of a simplified CDMA Terrestrial Radio Access network architecture. As such, Fig. 1 provides a relatively higher level illustration, with a core network 9 providing two-way communications to and from a plurality of radio network subsystems (RNSs) 10. The illustrated network includes a number of the Radio Network Subsystems (RNSs) 10, two of which are shown. The RNSs 10 typically provide mobile communication services in different geographic regions, although there may be some overlap, particularly, if the systems 10 are operated by competing service providers. The core network 9 provides communications between the RNS subsystems 10, for example, for transport of packet switched data and/or time-division multiplexed (TDM) voice information. Each RNS subsystem 10 comprises a radio network controller (RNC) 11, a plurality of base stations 13 serving a plurality of mobile stations 15. The RNCs 11 in the radio network subsystems 10 may be interconnected, for example by the line 12, for signaling and/or traffic communications in addition to those transported through the core network 9.

[0038] Each base station (BS) 13 has a BS-spread-spectrum transmitter and a BS-spread-spectrum receiver, shown together as a single transceiver (XSCV'R) system 17 for simplicity in this drawing. Each of the mobile stations (MS) 15 has an MS-spread-spectrum transmitter and an MS-spread-spectrum receiver forming a transceiver (not separately shown) that is complimentary to the transceivers 17. Exemplary transmitters and receivers for use in the MS and BS network elements are discussed in more detail below with regard to Figs. 15 and 16.

[0039] In a typical embodiment offering packet switched data communications services, the radio network controllers (RNCs) 11 provide two-way packet switched data communications through the core 9 to a wide area network (not shown), for example a packet-switched network such as an Intranet and/or the public Internet. The RNCs 11, the core network 9 and the wide area packet network provide the MS units 15 with two-way packet data communications to and from an array of data communication devices, for example IP telephones, personal computers (PCs), host computers and servers. Although shown as handsets, the mobile stations 15 may be embodied as any user device that may conveniently incorporate or connect to an appropriate mobile/portable transceiver. Examples of other types of mobiles stations include but are not limited to personal digital assistants (PDAs), laptop PCs and handheld PCs.

[0040] The exemplary CDMA system provides a number of logically different channels for upstream and downstream communications over the airlink interface. Each channel is defined by one or more of the codes, for example the spreading code and/or the scrambling code. Several of the channels are common channels, but most of the channels are used for uplink or downlink packet communications between the base stations 13 and the mobile stations 15. As will be discussed, certain channels are signaling or control channels, whereas other channels carry the actual packet data traffic for users' communications services. Although some traffic channels of the CDMA network may be shared or common access channels, discussion here will focus of transport of traffic packets over dedicated channels, that is to say traffic channels that are allocated to a particular user or mobile station, and as such, are dedicated to that user or station for at least some time or length of transmission.

[0041] In operation, the RNC 11 measures traffic through the base stations 13 going to and from the mobile stations 15. In this way, the radio network controller (RNC) 11 monitors traffic demand in the illustrated network subsystem 10. The RNC 11 assigns physical channel resources to the mobile stations 15 within each cell of each base station 13. In general, each user's mobile station 15 continuously monitors the EP-DL-FACH channel. The EP-DL-FACH is a time-multiplexed channel, however, the slot location for the i^{th} user is not predefined. A time-out timer will ensure a mobile station gives up on an over-due response from base station 13. This could be caused by errors on the Uplink. A mobile station 15 could monitor the activity on the EP-DL-FACH. Its access capabilities (probability of transmitting access packets) could be reduced in order to lower the aggregate uplink (UL) load. The node controlling the base station 13 could also periodically transmit the loading on the EP-UL-PDCH, in order to regulate the UL accesses. Multiple EP-DL-FACH channels could operate simultaneously. Similarly, multiple associated EP-DL-PSCCHs could operate simultaneously.

[0042] Fig. 2 illustrates the signal flow between a mobile station 15 and a base station 13, implementing an enhanced packet (EP) uplink, using a packet transfer protocol (PTP). To appreciate the operations represented by the example, it may help first to briefly review the relevant channel nomenclature. Although the network (Fig. 1) may provide other types of channels, for purposes of this discussion, the transmission channel types in the example include: a PSCCH or "Packet Sharing Control CHannel," a PDCH or "Physical Dedicated CHannel," a PCCH or "Packet Control Channel," and a FACH or "Forward Access CHannel." To distinguish the direction of transmission, channels transmitted from a mobile station 15 to a base station 13 are designated as UL for UpLink channels, whereas channels transmitted from a base station 13 to a mobile station 15 are designated DL for DownLink channels. In both directions, channels providing enhanced packet-related services also are designated as EP channels, for purposes of this discussion.

[0043] Hence, the top line of the diagram (Fig. 2) shows the signals sent from a base station 13 on the associated downlink physical dedicated channel (associated DL-PDCH). The next line shows the signals sent from a base station 13 on the enhanced packet downlink Packet sharing control channel (EP-DL-PSCCH). The third line of the diagram shows the signals sent from a base station 13 on the enhanced packet downlink forward access channel (EP-DL-FACH). The lower three lines in the drawing represent uplink (UL) signals, on the enhanced packet uplink Packet Control Channel (EP-UL-PCCH), the enhanced packet uplink physical dedicated channel (EP-UL-PDCH) and the associated uplink physical dedicated channel (associated UL-PDCH).

[0044] As noted, in a CDMA type network, channels are defined by different codes used in the direct-sequence spread-spectrum processing of the transmitted signals. Hence, in the example of Fig. 2, there are three codes used for three uplink channels and three codes used for downlink channels. Of course, the base station my be sending and receiving on other code channels, e.g. for common channel communications, for common access communications with other mobile stations, and/or for dedicated communications with other mobile stations.

[0045] In this example, once a link is set up between a mobile station 15 of user j and a base station 13, the base station transmits power control signals over the associated downlink channel, e.g. the Associated DL-PDCH; and the mobile station transmits power control signals over an associated uplink channel, e.g. the Associated UL-PDCH. These transmissions provide two-way closed loop transmit power control. In accord with the present concepts, the mobile station 15 of user j will imitate the packet communication procedure by sending a data channel initialization request to the base station 13 through an uplink channel designed for control signaling associated with the data transmission, e.g. the EP-UL-PCCH in the illustrated example. The data channel initialization request is basically a request to allow this user, user j, to start an uplink transmission of the data packet(s), although the request may also contain other information such as the buffer state of the mobile station and the priority or quality of service desired for the uplink data transmission.

[0046] The network, upon receipt of the data channel initialization request by the base station 13, decides whether to grant the data channel to the requesting user. The decision may be performed by the RNC 11, by the base station or by another control node of the radio network subsystem (RNS) 10, although for convenience of discussion here, it is assumed that the decision functionality resides at the serving base station 13. If the base station decides to grant the request, it will send back a data channel request-granted message to the mobile station of the particular user, in this case for the user j. In the example, the base station 13 sends the data channel request-granted message for user j back over the downlink forward access channel (EP-DL-FACH). The data channel request-granted message contains the length of the allowed transmission and the scheduled start time of the transmission (T0), if T0 has not been determined beforehand. It can also contain other information that the mobile station needs to have for the data packet transfer, such as HARQ-related information and channelization code information.

[0047] The start time could be related to the time for start of the uplink transmission. However, in the example, at the allotted time T0, the base station will start transmission of at least control information pertinent to the uplink data packet transmission over a downlink shared control channel, e.g. the EP-DL-PSCCH, and the mobile station will start uplink transmission at a predetermined time thereafter. In the example, the control signaling transmission over the EP-DL-PSCCH includes one or more of "HARQ" or Hybrid-ARQ (Automatic Repeat reQuest) information, an uplink modulation scheme, and an uplink channelization code.

[0048] Hybrid ARQ is an implicit link adaptation mechanism. The amount of energy transmitted per packet of information depends on whether the channel is reliable during the transmission of the packet, by transmitting additional information about the packet once the received packet was considered to have been received in error. There are different types of HARQ. Chase combining involves the retransmission of the same coded packet. The receiver then combines the multiple received copies normally weighted by their received SNRs (signal to noise ratios).

[0049] For every received packet, the receiver provides an indication whether the packet was received correctly or not by transmitting back ACKs for correct packet receptions and NACKs for incorrect packet receptions. There are two main ways for transmitting ACK and NACK information to the receiver. One is selective-repeat (SR) and the other is stop-and-wait (SAW). Typically in SR, the transmitter sends a number of packets while waiting for a response (or lack thereof) about the correct or incorrect reception of the transmitted packets. Stop-and-Wait is one of the simplest forms of ARQ requiring very little overhead. In stop-and-wait, the transmitter operates on the current packet until the packet has been correctly received. In the example, the mobile station is transmitting packets over an uplink channel, and the base station is sending the ACK/NACK signals, in this case, over the EP-DL-PSCCH.

[0050] In a typical network, the wireless communications may utilize a number of different modulation techniques, e.g. to support different data rates. Also, the network typically provides a number of channels for use as the UL-PDCH, and for each such channel there is a different channelization code. Hence, the base station 13 can direct the mobile station to use a particular modulation scheme and uplink channelization code for sending the data packet, by specifying an uplink modulation and channelization code in the data channel request-granted message. The ability to specify and change the modulation scheme and coding rate provides increased flexibility in adjusting the information data rate without greatly impacting the operation of the receiver. This is known as an explicit Link Adaptation (LA) mechanism and it is referred to as Adaptive Modulation and Coding (AMC).

[0051] As outlined above, the base station started transmission over the EP-DL-PSCCH for this user's communication session at the specified start time T0. At time T2, a pre-determined time after T0, the mobile station will begin its transmission of the data packet over the uplink channel. During the entire data packet transmission, the base station will continue sending back control information relating to the uplink data packet transmission over the shared downlink channel (on the EP-DL-PSCCH channel in this example). Based on the control information received over the shared downlink channel, the mobile station will adjust the modulation scheme and channelization code of the data packet transfer.

[0052] Optionally, at time T1, a pre-determined time between T0 and T2, the mobile station can also send over the other uplink channel (EP-UL-PCCH), which is designed for control signaling associated with the data transmission (EP-UL-PCCH), transport format information (TFI). The TFI can enable the base station receiver to determine the manner by which the transmitted data has been formatted into a packet. Both the transmitter and receiver know a predefined set of possible ways of formatting a packet. The mobile station transmitter sends the TFI along with the transmitted packet to the base station receiver.

[0053] In an alternative embodiment, the data channel initialization request from the mobile station (user j) may already contain the start time of the data transmission and length of transmission, and the mobile station will start its transmission at T0 without any data channel request-granted message from the base station.

[0054] In practice, it is possible that the uplink power control channel (e.g. the Associated UL-PDCH) and the uplink control-signaling channel (e.g. the UL-PCCH) are the same channel. The use of different names of the channels in this example is for separation and easy understanding of their functionality only. The different functionality can well be carried on a common physical channel, to reduce hardware and channel resource requirements, etc., as illustrated in Fig. 3.

[0055] Fig. 4 is an enhanced uplink dedicated packet channel system block diagram showing transmission from the base station 13 for multiple users' mobile stations 15. Like the earlier example of Fig. 2, the multiple user example, utilizes three downlink code channels from the base station to the mobile station and three uplink code channels from the mobile stations to the base station. The downlink channels include the associated physical dedicated channel (associated DL-PDCH), the enhanced packet downlink Packet Sharing Control CHannel (EP-DL-PSCCH) and the enhanced packet downlink forward access channel (EP-DL-FACH). The uplink (UL) channels include the enhanced packet uplink Packet Control Channel (EP-UL-PCCH), the enhanced packet uplink physical dedicated channel (EP-UL-PDCH) and the associated uplink physical dedicated channel (associated UL-PDCH).

[0056] In this example, each user is allocated usage for some amount of time, and use by or for the user j appears as slots on respective channels. For example, on the EP-DL-PSCCH channel transmissions intended for the user j follow those for user j0 and precede those for user j1. The transmissions on the EP-DL-FACH may not follow the same order, as this channel carries signaling that may not lead to communications on the EP-DL-PSCCH and UP-UL-PDCH channels, for example, to tell certain users' mobile stations to defer a requested communication.

[0057] However, once a link is set up between a mobile station 15 of user (e.g. user j) and a base station 13, the base station transmits power control signals over an associated downlink channel, e.g. the Associated DL-PDCH, and the mobile station transmits power control signals over an associated uplink channel, e.g. Associated UL-PDCH. In accord with the present concepts, the mobile station will then send a data channel initialization request to the base station through an uplink channel designed for control signaling associated with the data transmission, e.g. the EP-UL-PCCH in the illustrated example. The data channel initialization request is basically a request to allow this user, user j, to start an uplink transmission of the data packet(s), although the request may also contain other information such as the buffer state of the mobile station and the priority or quality of service desired for the uplink data transmission.

[0058] The base station 13, upon receiving the data channel initialization request decides whether to grant the data channel to the requesting user. If the base station decides to grant the request, it will send back a data channel request-deferred message. However, if the base station decides to grant the request, it will send back a data channel request-granted message to the mobile station of the particular user, in this case user j, on the EP-DL-FACH channel in this example. The data channel request-granted message contains the length of the allowed transmission and the scheduled start time of the transmission (T0), if T0 has not been determined beforehand. It can also contain other information that the mobile station needs to have for the data packet transfer, such as HARQ-related information, modulation scheme and/or channelization code information.

[0059] At the allotted time T0, the base station 13 will start transmission over a downlink shared control channel, e.g. the EP-DL-PSCCH, and this transmission will include control information pertinent to the uplink data packet transmission. In the example, the control information contains the "HARQ" or Hybrid-ARQ information, an uplink modulation scheme, and an uplink channelization code. For every received packet, the base station receiver provides an indication whether the packet was received correctly or not by transmitting back ACKs for correct packet receptions and NACKs for incorrect packet receptions. In this example, the base station 13 transmits the ACK/NACK signaling on the EP-DL-PSCCH channel.

[0060] At time T2, a pre-determined time after T0, the mobile station will begin its transmission of the data packet. During the entire data packet transmission, the base station will continue sending back control information relating to the uplink data packet transmission over the shared downlink channel (on the EP-DL-PSCCH channel in this example). Based on the control information received over the shared downlink channel, the mobile station will adjust the modulation scheme and channelization code of the data packet transfer. The mobile station also adjusts its packet transmissions as needed, e.g. to re-send packets that have not been properly received, based on receipt of the ACK/NACK signaling on the EP-DL-PSCCH channel.

[0061] Fig. 5 shows another embodiment of the enhanced packet channel communications, in this case, where an optional channel-acquired message is sent by the base station to the mobile station to indicate that the base station has acquired the Associated UL-PDCH.

[0062] Fig. 6 shows yet another embodiment, where the Associated UL-PDCH and Associated DL-PDCH are immediately released after the scheduled data transmission. Specifically, the data channel request-granted message specifies an allotted length of transmission. The channel resources are released for reassignment to a mobile station immediately after the end of the allocated transmission. In the example, the transmission length is specified as a time (duration from start or a specific end time), however, those skilled in the art that the transmission length could be specified in other terms, for example, amount of data (e.g. number of packets).

[0063] Fig. 7 shows yet another embodiment, where an optional preamble or header is added before the transmission over the Associated UL-PDCH in order to facilitate earlier detection of such Associated UL-PDCH by the base station.

[0064] Fig. 8 shows yet another embodiment of the invention where a channel release message is sent by the base station to the mobile station at a pre-determined time after the end of the control information transmission.

[0065] Fig. 9 shows the basic enhanced uplink dedicated packet channel method when multiple data packets are sent during the same link.

[0066] In Fig. 9a, two packet data transfers are implemented via the use of a two Different Radio Links. After the MS completed a packet data transfer over Radio Link 0, Radio Link 1 became more reliable for uplink transmissions. The RS then send a Channel_Initialization_Request to Radio Link 1. Radio Link 1 responds over its own EP-DL-FACH.

[0067] In Fig. 10, a new mechanism to reduce the power of the control channels (the overhead) is introduced. This power control method can be applied to the enhanced uplink discussed above or to other systems or methods. With this power control technique, after a certain inactivity time T_{inact} following the transmission of the control information from the base station (or in other methods, after the end of the data packet), the base station will send a power reduction message to the mobile station and ask the mobile station is instruct the base station to reduce power. Upon receipt of the power reduction message, the mobile station will send back a power reduction confirmation message, after which both the mobile station and the base station will instruct each other to lower their power of transmission of their control channels. For simplicity of illustration, Fig. 10 does not show the uplink data channel and has combined the power control channel with the signaling control (see description for Fig. 3).

[0068] In Fig. 11, you can see how the data channel request subsequent to the power reduction in the control channels is used also as a power resumption request. When the mobile station 15 sends out the data channel request, it at the same time instructs the base station 13 to increase its power of the downlink (DL) power control channel. When the data message channel granted message is sent by the base station, the mobile station also instructs the mobile station to increase its power of the uplink (UL) power control channel. After the data packet is sent and a certain inactivity time T_{inact}, the mobile station and the base station can go to the power reduction stage again.

[0069] Alternatively, as in Fig. 12, while the control channel power is reduced, the mobile staion can send these periodic Buffer State Measurements Indicators to the base station. When a Buffer State Measurements Indicator indicates that the data in the buffer of the MS has exceeded a certain threshold, the base station will then send out a data packet transmission request message to the mobile station to instruct the mobile station to send a data packet and resume power of the UL power control channel. The mobile station will send back a confirmation message and also resume power of the DL power control channel.

[0070] Similarly, instead of reducing power in the power control channels as in Fig. 10-12 after the reduction message, the reduction can be in the form of gated transmission of the power control channels, as in Fig. 13.

[0071] Fig. 14 teaches the use of a modified Common Packet Channel (CPCH) approach to for initial link set up. The link request resides in the CPCH message. The link acknowledgment comes down in the CPCH downlink instead of via FACH.

[0072] Figs 15 and 16 illustrate elements of the stations, in an example of the system of Fig. 1. For purposes of this discussion here, it will be assumed that the examples of Figs. 1, 15 and 16 implement a processing technique such a one of those shown in Figs. 2 or 4.

[0073] Fig. 15 illustrates an example of a MS spread-spectrum transmitter and MS spread-spectrum receiver, essentially in the form of an MS base-band processor 207 for performing the PHY layer functions and an interface 208 for performing the MAC layer functions, of the transceiver at a mobile station 15.

[0074] The MS spread-spectrum receiver includes an antenna 209 coupled to a circulator 210, a receiver radio frequency (RF) section 211, a local oscillator 213, a quadrature demodulator 212, and an analog-to-digital converter 214. The receiver RF section 211 is coupled between the circulator 210 and the quadrature demodulator 212. The quadrature demodulator is coupled to the local oscillator 213 and to the analog to the digital converter 214. The output of the analog-to-digital converter 214 is coupled to a programmable-matched filter 215. An receiver 216 for the associated downlink physical dedicated channel (Associated DL-PDCH), a receiver 217 for the enhanced packet downlink packet sharing control channel (EP-DL-PSCCH) and a receiver 218 for the enhanced packet downlink forward access channel (EP-DL-FACH) are coupled to the programmable-matched filter 215. A controller 219 is coupled to the receiver's 216, 217 and 218. The controller 219 of the MS base-band processor 207 in turn connects to the interface 208, for exchange of necessary signaling control information and data. For example, in the upstream direction, the control 219 passes received data to the interface 208 for MAC layer processing and communication thereof to the higher layer elements within or connected to the mobile station 15.

[0075] The interface 208 also outputs uplink (UL) data (EP-UL-DATA). The MS spread-spectrum transmitter includes a forward-error-correction (FEC) encoder 222 for encoding this downlink data. The encoder 222 also provides encoding for the Hybrid Automatic Repeat reQuest (HARQ) signal. The FEC/HARQ encoder 222 is coupled through an interleaver 223 to a QAM modulator 224. The controller 219 controls the operation of the FEC/HARQ encoder 222 and the interleaver 223. The controller 219 also provides various signaling and/or control data to one or more modulators 225. In the mobile station, these signals include preamble signals and the TFI signal, discussed above. The outputs from the modulators 224 and 225 are added in a combiner 226.

[0076] A spreading-sequence generator 227 is coupled to a product device 226, which receives the combined downlink information (modulated) from the combiner 226. A digital-to-analog converter 229 is coupled between the product device 228 and a quadrature modulator 230. The quadrature modulator 230 is coupled to the local oscillator 213 and supplies a modulated analog output signal to an transmitter RF section 231. The transmitter RF section

231 is coupled to the circulator 210 so as to provide an RF single of the appropriate power level to the antenna for wireless transmission over the air to one or more base stations 13.

[0077] The controller 219 has control links coupled to the analog-to-digital converter 214, the programmable-matched filter 215, the receivers 216, 217 and 218, the digital-to-analog converter 229, the spreading sequence generator 227, the combiner 226, the interleaver 223, the and the FEC/HARQ encoder 222.

[0078] A received spread-spectrum signal from antenna 209 passes through circulator 210 and is amplified and filtered by the receiver RF section 211. The local oscillator 213 generates a local signal, which the quadrature demodulator 212 uses to demodulate in-phase and quadrature phase components of the received spread-spectrum signal. The analog-to-digital converter 214 converts the in-phase component and the quadrature-phase component to digital signals. These functions are well known in the art, and variations to this block diagram can accomplish the same functions.

[0079] The programmable-matched filter 215 despreads the received spread-spectrum signal components. A correlator, as an alternative, may be used as an equivalent means for despeading the received spread-spectrum signal.

[0080] The DL-PDCH receiver 216 detects pilot and TPC (transmit power control) signaling in the received spread-spectrum signal. The EP-DL-PSCCH receiver 217 detects the various channel control signaling (ACK/NACK, modulation, code set, HARQ, etc.) in the received spread-spectrum signal. The EP-DL-FACH receiver 218 detects and processes the request-granted/deferred messages on the DL-FACH channel in the received spread-spectrum signal. Detected data and signaling from the downlink are outputted from the controller 219 to the interface 208, and the interface passes the data to the higher layer elements in or associated with the MS 15.

[0081] The higher level elements of the mobile station (and/or a device connected to the mobile station) supply uplink (UL) data and control information to the interface 208. In the MS transceiver, the MAC layer elements, typically in the interface 208, supply data and signaling information, intended for uplink transmission, to the input of the FEC/HARQ encoder 222. The signaling and data are FEC encoded by the FEC encoder 222, interleaved by the interleaver 223 and QAM modulated at 224. The combiner 226 produces a combined modulated stream, containing the modulated uplink data from modulator 224 and the modulated signaling (preamble and TFI) and control from modulators 225 and supplies that stream to the product device 226. The stream is spread-spectrum processed by the product device 226, with a selected spreading chip-sequence from the spreading-sequence generator 227. The spread uplink stream is converted to an analog signal by the digital-to-analog converter 228, and in-phase and quadrature-phase components are generated by the quadrature modulator 230 using a signal from local oscillator 213. The modulated downlink packet is translated to a carrier frequency, filtered and amplified by the transmitter RF section 231, and then it passes through the circulator 210 and is radiated by antenna 209.

[0082] Fig. 16 illustrates an example of a base station spread-spectrum transmitter and a BS spread-spectrum receiver, essentially in the form of a BS base-band processor 307 for performing the PHY layer functions and an interface 308 for performing the MAC (media access control) layer functions, of the base station transceiver 17 at a base station 13.

[0083] The BS spread-spectrum receiver includes an antenna 309 coupled to a circulator 310, a receiver radio frequency (RF) section 311, a local oscillator 313, a quadrature demodulator 312, and an analog-to-digital converter 314. The receiver RF section 311 is coupled between the circulator 310 and the quadrature demodulator 312. The quadrature demodulator is coupled to the local oscillator 313 and to the analog to digital converter 314. The output of the analog-to-digital converter 314 is coupled to a programmable-matched filter 315. A receiver 316 for the associated uplink channel (UL-PDCH), a receiver 317 for the enhanced packet uplink physical dedicated channel (EP-UL-PDCH) and a receiver 318 for the enhanced packet uplink packet control channel (EP-UL-PCCH) are coupled to the programmable-matched filter 315. A controller 319 is coupled to the receiver's 316, 317 and 318. The controller 319 of the BS base-band processor 307 in turn connects to the interface 308, for exchange of necessary signaling control information and data. For example, in the upstream direction, the control 319 passes received data to the interface 308 for MAC layer processing and communication thereof to the higher layer elements at or within the network.

[0084] The interface 308 also outputs downlink (DL) data (EP-DL-DATA). The BS spread-spectrum transmitter includes a forward-error-correction (FEC) encoder 322 for encoding this downlink data. The encoder 322 also provides encoding for the Hybrid Automatic Repeat reQuest (HARQ) signal. The FEC/HARQ encoder 322 is coupled through an interleaver 323 to a QAM modulator 324. The controller 319 controls the operation of the

FEC/HARQ encoder 322 and the interleaver 323. The controller 319 also provides various signaling and/or control data to one or more modulators 325. The outputs from the modulators 324 and 325 are added in a combiner 326.

[0085] A spreading-sequence generator 327 is coupled to a product device 326, which receives the combined downlink information (modulated) from the combiner 326. A digital-to-analog converter 329 is coupled between the product device 328 and a quadrature modulator 330. The quadrature modulator 330 is coupled to the local oscillator 313 and supplies a modulated analog output signal to an transmitter RF section 331. The transmitter RF section 331 is coupled to the circulator 310 so as to provide an RF single of the appropriate power level to the antenna for wireless transmission over the air to one or more mobile stations.

[0086] The controller 319 has control links coupled to the analog-to-digital converter 314, the programmable-matched filter 315, the receivers 316, 317 and 318, the digital-to-analog converter 329, the spreading sequence generator 327, the combiner 326, the interleaver 323, the and the FEC/HARQ encoder 322.

[0087] A received spread-spectrum signal from antenna 309 passes through circulator 310 and is amplified and filtered by the receiver RF section 311. The local oscillator 313 generates a local signal, which the quadrature demodulator 312 uses to demodulate in-phase and quadrature phase components of the received spread-spectrum signal. The analog-to-digital converter 314 converts the in-phase component and the quadrature-phase component to digital signals. These functions are well known in the art, and variations to this block diagram can accomplish the same functions.

[0088] The programmable-matched filter 315 despreads the received spread-spectrum signal components. A correlator, as an alternative, may be used as an equivalent means for despeading the received spread-spectrum signal.

[0089] The associated UL-PDCH receiver 316 detects pilot and TPC signaling in the received spread-spectrum signal. The EP-UL-PDCH receiver 317 detects the enhanced uplink packet transmissions in the received spread-spectrum signal. The EP-UL-PCCH receiver 318 detects the transmission format information (optional) of the received spread-spectrum signal. Detected data and signaling from the uplink channels are outputted from the controller 319 to the interface 308, and the interface passes the data to the higher layer elements in or associated with the base station 13 and through the link to the RNC 11.

[0090] The RNC 11 supplies data and signaling over a link to the base station. In the BS transceiver, the MAC (mead access control) layer elements, typically in the interface 308, supply downlink (DL) data and signaling information, intended for downlink transmission, to the input of the FEC/HARQ encoder 322. The signaling and data are FEC encoded by the FEC encoder 322, interleaved by the interleaver 323 and QAM modulated at 324. The combiner 326 produces a combined modulated stream, containing the modulated downlink data from modulator 324 and the modulated signaling and control from modulators 325 and supplies that stream to the product device 326. The stream is spread-spectrum processed by the product device 326, with a selected spreading chip-sequence from the spreading-sequence generator 327. The spread downlink stream is converted to an analog signal by the digital-to-analog converter 328, and in-phase and quadrature-phase components are generated by the quadrature modulator 330 using a signal from local oscillator 313. The modulated downlink packet is translated to a carrier frequency, filtered and amplified by the transmitter RF section 331, and then it passes through the circulator 310 and is radiated by antenna 309.

[0091] The following is a summary of the HS-UL Packet-Mode Basic Operation Attributes. The mobile station 15 requests an Enhanced Packet Uplink (EP-UL) connection through a random access channel (RACH) or common packet channel (CPCH). The network node (base station 15 and/or RNC 11) determines whether there are uplink resources available and allows of disallows the mobile station an uplink connection, as indicated by a request-granted or request-deferred message sent back through a forward access channel (FACH). If the resources are granted, the network node relays the parameters of the Associated DL-PDCH through the FACH.

[0092] If connection is granted, both the mobile station 15 and the network node enact an EP (Enhanced Packet) associated PDCH channel or EP- UL-PDCH. The EP-UL-PDCH parameters are either explicitly relayed via RACH/CPCH signaling or implicitly via the UE-ID over the RACH/CPCH. The network node could optionally send an EP-UL_Channel_Acquired message to the mobile station. This could be a simple an all 1's sequence for a predetermined time interval. After a predetermined time offset from the reception of the EP-UL_Channel_Acquired message or the acquisition of the A_DL_PDCH, the mobile station sends its Channel_Initialization_Request.

[0093] The network node will respond within a predetermined time interval with a message over the EP-DL-FACH, directed towards that user's mobile station, only with specific information about the HS_UL transmission. The specific parameters could include Start of Transmission, Time Duration of Transmission (End of Transmission), HARQ related information like type of combining and Channelization Code Set information. Flexibility could be given to the mobile station to choose from a subset of possible channelization codes and transmission packet formats.

[0094] The Uplink packet transmission could be deferred to a later time if network node determines that the requested resources are not currently available. By deferring the packet transmission, the network node might or might not be required to assign UL channels to the mobile station. If an assignment to a deferred transmission does not arrive within a predetermined time interval, the mobile station will try a channel initialization request again.

[0095] An UL_HS_Channel_Release message could be sent at any time over the Associated DL-PDCH or the EP-DL-FACH. All UL-HS associated transmissions are discontinued immediately.

[0096] After transmission of the Channel_Request_Granted message from the network, the network node will start transmitting the information on the EP-DL-PSCCH for that mobile station, relative to the Start Time relayed to the UE over the EP-DL-FACH. This information could include (but is not limited to) ACK/NACKs, Uplink Modulation scheme and the Uplink Channelization Code Set. This is information generated in response to the channel measurements made by receiving the Associated EP-UL-PDCH or the Associated UL-PDCH.

[0097] In response to the information received over the EP-DL-PSCCH, the mobile station will generate packets of transport formats within the allowed subset as defines by the EP-DL-PSCCH. The specific Transport Format information used by the mobile station to transport its packets is transmitted over the EP-UL-PCCH or the Associated EP-UL-PDCH. The Transport Format information for each transmitted packet could be transmitted ahead or earlier than the transmitted packet.

[0098] The Uplink Packet Data is transmitted over the EP_UL_PDCH. The Transport Format chosen is dictated in part by the EP-DL-PSCCH. The EP-UL-PDCH is transmit power controlled by the Associated DL-PDCH. The EP-UL-PDCH is transmitted at a constant power offset in dB relative to the Associated UL-PDCH or the control part of the Associated EP-UL-PDCH.

[0100] The control part of the Associated UL_PDCH or the Associated EP-UL-PDCH power controls the Associated DL-PDCH. All transmissions to the mobile station from EP-DL-FACH and EP-DL-PSCCH are being power controlled implicitly by being transmitted at a relative power offset in dB relative to the power transmitted over the Associated DL-PDCH which is power controlled by the Associated UL-PDCH or the control part of the Associated EP-UL-PDCH.

[0101] An EP-DL_Channel_Power_Reduction_Message transmitted by the network node, over either the Associated DL-PDCH or the EP-DL-FACH, signals the mobile station to decrease the power level requirements on the received Associated DL-PDCH.

[0102] An EP-UL_Channel_Power_Reduction_Confirmation_Message transmitted by the mobile station over either the Associated UL-PDCH or the Associated EP-UL-PDCH signals network that EP-DL_Channel_Power_Reduction_Message has been received and that the mobile station will decrease the power level requirements on the received Associated DL-PDCH. Also, network node will automatically decrease the power level requirements on the received Associated UL-PDCH or the Associated EP-UL-PDCH.

[0103] Measurements of the mobile station buffer data size can be transmitted to base station and/or the RNC, either over the Associate UL-PDCH or the Associated EP-UL-PDCH.

[0104] While in the power saving mode, the mobile station could request an uplink packet transmission by sending an EP-UL_Packet_Transmission_Request. The network node could respond positively by sending an EP-UL_Packet_Transmission_Request _Granted message. Both the mobile station and the network node then change their received power level requirements on the transmitted Associated DL-PDCH and Associated EP-PDCH or Associated UL-PDCH control parts.

[0105] The above process could be initiated by a base station transmission of an EP-UL_Channel_Packet_Transmission_Request message. The mobile station will respond with an EP-UL_Packet_Transmission_Setup_Acknowledgement. Both base station and the mobile station are appropriately taken out of their power saving modes.

[0106] An enhanced packet synchronization preamble (EP-SP) could be used to enable the base station an easier synchronization to the Associated EP-UL_PDCH or the Associated

UL-PDCH channels. This preamble could be transmitted over its own Enhanced Packet - Synchronization Preamble Channel (EP-SPCH). The timing of the received EP-SP could then be used to obtain the timing of the Associated EP-UL_PDCH or the Associated UL-PDCH channels.

[0107] The RS while operating in a Soft Handoff mode, could request an UL packet transmission to different base stations for different UL packet transfers.

[0108] While the foregoing has described what are considered to be the best mode and/or other examples, it is understood that various modifications may be made therein and that the subject matter disclosed herein may be implemented in various forms and examples, and that they may be applied in numerous applications, only some of which have been described herein. It is intended by the following claims to claim any and all modifications and variations that fall within the true scope of the present concepts.

What is Claimed Is:

1. In a code-division-multiple-access (CDMA) system employing spread-spectrum modulation comprising a base station (BS) comprising a BS-spread-spectrum transmitter and a BS-spread-spectrum receiver, and at least one mobile stations (MS) comprising an MS-spread-spectrum transmitter and an MS-spread-spectrum receiver, a method comprising the steps of:

transmitting from the MS-spread-spectrum transmitter of the one mobile station a spread-spectrum signal signifying a request to utilize an uplink channel;

receiving the request to utilize the uplink channel from the one mobile station at the BS-spread-spectrum receiver;

processing the received request to determine whether or not to grant the requested access;

if the processing results in a determination to grant access, transmitting from the BS-spread-spectrum transmitter a spread spectrum signal comprising a channel-request-granted message for the one mobile station, the channel-request-granted message comprising control information specifying a transmission start time and a transmission length;

receiving the channel-request-granted message from the base station at the MS-spread-spectrum receiver the one mobile station;

at the specified transmission start time, initiating transmission from the BS-spread-spectrum transmitter of a spread spectrum signal comprising control signaling related to the granted access over a downlink channel;

receiving the spread spectrum signal comprising control signaling at the MS-spread-spectrum receiver the one mobile station;

at a predetermined time after the specified transmission start time, starting transmission of a spread spectrum signal containing packet data over the uplink channel from the MS-spread-spectrum transmitter of the one mobile station, in a manner in accord with the received control information; and

ceasing the transmission of the spread spectrum signal containing packet data over the uplink channel from the mobile station, upon completion of transmission of packet data of the specified transmission length.

2. The method of claim 1, wherein when the transmission of the spread spectrum signal containing packet data over the uplink channel ceases, the uplink physical dedicated channel is immediately released.

3. The method of claim 1, wherein the channel-request-granted message further comprises at least one of Hybrid-ARQ (Automatic Repeat reQuest) information, data identifying an uplink modulation scheme, and an uplink channelization code related to an uplink physical dedicated channel assigned for use by the MS spread-spectrum transmitter of the one mobile station.

4. The method of claim 1, wherein:

the transmitting of the spread spectrum signal comprising the channel-request-granted message utilizes a downlink forward access channel; and

transmission from the BS-spread-spectrum transmitter of a spread spectrum signal comprising control signaling related to the granted access uses a downlink packet sharing channel.

5. The method of claim 4, wherein control information comprises at least one of Hybrid-ARQ (Automatic Repeat reQuest) information, data identifying an uplink modulation scheme, and an uplink channelization code related to the transmission by the one mobile station on the uplink physical dedicated channel.

6. The method of claim 1, further comprising:

transmitting from the MS-spread-spectrum transmitter of the one mobile station a spread-spectrum signal containing format information,

wherein the transmission signal containing the format information begins between the specified transmission start time and the predetermined time after the specified start time.

7. The method of claim 6, wherein the transmitting of the spread-spectrum signal containing format information utilizes an uplink packet control channel.

8. The method of claim 1, wherein the uplink channel is a physical dedicated channel.

9. The method of claim 1, wherein the uplink channel is a common packet channel.

10. The method of claim 1, wherein the request to utilize the uplink channel comprises control information specifying a buffer state of the one mobile station or a quality of service level desired for the requested access.

11. In a wireless code-division-multiple-access (CDMA) spread-spectrum communication network comprising a base station for serving one or more mobile stations, a method comprising:

receiving a data channel initialization request, for access to an uplink channel, at the base station from one mobile station;

determining whether or not to grant the mobile station the requested access to the uplink channel;

if it is determined to grant the mobile station the requested access to the uplink channel, transmitting a channel-request-granted message for the one mobile station, the channel-request-granted message comprising control information specifying a transmission start time and a transmission length;

at the specified start time, initiating transmission of control signaling related to the requested access, for the one mobile station; and

receiving a packet data transmission of the specified transmission length from the one mobile station over the uplink channel.

12. The method of claim 11, wherein the control information in the channel-request-granted message further comprises at least one of Hybrid-ARQ (Automatic Repeat reQuest) information, data identifying an uplink modulation scheme, and an uplink channelization code related to the transmission by the one mobile station on the uplink physical dedicated channel.

13. The method of claim 11, wherein the control signaling related to the requested access, for the one mobile station, comprises a least one of Hybrid-ARQ (Automatic Repeat reQuest) information, data identifying an uplink modulation scheme, and an uplink channelization code related to the transmission by the one mobile station on the uplink channel.

14. The method of claim 11, wherein

the transmitting of the channel-request-granted message utilizes a downlink forward access channel; and

transmitting of the control signaling related to the granted access uses a downlink packet sharing channel.

15. The method of claim 11, further comprising releasing at least one resource related to the uplink physical dedicated channel when the reception of the packet data over the uplink channel ceases after receipt of the transmission of the specified length.

16. The method of claim 11, wherein the uplink channel is a physical dedicated channel.

17. The method of claim 11, wherein the uplink channel is a common packet channel.

18. In a wireless code-division-multiple-access (CDMA) spread-spectrum communication network comprising a base station for serving one or more mobile stations, a method comprising:

transmitting a data channel initialization request, for access to an uplink channel, to the base station from one mobile station;

receiving a channel-request-granted message at the one mobile station, the channel-request-granted message comprising control information specifying a start time and a transmission length;

after the specified start time, receiving control signaling related to the requested access at the one mobile station; and

transmitting packet data from the one mobile station over the uplink channel of the specified transmission length, beginning at a time following initial reception of the control signaling.

19. The method of claim 18, further comprising transmitting format information associated with the packet data from the one mobile station, following receiving of the control signaling and before beginning the transmitting of the packet data over the uplink channel.

20. The method of claim 19, wherein the uplink channel comprises a physical dedicated channel.

21. The method of claim 20, wherein the transmitting of the format information utilizes an uplink packet control channel.

22. The method of claim 20, wherein:

the channel-request-granted message is received over a downlink forward access channel; and

the control signaling related to the requested access is received over a downlink packet sharing control channel.

23. A base station for use in a code-division-multiple-access (CDMA) system employing spread-spectrum modulation, the base station (BS) comprising:

a BS-spread-spectrum transceiver system, for transmitting and receiving spread-spectrum modulated signals to and from a mobile station; and

a media access control interface, coupled to the BS-spread-spectrum transceiver system, for receiving and sending packet data between a network and the BS-spread-spectrum transceiver system, and for controlling signal communications of the BS-spread-spectrum transceiver system in support of wireless communications operations of the base station, such that in operation, the base station is for performing the following sequence of operations:

receiving a data channel initialization request, for access to an uplink channel, at the base station from one mobile station;

determining whether or not to grant the mobile station the requested access to the uplink channel;

if it is determined to grant the mobile station the requested access to the uplink channel, transmitting a channel-request-granted message for the one mobile station, the channel-request-granted message comprising control information specifying a transmission start time and a transmission length;

at the specified start time, initiating transmission of control signaling related to the requested access, for the one mobile station; and receiving a packet data transmission of the specified transmission length from the one mobile station over the uplink channel.

24. The base station as in claim 23, wherein the BS-spread-spectrum transceiver system comprises a base band processor.

25. The base station as in claim 24, wherein the base band processor comprises:

a spread-spectrum transmitter;

a spread spectrum receiver;

a controller, responsive to signals from the spread-spectrum receiver and the media access control interface, for controlling operations of the spread-spectrum transmitter.

26. The base station as in claim 25, wherein the spread-spectrum transmitter transmits the channel request-granted message on a downlink forward access channel and transmits the control signaling on a downlink packet sharing control channel.

27. A mobile station for use in a code-division-multiple-access (CDMA) system employing spread-spectrum modulation, the mobile station (MS) comprising:

an MS-spread-spectrum transceiver system, for transmitting and receiving spread-spectrum modulated signals to and from a mobile station; and

a media access control interface, coupled to the MS-spread-spectrum transceiver system, for receiving and sending packet data for the mobile station through the MS-spread-spectrum transceiver system, and for controlling signaling communications of the MS-spread-spectrum transceiver system in support of wireless communications operations of the mobile station through with a base station of the CDMA system, such that in operation, the mobile station is for performing the following sequence of operations:

transmitting a data channel initialization request, for access to an uplink channel, to the base station from one mobile station;

receiving a channel-request-granted message at the one mobile station, the channel-request-granted message comprising control information specifying a start time and a transmission length;

after the specified start time, receiving control signaling related to the requested access at the one mobile station; and transmitting packet data from the one mobile station over the uplink channel of the specified transmission length, beginning at a time following initial reception of the control signaling.

28. The mobile station of claim 27, wherein the operations performed by the mobile station further comprise transmitting format information associated with the packet data from the one mobile station, following receiving of the control signaling and before beginning the transmitting of the packet data over the uplink channel.

29. The mobile station of claim 27, wherein the MS-spread-spectrum transceiver system comprises a base band processor.

30. The mobile station as in claim 27, wherein the base band processor comprises:

a spread-spectrum transmitter;

a spread spectrum receiver;

a controller, responsive to signals from the spread-spectrum receiver and the media access control interface, for controlling operations of the spread-spectrum transmitter.

31. The mobile station as in claim 30, wherein the spread-spectrum transmitter transmits the channel request message on an uplink packet control channel.

32. The mobile station as in claim 30, wherein the spread-spectrum transmitter transmits format information associated with the packet data from the one mobile station to the base station via the uplink packet control channel.

33. In a wireless code-division-multiple-access (CDMA) spread-spectrum communication network comprising a base station for serving one or more mobile stations, a method comprising:

sending control signaling to and receiving a packet data transmission from, one mobile station, over at least one CDMA spread-spectrum wireless channel;

detecting a length of inactivity on the at least one CDMA spread-spectrum wireless channel after the sending and receiving;

in response to the detected inactivity, sending a power down request message to the one mobile station;

receiving a power down confirmation message from the one mobile station; and transmitting at least one further signal for the one mobile station at a reduced power.

34. The method of claim 33, wherein the step of sending control signaling to and receiving a packet data transmission from, one mobile station comprises:

receiving a data channel initialization request, for access to an uplink channel, from the one mobile station;

determining whether or not to grant the mobile station the requested access to the uplink channel;

if it is determined to grant the mobile station the requested access to the uplink channel, transmitting a channel-request-granted message for the one mobile station, the channel-request-granted message comprising control information specifying a transmission start time and a transmission length;

at the specified start time, initiating transmission of control signaling related to the requested access, for the one mobile station; and

receiving a packet data transmission of the specified transmission length from the one mobile station over the uplink channel.

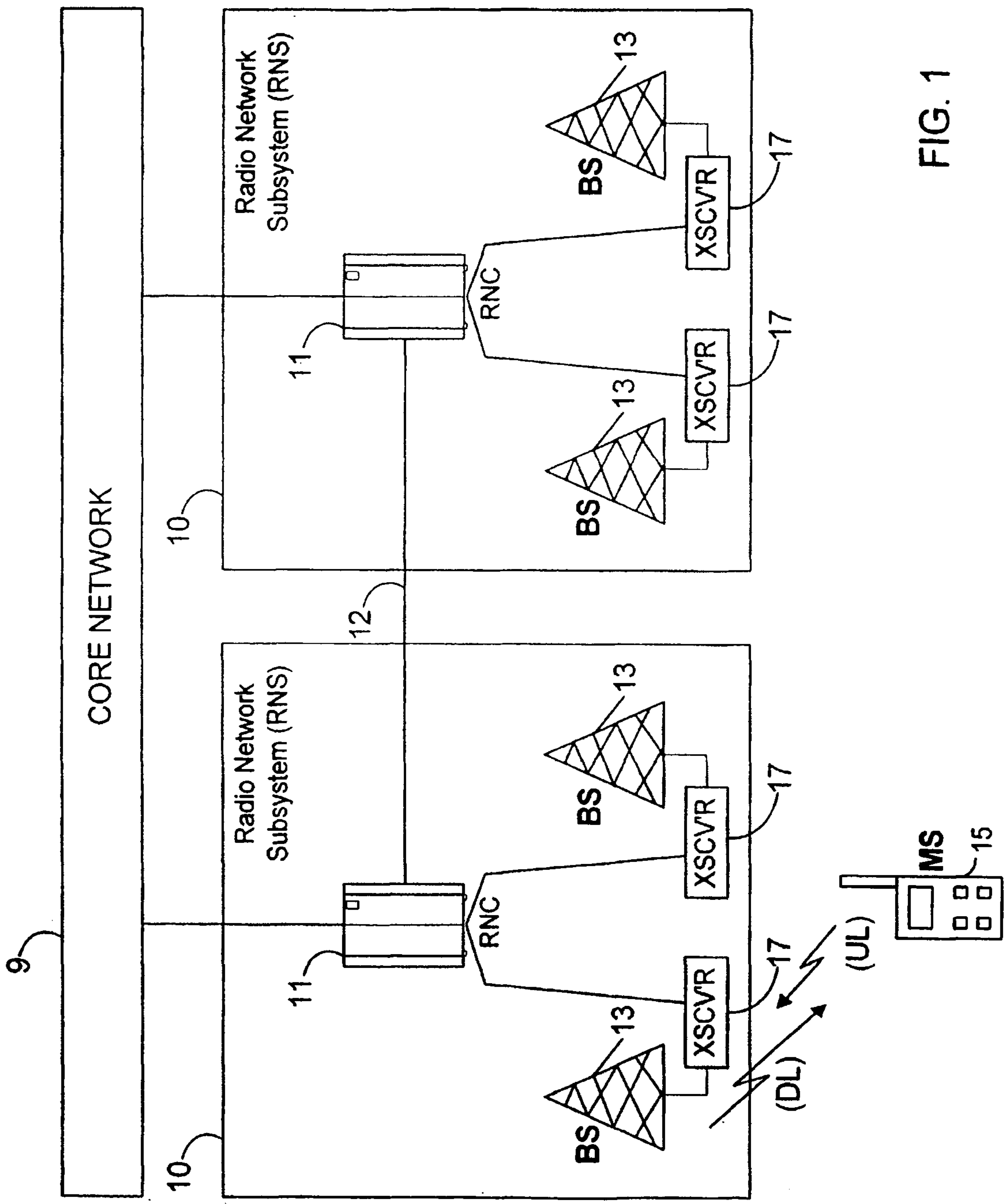

CORE NETWORK
9
Radio Network Subsystem (RNS)
Radio Network Subsystem (RNS)
10
10
11
11
12
RNC
RNC
XSCV'R
XSCV'R
XSCV'R
XSCV'R
17
17
17
17
BS
BS
BS
BS
13
13
13
13
MS
15
(UL)
(DL)

FIG. 1

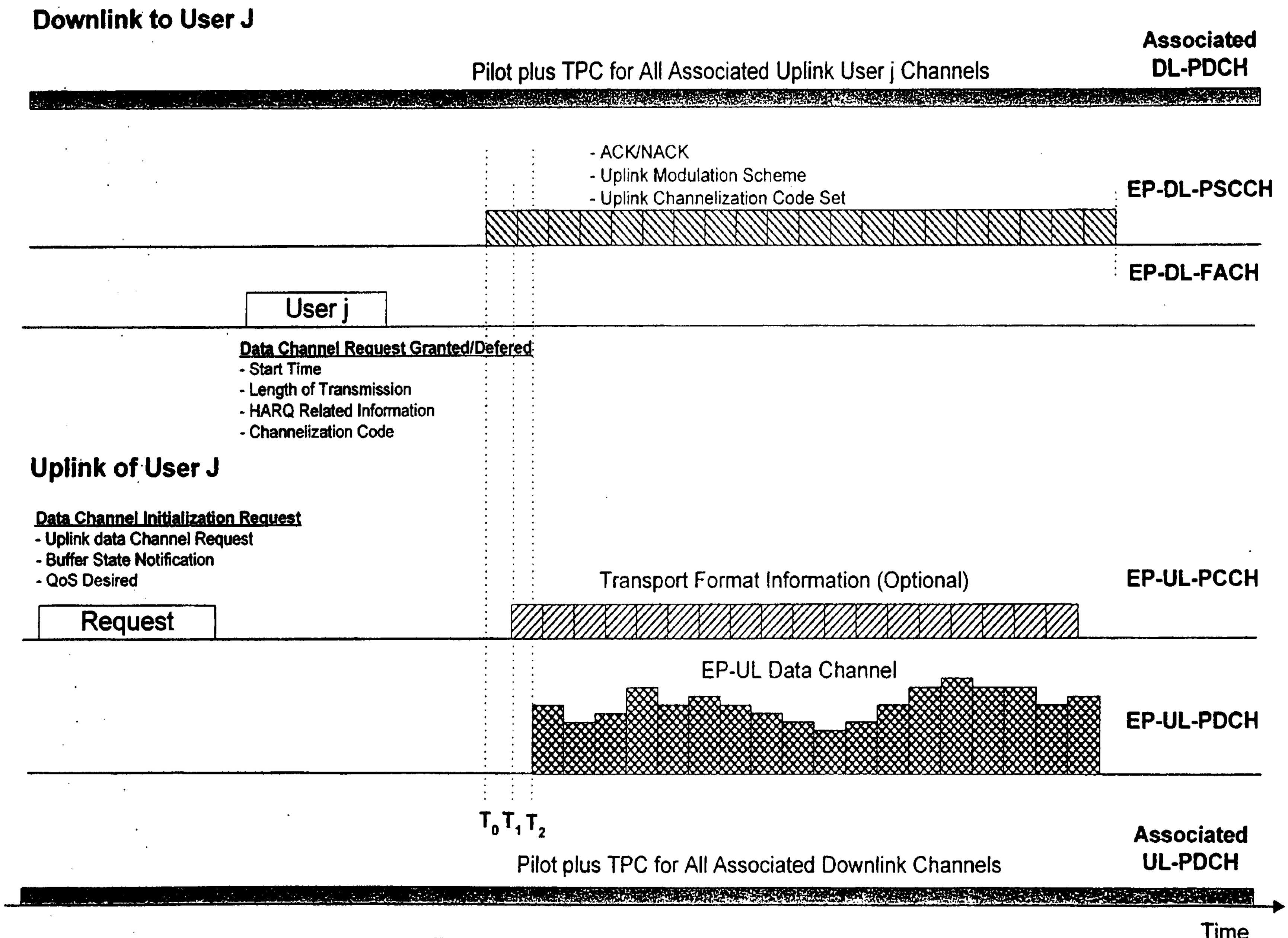


Fig. 2 EP-UL Packet Transfer Protocol (PTP)

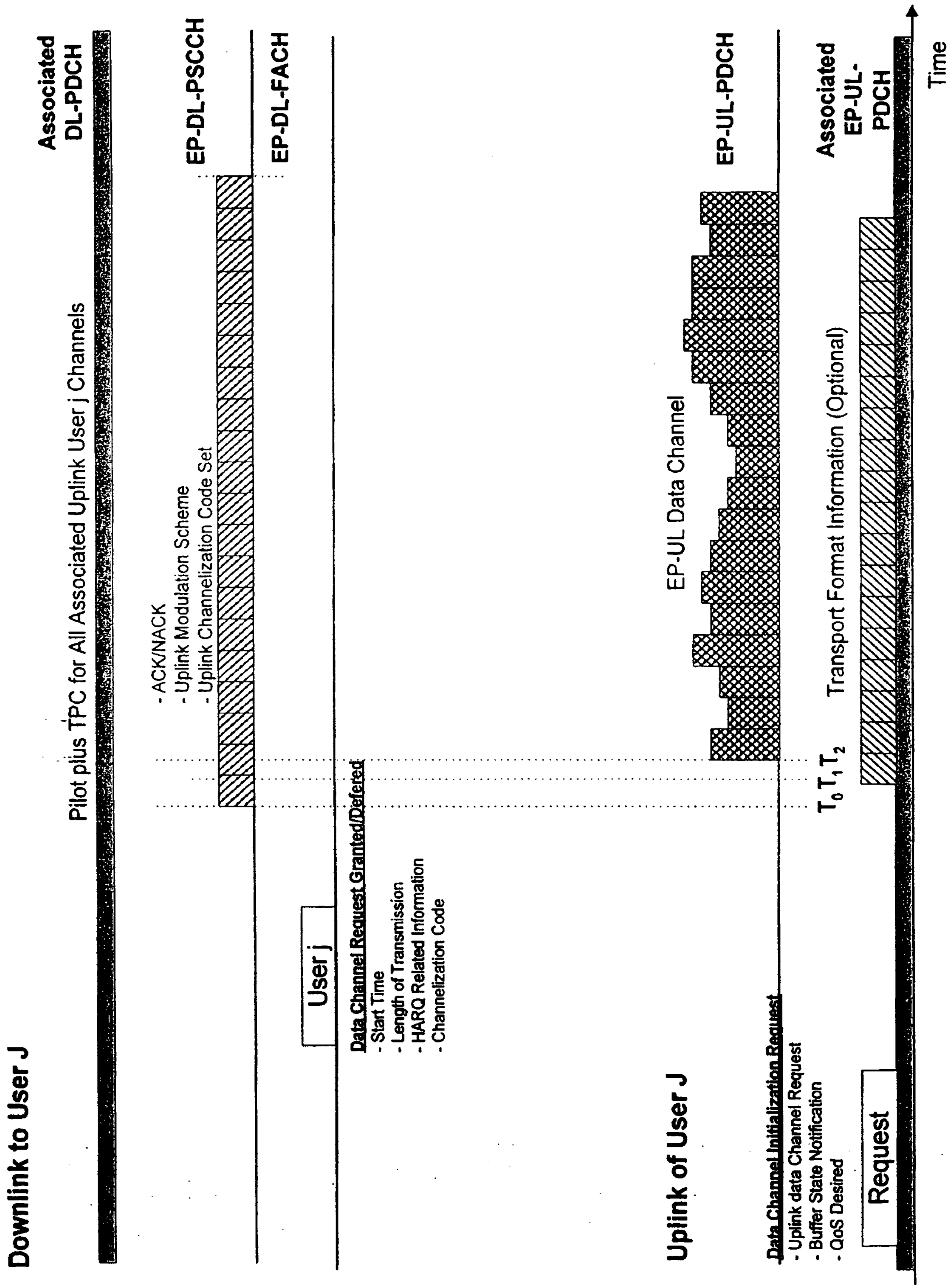


Fig. 3 EP-UL Packet Transfer Protocol

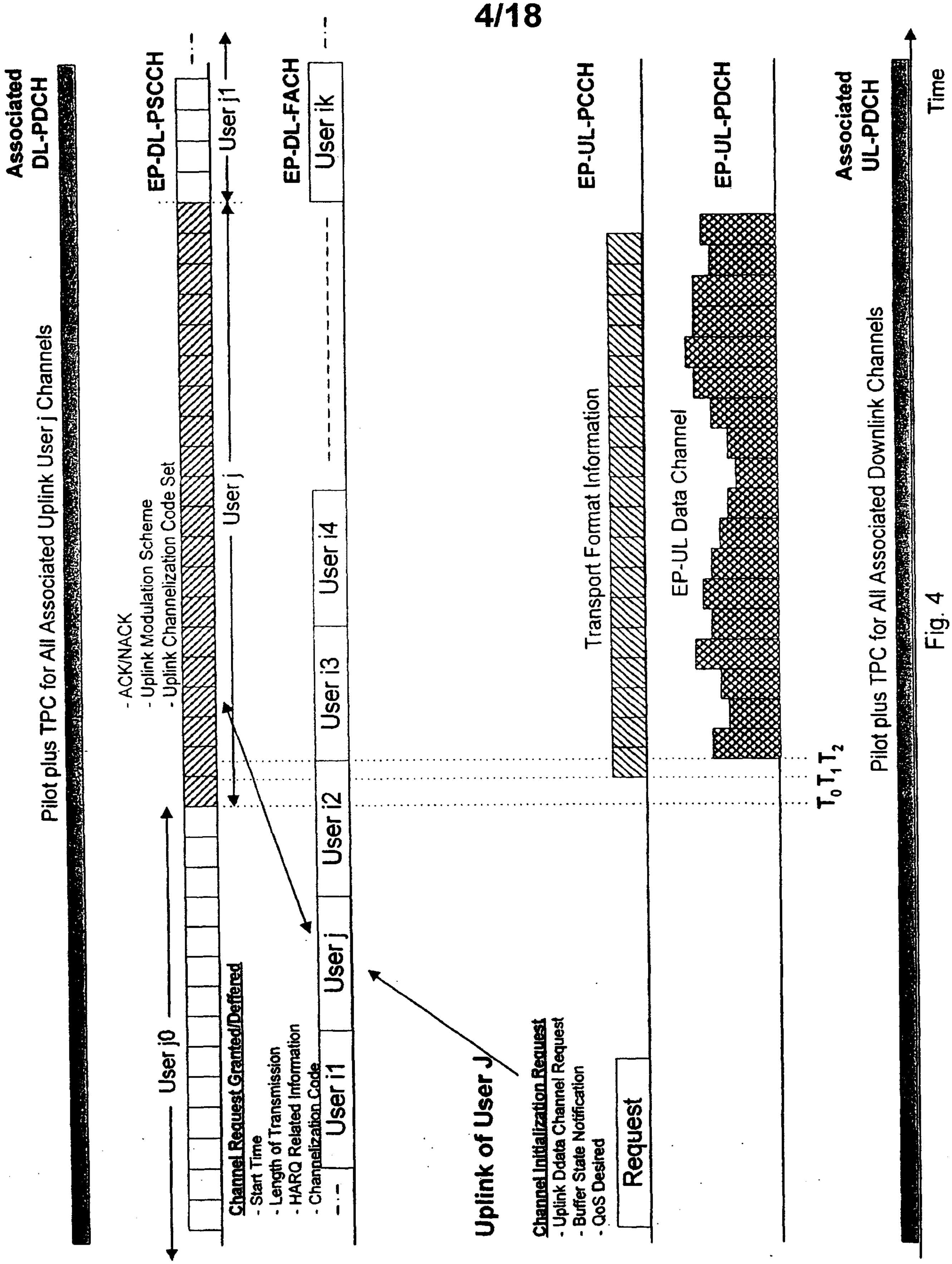
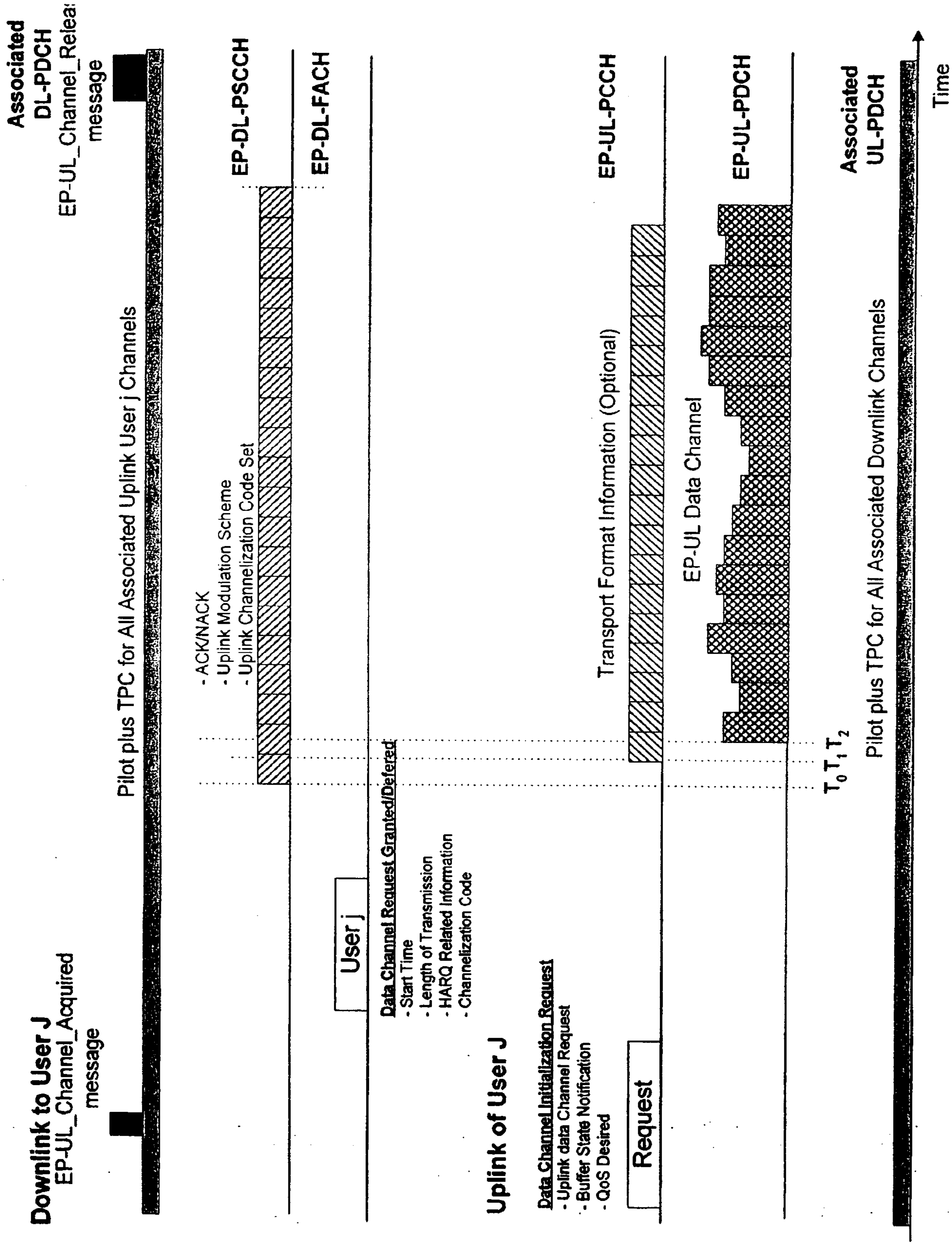

Associated DL-PDCH
Pilot plus TPC for All Associated Uplink User j Channels
EP-DL-PSCCH
User j0
User j
User j1
- ACK/NACK
- Uplink Modulation Scheme
- Uplink Channelization Code Set
Channel Request Granted/Deffered
- Start Time
- Length of Transmission
- HARQ Related Information
- Channelization Code
EP-DL-FACH
User i1
User j
User i2
User i3
User i4
User ik
Uplink of User J
Channel Initialization Request
- Uplink Ddata Channel Request
- Buffer State Notification
- QoS Desired
Request
EP-UL-PCCH
Transport Format Information
EP-UL-PDCH
EP-UL Data Channel
T_0 T_1 T_2
Associated UL-PDCH
Pilot plus TPC for All Associated Downlink Channels
Time

Fig. 4



Downlink to User J
EP-UL_Channel_Acquired message
Associated DL-PDCH
EP-UL_Channel_Releas message
Pilot plus TPC for All Associated Uplink User j Channels
- ACK/NACK
- Uplink Modulation Scheme
- Uplink Channelization Code Set
EP-DL-PSCCH
EP-DL-FACH
User j
Data Channel Request Granted/Deferred
- Start Time
- Length of Transmission
- HARQ Related Information
- Channelization Code
Uplink of User J
Data Channel Initialization Request
- Uplink data Channel Request
- Buffer State Notification
- QoS Desired
Request
Transport Format Information (Optional)
EP-UL-PCCH
EP-UL Data Channel
EP-UL-PDCH
T_0 T_1 T_2
Pilot plus TPC for All Associated Downlink Channels
Associated UL-PDCH
Time

Fig 5

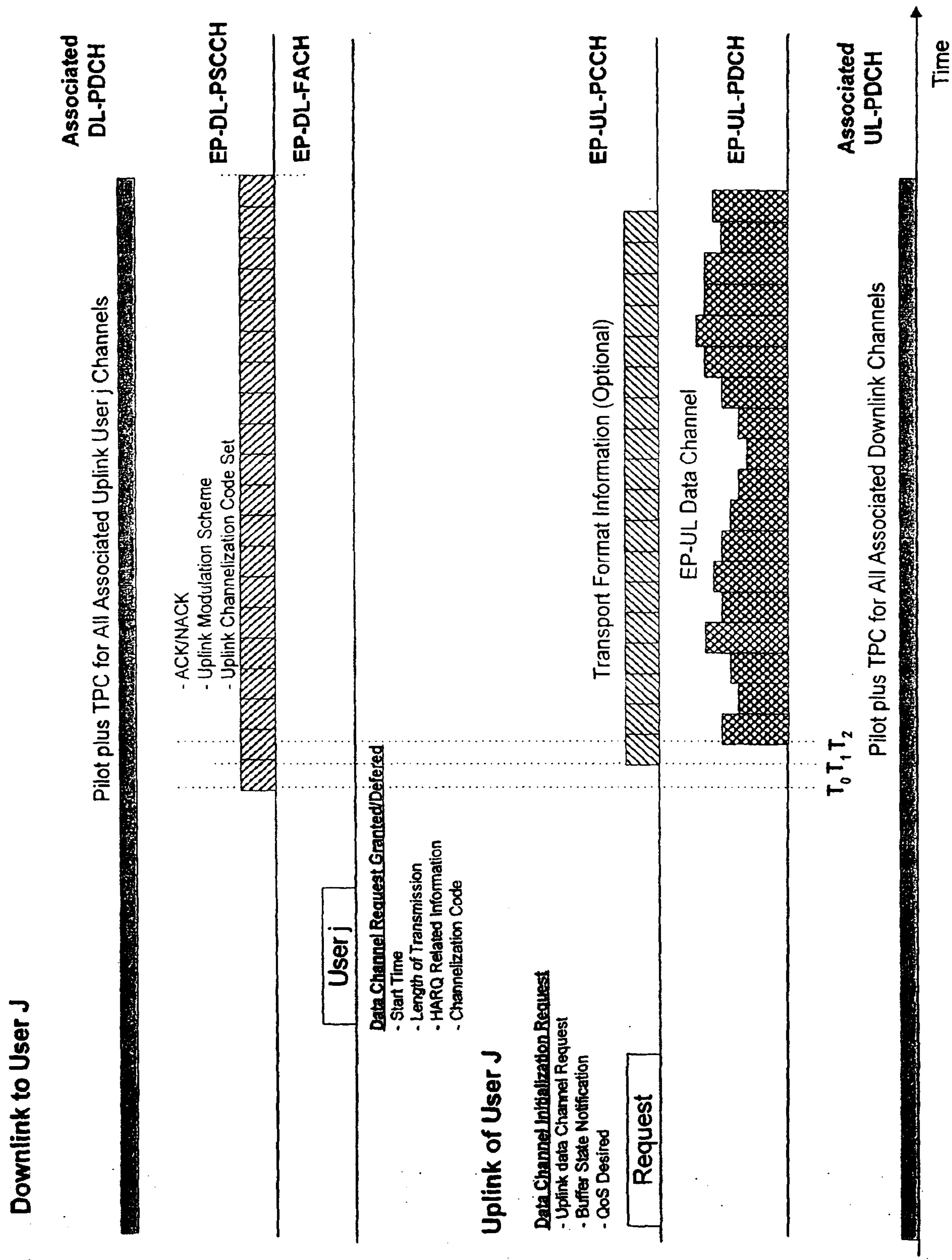

Downlink to User J
Associated DL-PDCH
Pilot plus TPC for All Associated Uplink User j Channels
EP-DL-PSCCH
- ACK/NACK
- Uplink Modulation Scheme
- Uplink Channelization Code Set
EP-DL-FACH
User j
Data Channel Request Granted/Defered
- Start Time
- Length of Transmission
- HARQ Related Information
- Channelization Code
Uplink of User J
Data Channel Initialization Request
- Uplink data Channel Request
- Buffer State Notification
- QoS Desired
Request
EP-UL-PCCH
Transport Format Information (Optional)
EP-UL-PDCH
EP-UL Data Channel
T0 T1 T2
Associated UL-PDCH
Pilot plus TPC for All Associated Downlink Channels
Time

Fig 6

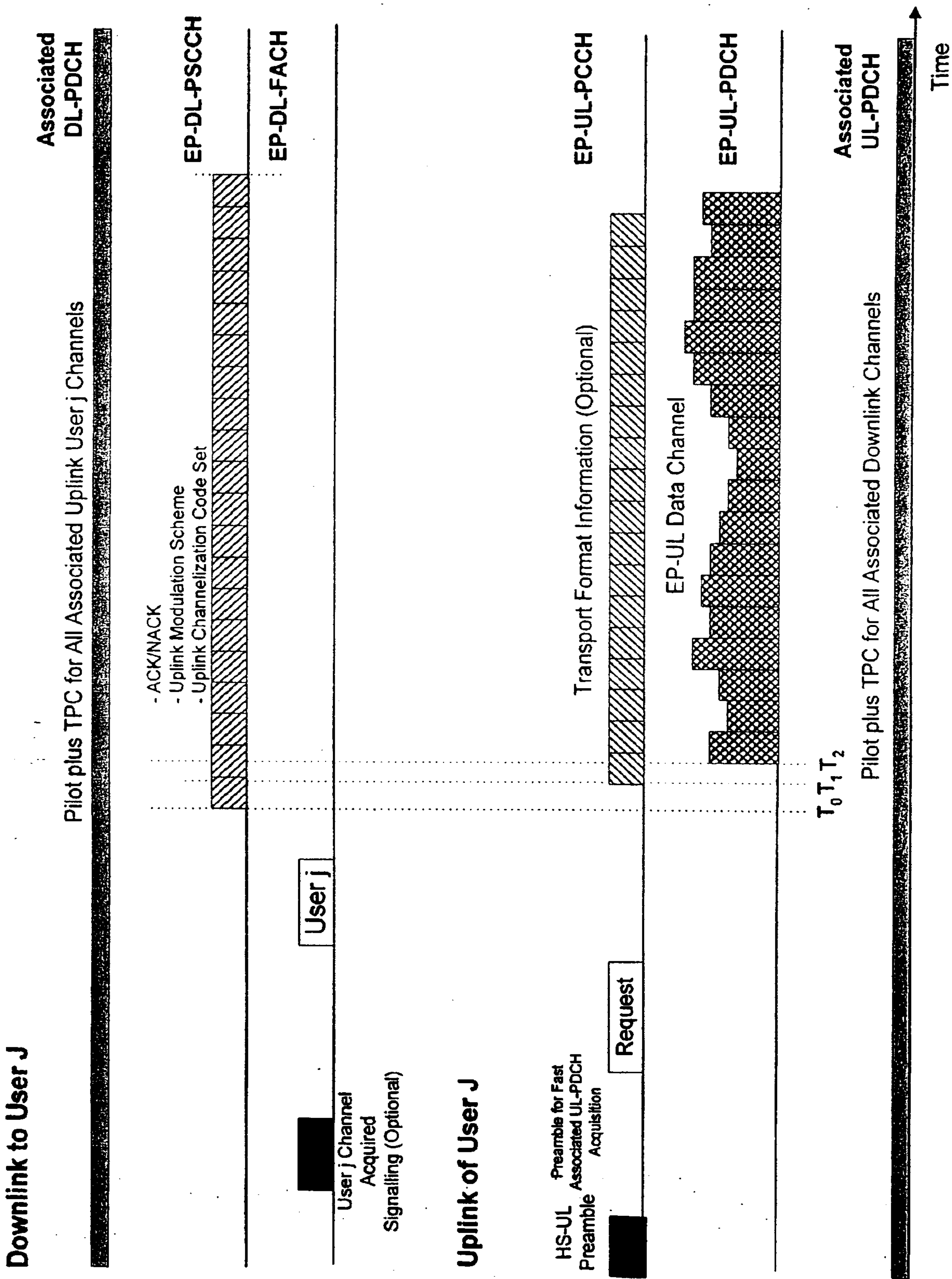

Downlink to User J
Associated DL-PDCH
Pilot plus TPC for All Associated Uplink User j Channels
EP-DL-PSCCH
- ACK/NACK
- Uplink Modulation Scheme
- Uplink Channelization Code Set
EP-DL-FACH
User j
User j Channel Acquired Signalling (Optional)
Uplink of User J
HS-UL Preamble
Preamble for Fast Associated UL-PDCH Acquisition
Request
EP-UL-PCCH
Transport Format Information (Optional)
EP-UL-PDCH
EP-UL Data Channel
T0 T1 T2
Associated UL-PDCH
Pilot plus TPC for All Associated Downlink Channels
Time

Fig. 7

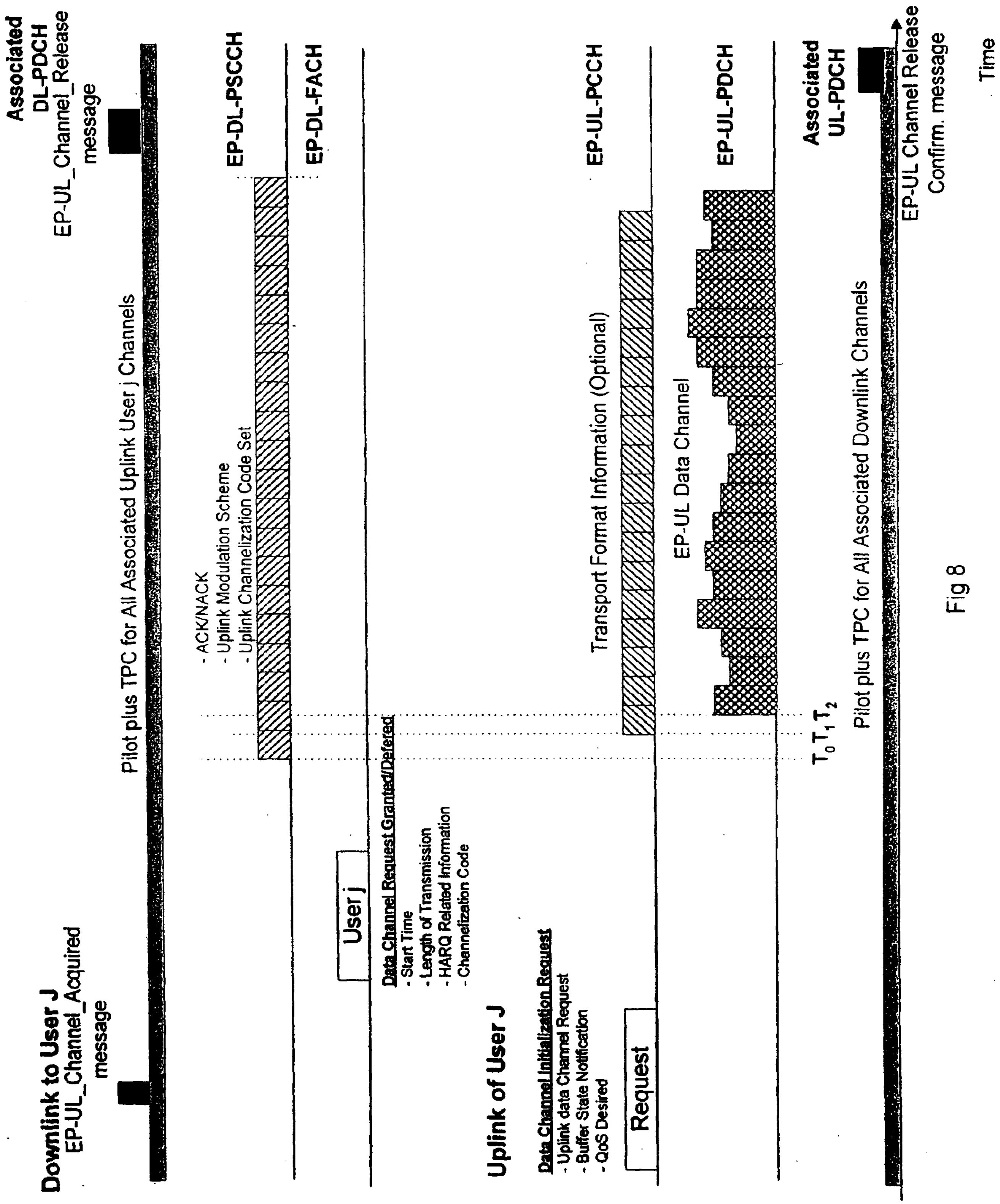

Downlink to User J
EP-UL_Channel_Acquired message
User j
Data Channel Request Granted/Deferred
- Start Time
- Length of Transmission
- HARQ Related Information
- Channelization Code
Uplink of User J
Data Channel Initialization Request
- Uplink data Channel Request
- Buffer State Notification
- QoS Desired
Request
Pilot plus TPC for All Associated Uplink User j Channels
- ACK/NACK
- Uplink Modulation Scheme
- Uplink Channelization Code Set
EP-DL-PSCCH
EP-DL-FACH
Associated DL-PDCH
EP-UL_Channel_Release message
Transport Format Information (Optional)
EP-UL-PCCH
EP-UL Data Channel
EP-UL-PDCH
T0 T1 T2
Pilot plus TPC for All Associated Downlink Channels
Associated UL-PDCH
EP-UL Channel Release Confirm. message
Time

Fig 8

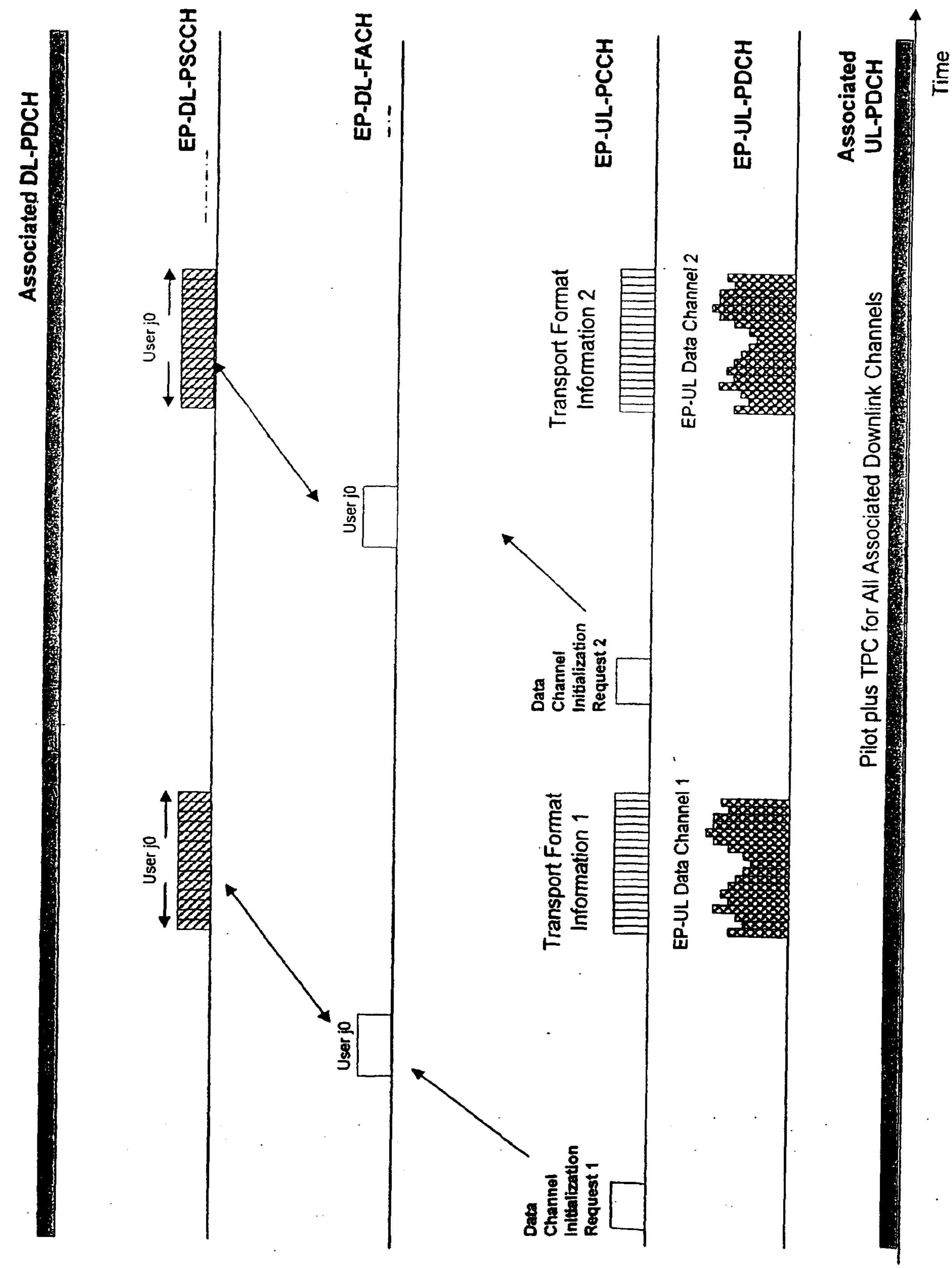

Associated DL-PDCH
EP-DL-PSCCH
EP-DL-FACH
EP-UL-PCCH
EP-UL-PDCH
Associated UL-PDCH
Time
User j0
User j0
User j0
User j0
Transport Format Information 1
Transport Format Information 2
Data Channel Initialization Request 1
Data Channel Initialization Request 2
EP-UL Data Channel 1
EP-UL Data Channel 2
Pilot plus TPC for All Associated Downlink Channels

Fig 9

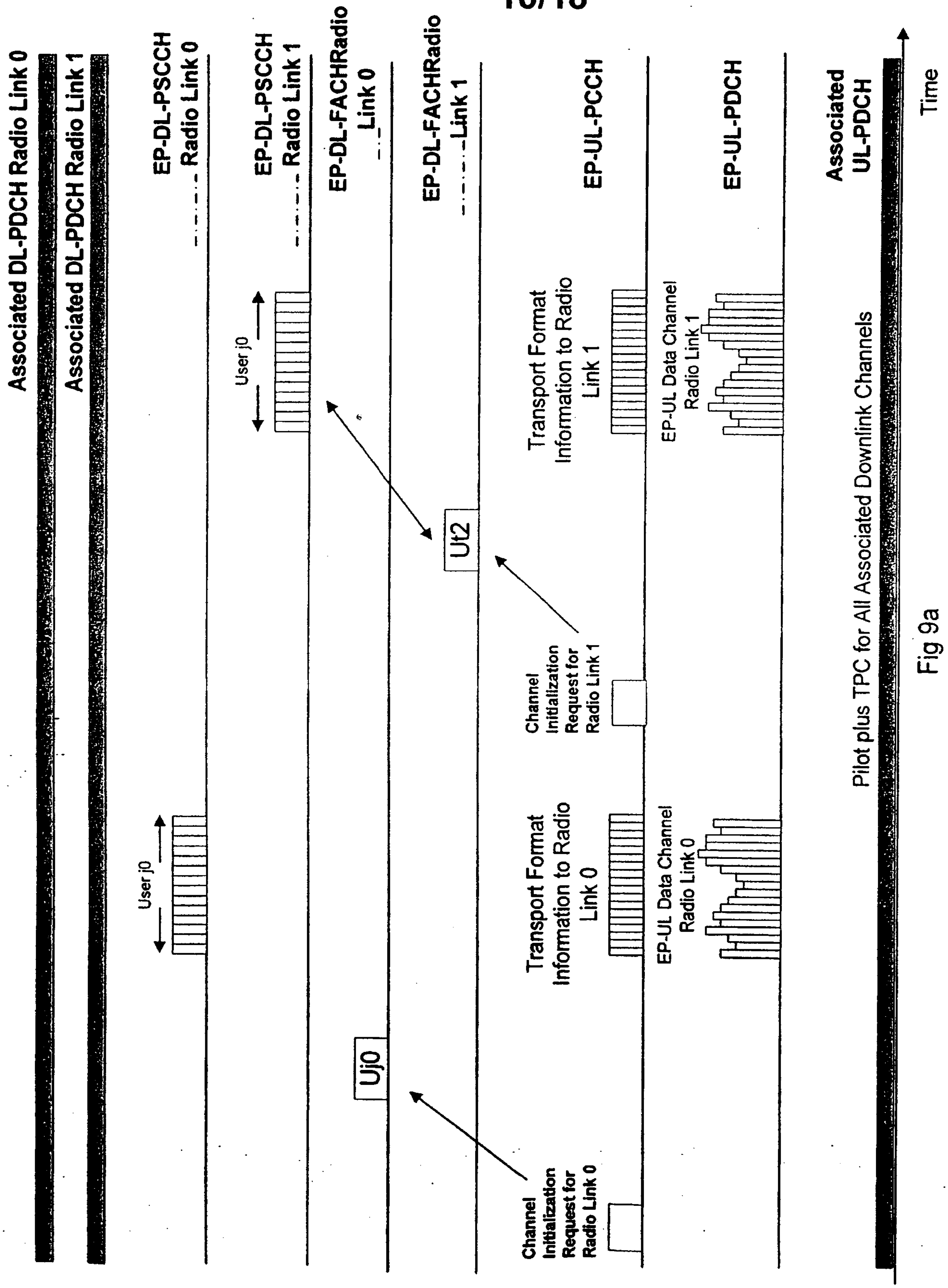

Associated DL-PDCH Radio Link 0
Associated DL-PDCH Radio Link 1
EP-DL-PSCCH Radio Link 0
EP-DL-PSCCH Radio Link 1
EP-DL-FACHRadio Link 0
EP-DL-FACHRadio Link 1
EP-UL-PCCH
EP-UL-PDCH
Associated UL-PDCH
Time
User j0
User j0
Uj0
Ut2
Channel Initialization Request for Radio Link 0
Channel Initialization Request for Radio Link 1
Transport Format Information to Radio Link 0
Transport Format Information to Radio Link 1
EP-UL Data Channel Radio Link 0
EP-UL Data Channel Radio Link 1
Pilot plus TPC for All Associated Downlink Channels

Fig 9a

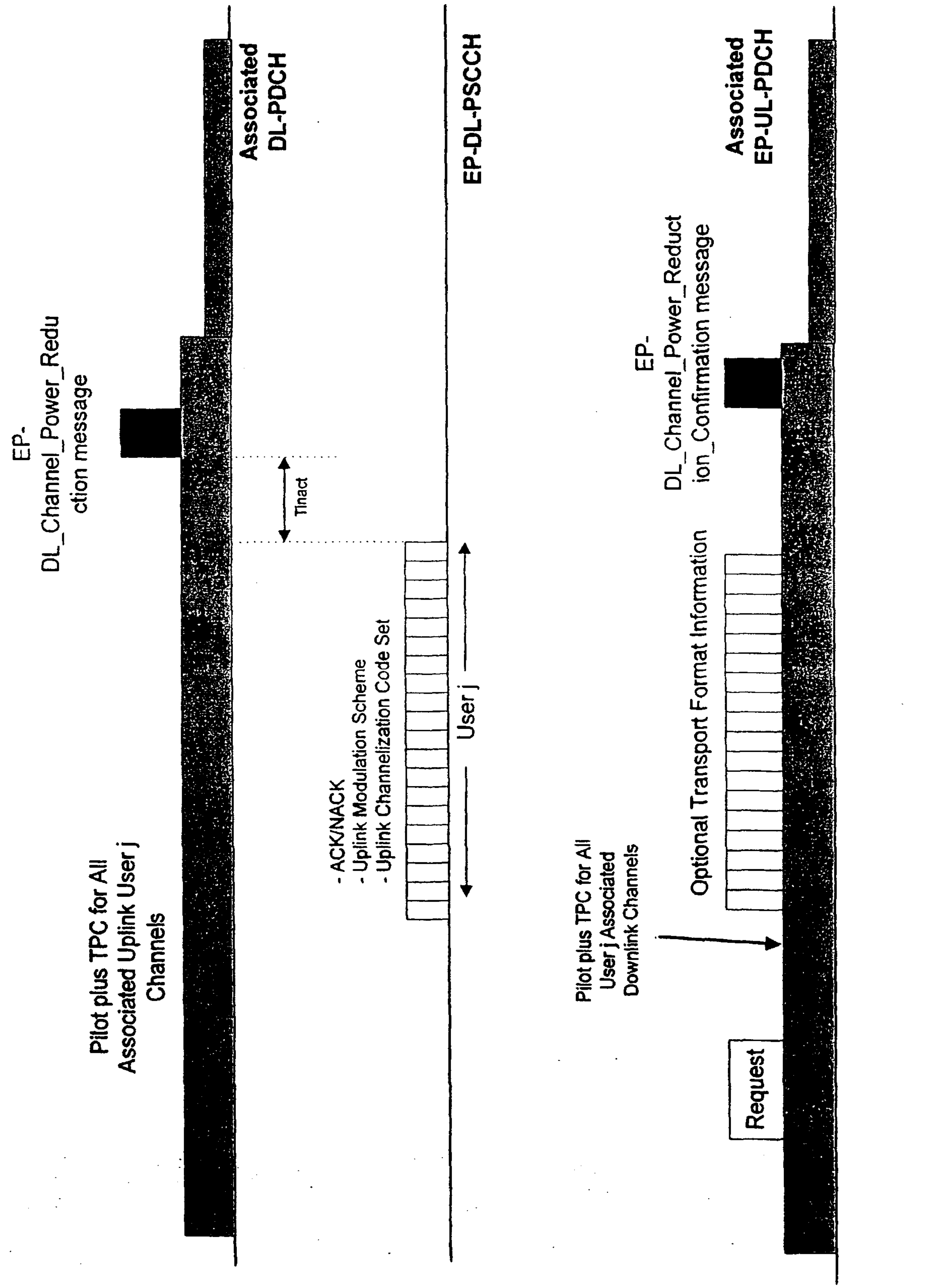
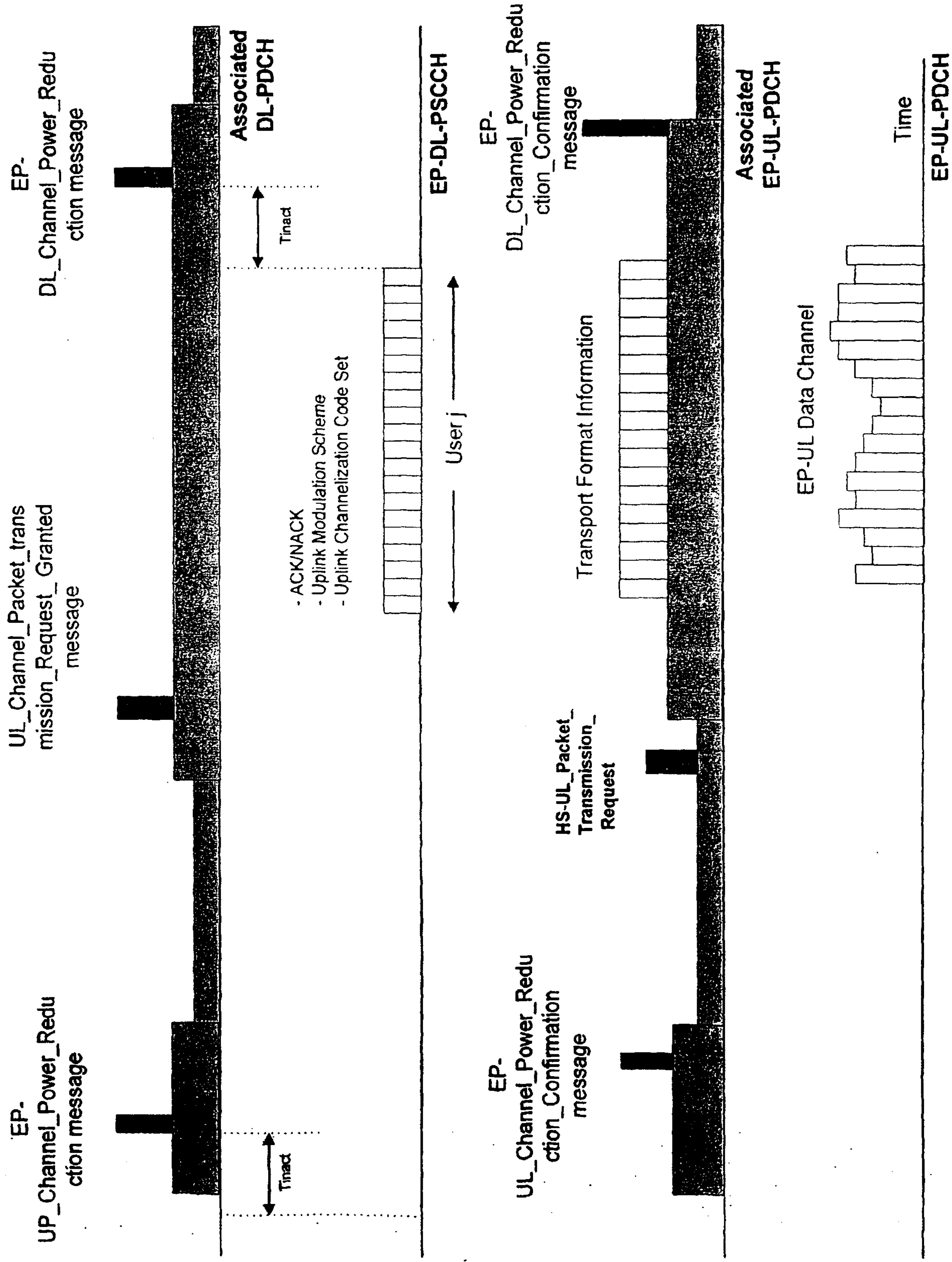

Associated DL-PDCH
EP-DL_Channel_Power_Reduction message
Pilot plus TPC for All Associated Uplink User j Channels
Tinact
EP-DL-PSCCH
- ACK/NACK
- Uplink Modulation Scheme
- Uplink Channelization Code Set
User j
Associated EP-UL-PDCH
EP-DL_Channel_Power_Reduction_Confirmation message
Optional Transport Format Information
Pilot plus TPC for All User j Associated Downlink Channels
Request

Fig 10



EP-DL_Channel_Power_Reduction message
UL_Channel_Packet_transmission_Request_Granted message
EP-UP_Channel_Power_Reduction message
Associated DL-PDCH
Tinact
Tinact
EP-DL-PSCCH
- ACK/NACK
- Uplink Modulation Scheme
- Uplink Channelization Code Set
User j
EP-DL_Channel_Power_Reduction_Confirmation message
Transport Format Information
HS-UL_Packet_Transmission_Request
EP-UL_Channel_Power_Reduction_Confirmation message
Associated EP-UL-PDCH
EP-UL Data Channel
Time
EP-UL-PDCH

Fig 11

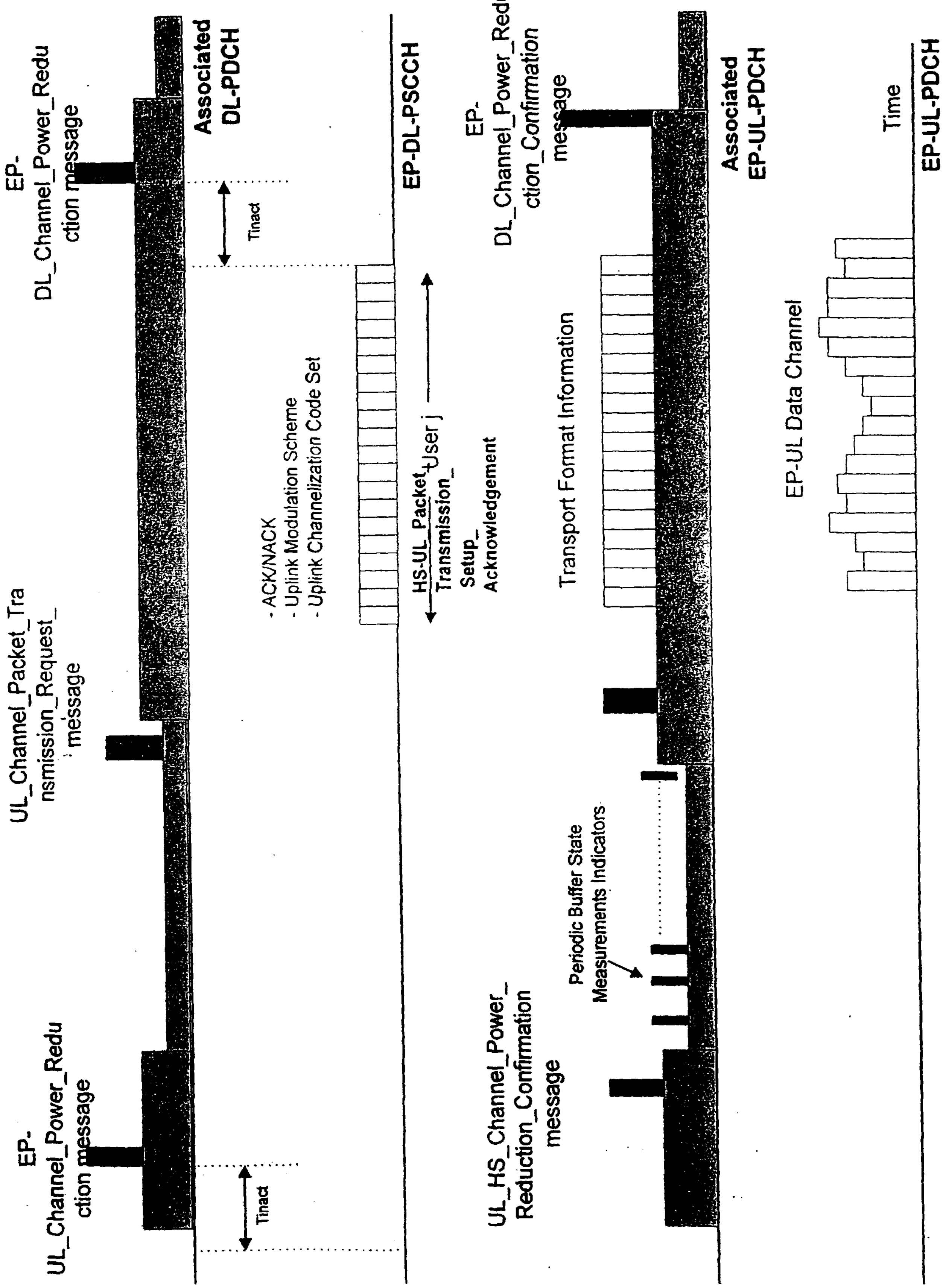

EP-
DL_Channel_Power_Redu
ction message
Associated
DL-PDCH
Tinact
UL_Channel_Packet_Tra
nsmission_Request_
message
EP-
UL_Channel_Power_Redu
ction message
Tinact
- ACK/NACK
- Uplink Modulation Scheme
- Uplink Channelization Code Set
EP-DL-PSCCH
HS-UL_Packet_
Transmission_
Setup_
Acknowledgement
User j
EP-
DL_Channel_Power_Redu
ction_Confirmation
message
Transport Format Information
Associated
EP-UL-PDCH
Periodic Buffer State
Measurements Indicators
UL_HS_Channel_Power_
Reduction_Confirmation
message
EP-UL Data Channel
Time
EP-UL-PDCH

Fig 12

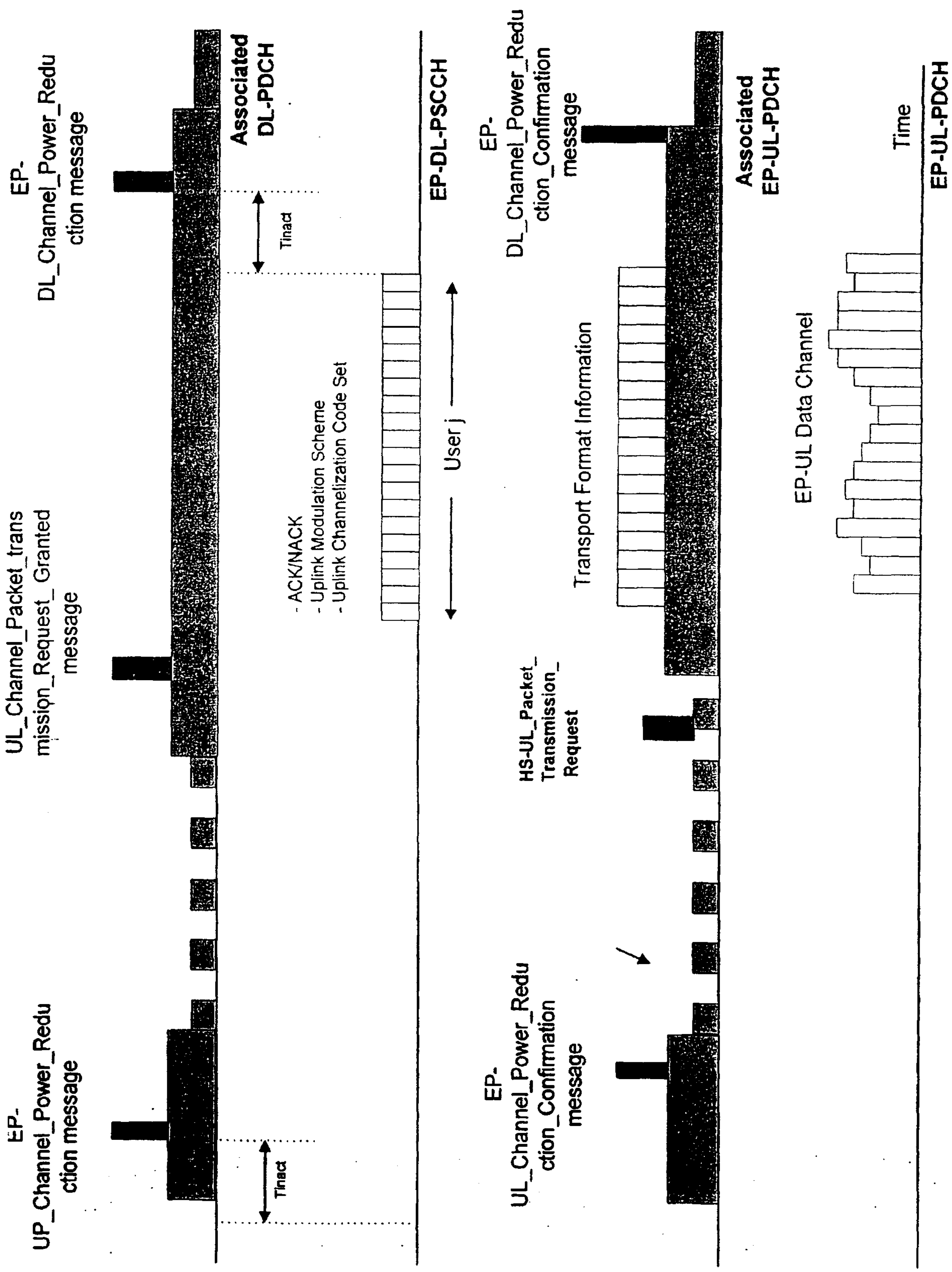

EP-
DL_Channel_Power_Reduction message
Associated
DL-PDCH
Tinact
UL_Channel_Packet_transmission_Request_ Granted message
EP-
UP_Channel_Power_Reduction message
Tinact
- ACK/NACK
- Uplink Modulation Scheme
- Uplink Channelization Code Set
EP-DL-PSCCH
User j
EP-
DL_Channel_Power_Reduction_Confirmation message
Transport Format Information
HS-UL_Packet_Transmission_Request
EP-
UL_Channel_Power_Reduction_Confirmation message
Associated
EP-UL-PDCH
EP-UL Data Channel
Time
EP-UL-PDCH

Fig 13

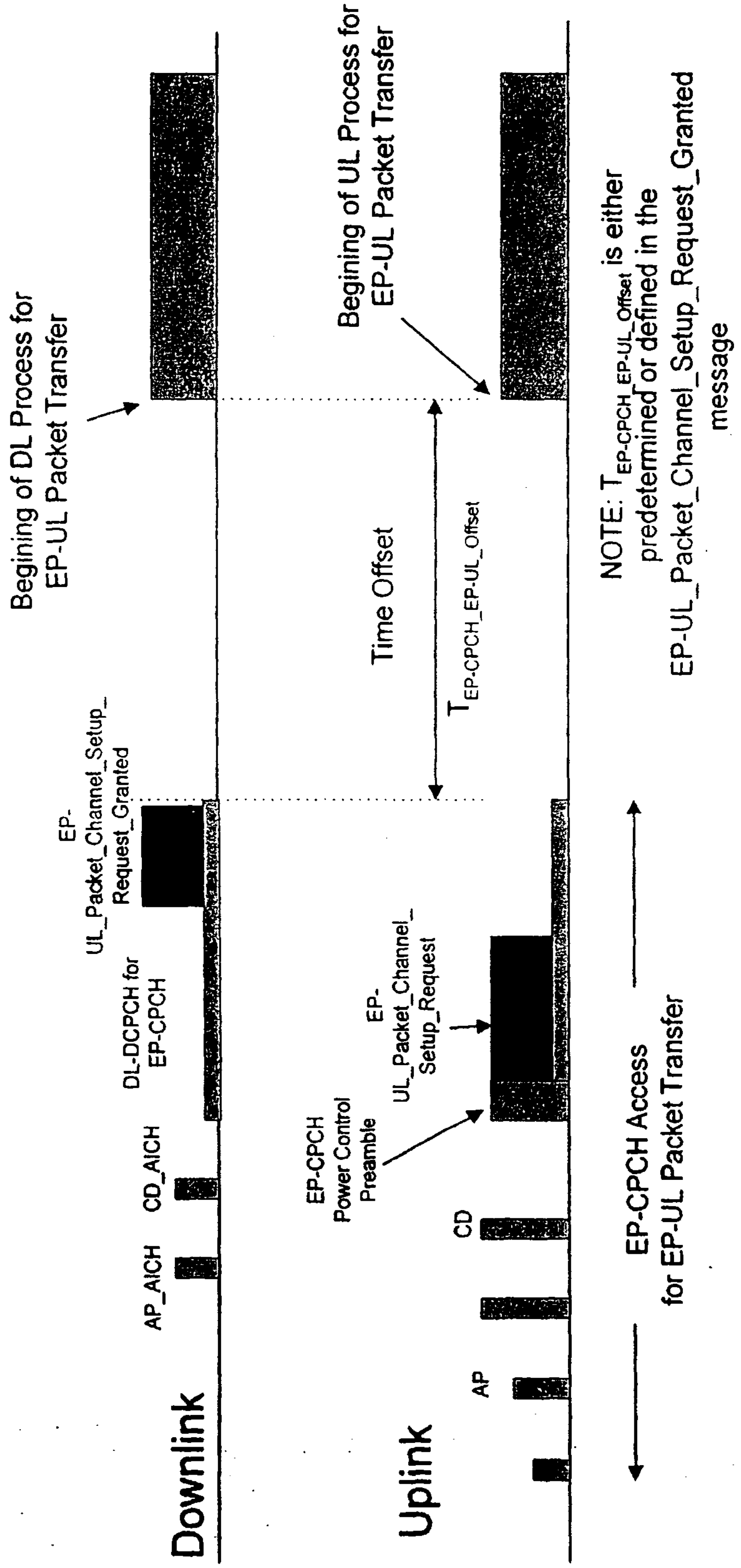


Fig. 14 EP-UL Packet Transfer Protocol (PTP) Using EP-CPCH for Initial Procedure Setup.

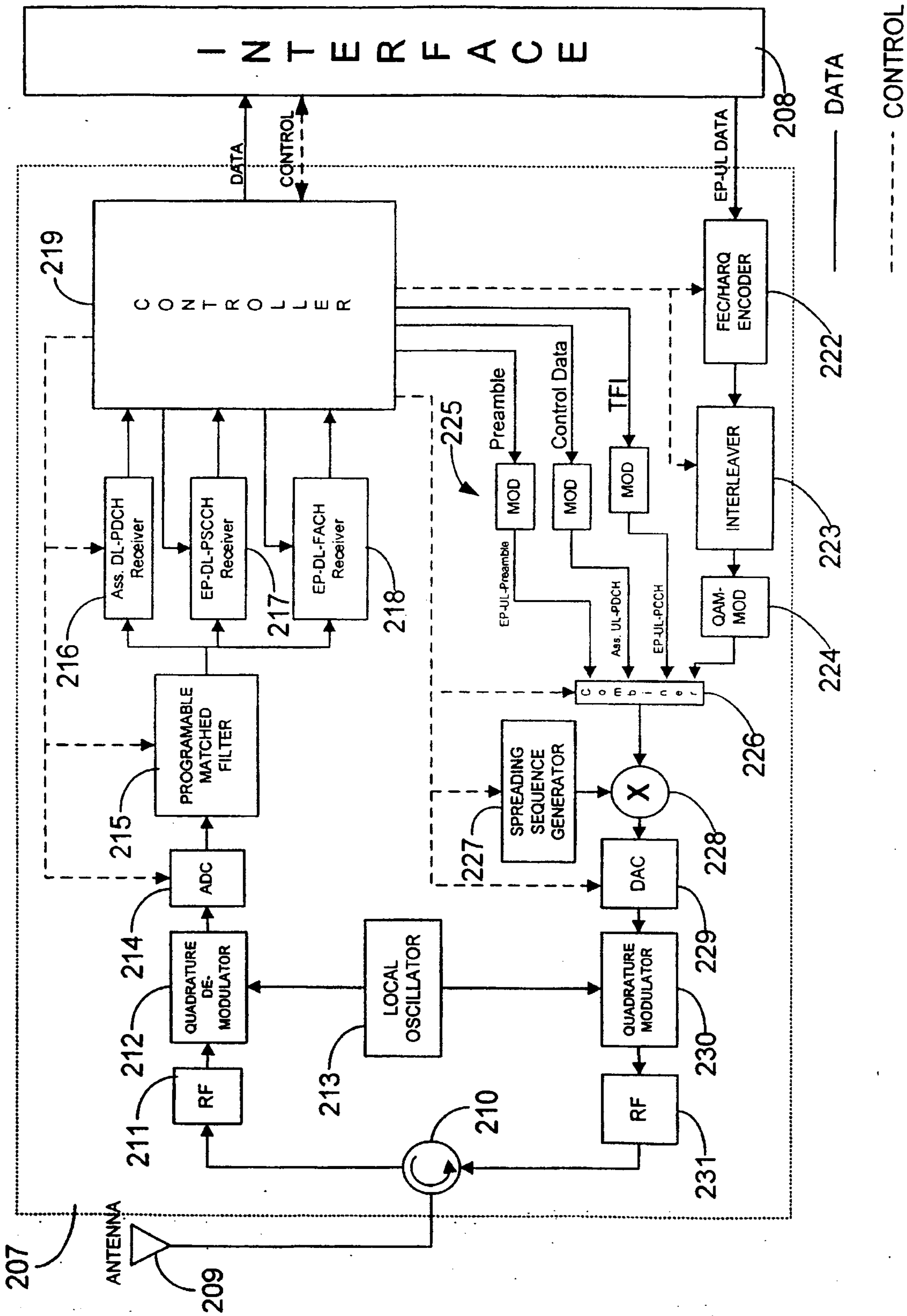


Fig. 15 Remote Station Tranceiver for Enhanced Uplink Packet Communications.

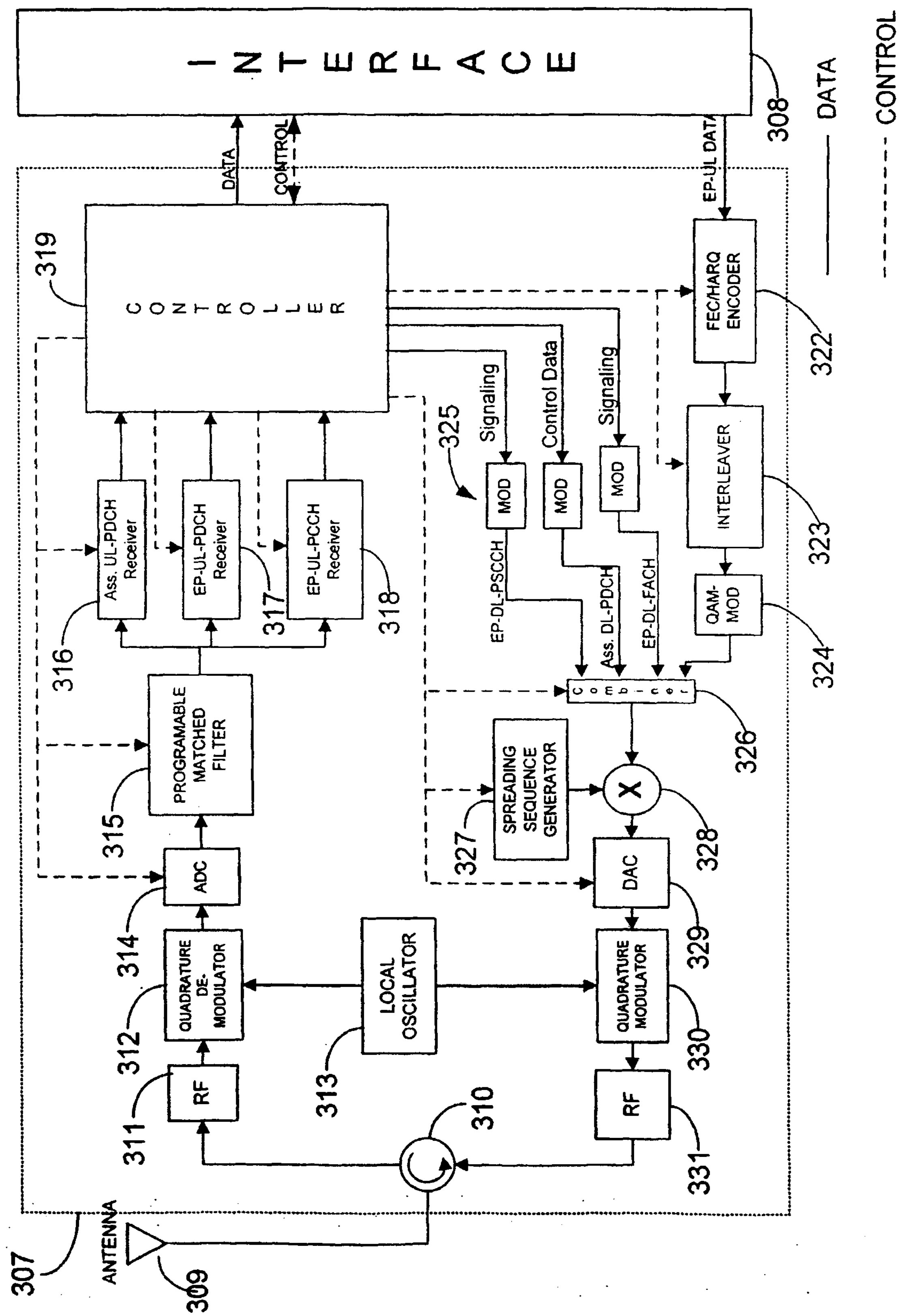


Fig. 16 Base Station (Node-B) Tranceiver for Enhanced Uplink Packet Communications.

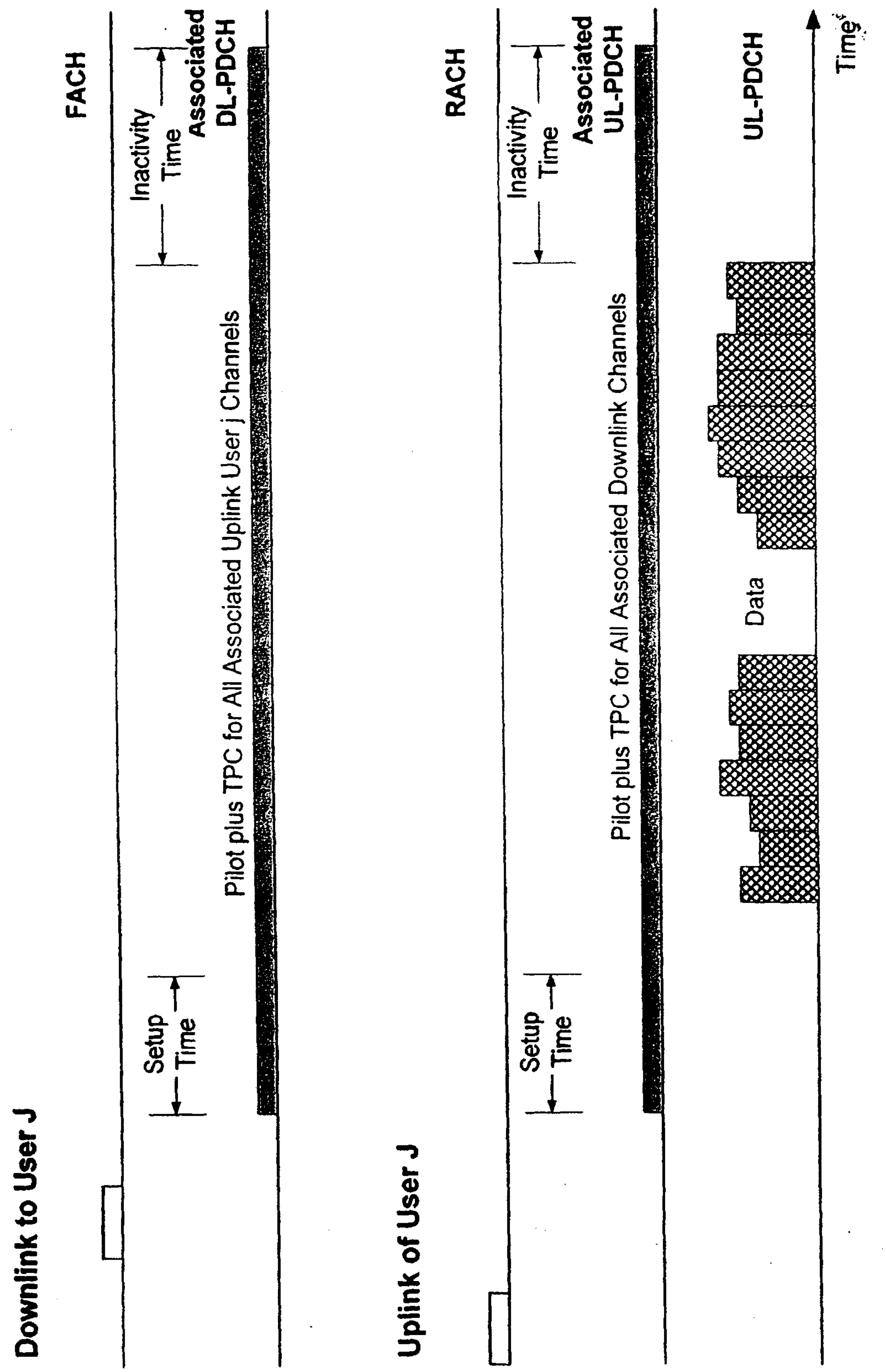


FIG. 17 UL DCH Packet Transfer Protocol (Prior Art)

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(54) **Title:** SYSTEM FOR UPLINK SCHEDULING PACKET BASED DATA TRAFFIC IN WIRELESS SYSTEM

(57) **Abstract:** A system for allocating bandwidth resources among various mobile stations which are wirelessly connected to a base station. The length of the data queue in each mobile station is determined and information regarding that length is placed in a field in the outgoing data packet. When it is received in the base station, this field is decoded and the queue length information used to allocate bandwidth resources among the mobile station connections. This allows a very quick response to data queue lengths and accordingly better service.

SYSTEM FOR UPLINK SCHEDULING PACKET BASED DATA TRAFFIC IN WIRELESS SYSTEM

TECHNICAL FIELD

This invention relates generally to a system for allocating resources for data streams and more particularly to a system for allocating transmission resources in a wireless system where the data includes an indication of its own resource needs.

BACKGROUND ART

In networks and other arrangements, a situation often develops where a limited number of resources, such as bandwidth must be shared among a plurality of links. In particular, in a wireless type network, a number of mobile stations may be connected to a base station by wireless connections. Each base station may have only a limited number of channels to make these connections. Since many such mobile devices now utilize more than basic voice data, the amount of data which flows can vary substantially. Thus in addition to voice communications, wireless devices may include real time video, e-mail, web based information, etc. In order to fairly allocate the resources available, it is necessary for the base station to make some judgment as to which mobile stations can utilize the channels.

The simplest arrangement, and one used largely in the past for voice data, is merely to dedicate a single channel for a single mobile station as long as it is connected. Only the assigned mobile station can use the channel. Depending on the original request, it is possible to assign more than a single channel but these multiple channels remain dedicated to that mobile station until the connection is terminated. No information is shared about the instantaneous amount of data waiting in the mobile station.

Another manner of handling the situation is to utilize a polling scheme where the base station polls each mobile station to learn the status of the data queue in each mobile station. This allows the base station to determine how to share the bandwidth resources among the different mobile stations. Thus, when polled the mobile station can send a response indicating whether it has data to transmit. For example, in a global system for mobile devices (GSM) time division multiple access (TDMA) system, the transmission opportunity for a mobile station is granted n frames after the base station receives the polling response from the mobile station, where n is the number of frames required to transmit a data block in the channel. Thus, there is a delay of multiple frames after polling, before an adjustment can be made.

Unfortunately, real time traffic such as video conference has unpredictable fluctuations in the data rate. Thus, any delay in adjusting the resources may mean that a link to a mobile station may not always have data in its transmission queue.

Since a dedicated channel assignment scheme does not allow any other mobile stations to use the channel when the assigned mobile station uplink queue is empty, the bandwidth assigned will not be used, which lowers overall spectrum efficiency. This leads to poor bandwidth utilization which will only get worse as the number of connections in the system increases. Also, during high data rate periods, the number of real time packets waiting in the uplink queue will increase. Due to the limited bandwidth share assigned to the mobile station, packet congestion can occur and an increasing number of packets can exceed their delay requirements.

While the polling scheme is more efficient than a dedicated channel assignment scheme from the perspective of bandwidth utilization, some bandwidth is still wasted because the mobile station cannot send actual data when sending a polled response. As polling becomes more frequency, more bandwidth is wasted. Further, additional delay is introduced because the packet has to wait while the poll is received and answered. Thus, the delay will further slow down transmission and counteracts any benefits gained by the polling.

DISCLOSURE OF INVENTION

Accordingly, the present invention provides a system for allocating transmission resources between the base station and a series of mobile stations.

The present invention also provides a method for allocating resources based on the amount of data waiting in a queue in each mobile station.

The present invention also provides a system for allocating bandwidth resources between a plurality of mobile stations and a single base station in a wireless network.

The present invention further provides a method for allocating bandwidth resources between a plurality of mobile stations and a single base station in a wireless network.

The present invention further provides a system for transmitting information concerning the amount of data in a queue so that resources may be allocated appropriately for the most efficient use of the resources.

The present invention still further provides a method for transmitting information regarding the amount of data stored in a queue in a mobile station in a wireless network.

Briefly, this invention is achieved by using a plurality of bits in each data segment to describe the size of the queue in that station. Once this is received in the base station, additional resources can be allocated if necessary.

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a schematic diagram showing the arrangement of the present system;

Figure 2 is a block diagram showing a mobile station according to the present invention;

Figure 3 is a block diagram showing a base station according to the present invention;

Figure 4 is a flow chart showing the method of determining the queue length; and

Figure 5 is a flowchart showing the method of utilizing the information.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views and more particularly to Figure 1 thereof, wherein the wireless system 10 is shown as including a base station 12 and mobile stations 14. As indicated in the figure, the individual mobile stations may be connected to the base station by wireless connections. Since the base station is allowed to use only a certain range of frequencies, there is limit to the bandwidth available to the mobile stations. Since this resource is limited, it is necessary to allocate this bandwidth so that the greatest amount of data can be moved in the shortest time. This improves the quality of service and avoids unnecessary delay for the users.

The present invention improves on previous schemes by allocating the bandwidth among the various mobile stations which are currently connected to the base station. In order to do this, it is necessary for the base station to have some idea of the amount of data in the queue in the individual mobile stations. Prior art systems do not provide for this information to be given to the base station, nor are the resources allocated in real time based on this information.

Data which is sent from the mobile stations to the base station is arranged in blocks according to the protocol governing the apparatus. Thus, such blocks include not only the data itself, but identification information and other bits which may be used for other purposes such as error checking, etc. In particular, in the enhanced general packet data radio services system (EGPRS), there is provided a field of four bits which are known as the countdown value of the block. Under the current scheme, the bandwidth allocated to the mobile station is fixed and these four bits indicate the queue length of that mobile station. In particular, it indicates the number of data blocks in the queue as long at it is less than 16. This provides an estimate of when the current data transfer will be finished. However, this is not used in any manner to control the resources available.

In the present arrangement, these four bits instead provide an indication of the data in the queue so that the base station may determine if additional resources are necessary in order to move the data at the optimum speed. While the particular data included in the four bits may have various different meanings, the preferred arrangement is to let the values of 0-8 indicate the number of data segments in the queue. These values will indicate a queue length if it is less than or equal to the segment rate. This segment rate is the parameter which is established between the mobile station and the base station during the set up phase. If the queue length exceeds the segment rate, the values of 9-15 in the four bit field indicate the additional bandwidth which is required in order to meet the delay/rate requirement of the packet.

Thus, as the individual packets are sent from the mobile station to the base station, the base station examines this four bit field and notes the situation in the queue at that mobile station. If additional resources are necessary, the base station will allocate additional bandwidth to that connection so that the data stored in the queue will move faster. This of course assumes that sufficient resources are available to add resources to that connection. Clearly, the base station must consider all of the requests of all of the connections before allocating these resources. Since the four bit field is sent with every packet, the base station is constantly updated as to the situation in each mobile station. Accordingly, it can closely monitor the situation and adjust it over a very short time period to improve the utilization of its resources. This arrangement is much faster than the polling scheme because the information is provided in each packet without wasting bandwidth for the polling communications. Further, the present arrangement utilizes a four bit field which is already present according to the current protocols. It is only necessary to provide that the base station and mobile station each have a proper system for adding the data and using the data.

Figure 2 shows a block diagram of a mobile station 14. While the station is shown as including a number of circuits, in fact, these functions could also be performed by software in a processor. A data generator 20 produces the data which is to be transmitted by the mobile station. This can include any of the normal devices which are utilized in a mobile station to produce data including a microphone to produce voice data, a keyboard to produce alpha numeric data, a camera for producing video data, etc. The specific type of data generation is not critical to the operation of the present invention. However, no matter what type of data is produced, it is sent to a data queue 22 to await its transmission. A queue length measuring device 24 observes the amount of data in the queue and determines the queue length. This queue length information is sent to encoder 26 which determines the four bit code to place in the field based on the length of the queue. Thus, in the preferred system described above, if the queue is less than the segment rate, a value between zero and eight is encoded and if the queue length is greater than the segment rate a value between nine and fifteen is encoded. The exact value in either of these ranges depends on the length of the queue. Other schemes of encoding could easily be used also merely by changing the encoding scheme. Thus, it would be possible to use a queue length value only if preferred or only a value for additional bandwidth. Other values could also be utilized as long as they relate in some manner to the length of the queue and can be utilized in the base station to allocate the bandwidth appropriately. Obviously, some encoding schemes will provide better information and allow for more appropriate allocation of resources.

Once the four bit code has been generated, it is added to the data block in a combiner 28. Thus, the code is added to the data block only when it reaches the front of the line in the queue so that the most updated information about the length of the queue can be given. Alternatively, the code can be added based on the length of the queue when the data block enters the queue, but this information would be slightly less fresh. In this alternative arrangement, the combiner would make the combination as the data enters the queue. In either case, when the packet is ready for transmission, it is sent to transmitter 30 so as to be connected to the base station through antenna 32.

As shown in Figure 3, base station 12 includes an antenna 34 and receiver 36 which receive the packet transmitted from antenna 32. Of course, this antenna and receiver are in communication with several mobile stations at the same time. For simplicity of discussion, it will, however, be discussed as if only a single mobile station were connected at a time. The receiver 36 forwards the received data onto signal processor 38 for further handling of the data and eventual connection of the data to output lines 40. However, decoder 42 looks at the data signal and determines the code in the four bit field which represents the queue length information. This decoder then provides the queue length information for the associated mobile station to the resource controller 44. The resource controller determines the situation in the data queue in the associated mobile station and determines whether additional resources should be allocated to that mobile station connection and if the resources are available. The controller obviously must prioritize the needs of the various stations in view of the resources available and distribute them in the most effective manner. This controller then determines the various bandwidth resources available for each mobile station and controls the receiver to arrange this. The actual decision process as to how to allocate the resources based on this information may vary. It may take into consideration the importance of the information, its time sensitivity, the importance of the particular user, or other factors in addition to the amount of data in each station. However, the allocation should be such as to give the best quality of service to as many stations as possible. However, the simple manner of making this choice is merely to allocate the most resources to the station with the largest queue without lowering the segment rate which has been guaranteed. Just as in the mobile stations, the various circuitry indicated for the base station may actually be hardwired devices or may be programmed functions of a processor.

In a preferable system, the real time data packet is split into data segments for the purpose of transmission. In packet cellular systems, data segments correspond to a radio link control/multiple access control (RLC/MAC) block, which is a layer 2 data block. Each data segment is transmitted individually over the transmission media when the opportunity is granted. A transmission opportunity is defined as any method used to transport a data segment on the transmission media. For example, in a time division multiple access system (TDMA) the transmission opportunity is a time slot and in a wideband code division multiple access (WCDMA) system it is the utilization of a unique WALSH code in a radio frame. The radio frame is shared by multiple users using different WALSH codes. The base station schedules the data packets and organizes the transmission opportunities for current user traffic. The present invention presents a model that will help the scheduling in the base station to provide for optimum service for all users in the uplink direction. Traffic information is sent in each block in the uplink. By including this information in one field of the block, real time information is provided to enable better scheduling.

While this arrangement has been described in terms of a wireless connection between a mobile station and a base station, it could also be applied to other systems where the connections are made by wire, fiber optic cable, etc. The only requirement is that the queue length information can be sent with the data block and that the resources can be allocated based on this data.

The method of operation of this system is seen in the flow charts of Figures 4 and 5. Figure 4 relates to the method of determining the queue length and encoding the four bit field in the mobile station. In step 100, the data queue length is determined. In step 102 the determined length is converted to a four bit code which is related to the queue length. This code is inserted in the data packet in step 104. The packet is then transmitted in step 106.

Figure 5 shows the method of utilizing this information in the base station. In step 110, the signal from a particular mobile station is received. In step 112 the data is forwarded. In step 114 a decoder receives the encoded four bit field and decodes it. In step 116 the resource controller receives the decoded information and determines the length of the queue. In step 118, the resources are based on this information.

Numerous additional modifications and various of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than is specifically described herein.

CLAIMS

What is claimed is:

1. A method of controlling communication resources in a transmission from a first network element to a second network element, where the communication resources are allocated by a controller, comprising:

monitoring an indication of future need of communication resources in said first network element;

sending the indication from the first network element to the controller;

controlling the communication resources between the first network element and the second network element based on this indication.

2. The method according to claim 1, wherein the first network element is connected to the controller by way of the second network element.

3. The method according to claim 1, wherein the indication includes information about a transmit buffer of the first network element.

4. The method according to claim 1, wherein the indication includes information on the additional resources needed for said first network element.

5. The method according to claim 3, wherein the indication includes a quantization scheme whose values correspond to predefined amounts of resources.

6. The method according to claim 4, wherein the indication includes information about a transmit buffer of the first network element.

7. A method according to claim 1, wherein the first network element is a mobile station and the second network element is a base station of a wireless communication network.

8. A system for controlling communication resources in a network, comprising:

a plurality of first stations;

a second station connected to said plurality of first stations through a plurality of communication links;

a controller for controlling the allocation of said communication resources among said links;

said allocation being performed in accordance with information transmitted from said first stations which indicates a need for communication resources.

9. The system according to claim 8, wherein said controller is part of said base station.

10. The system according to claim 8, wherein said first stations are mobile stations in a wireless network.

11. The system according to claim 8, wherein each of said plurality of first stations includes:

a data generator;

a data queue;

an encoder for generating a code representative of the length of the data queue;

a transmitter for transmitting said data with said code included therein as a field.

12. The system according to claim 8, wherein said base station includes a receiver for receiving a transmission and producing data;

a decoder for decoding a field of said data and producing an indication of the data queue in an associated first station;

wherein said controller receives said information from said decoder and allocates communication resources in accordance therewith.

13. The system according to claim 8, wherein said indication is provided for each data block transmitted.

FIG. 1

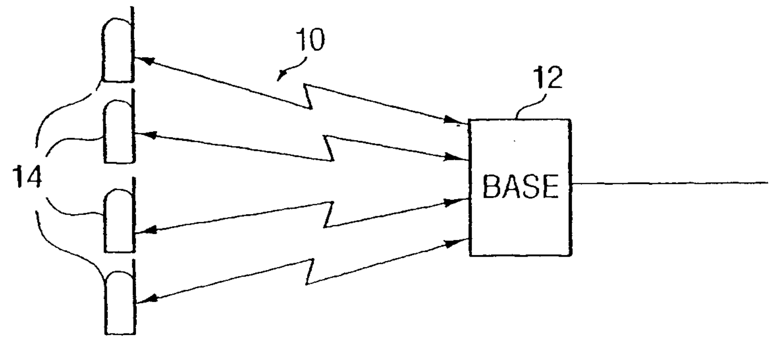


FIG. 2

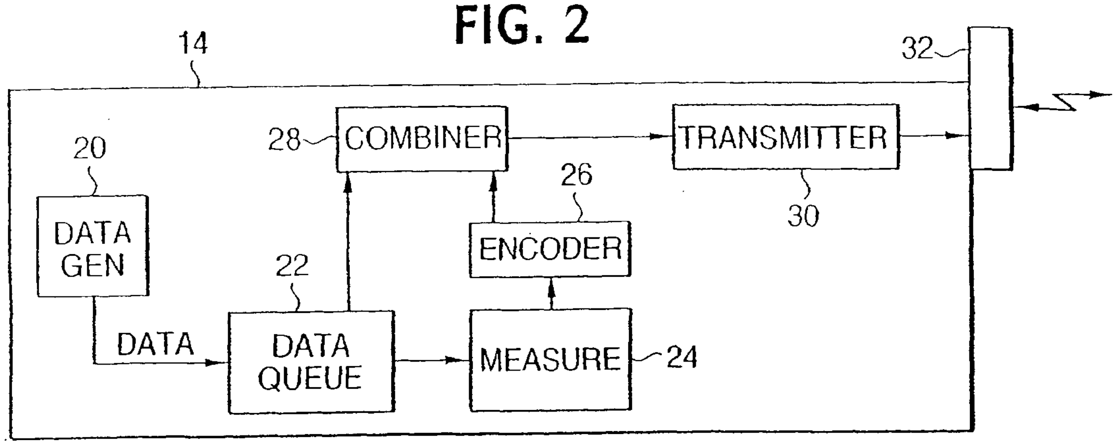
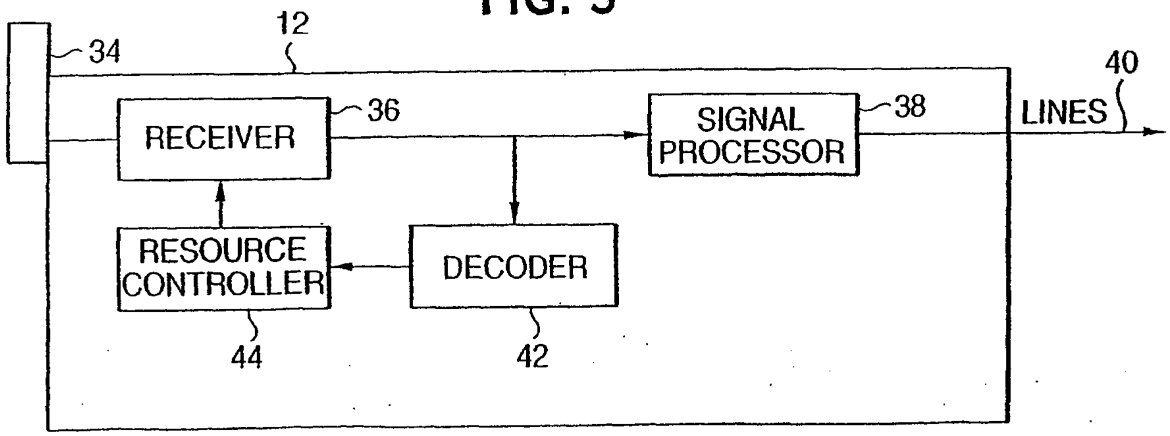


FIG. 3



1/2

FIG. 4

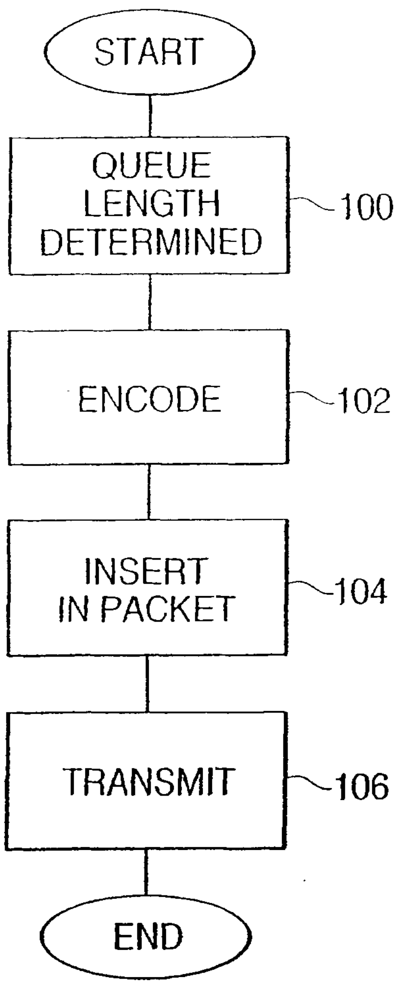
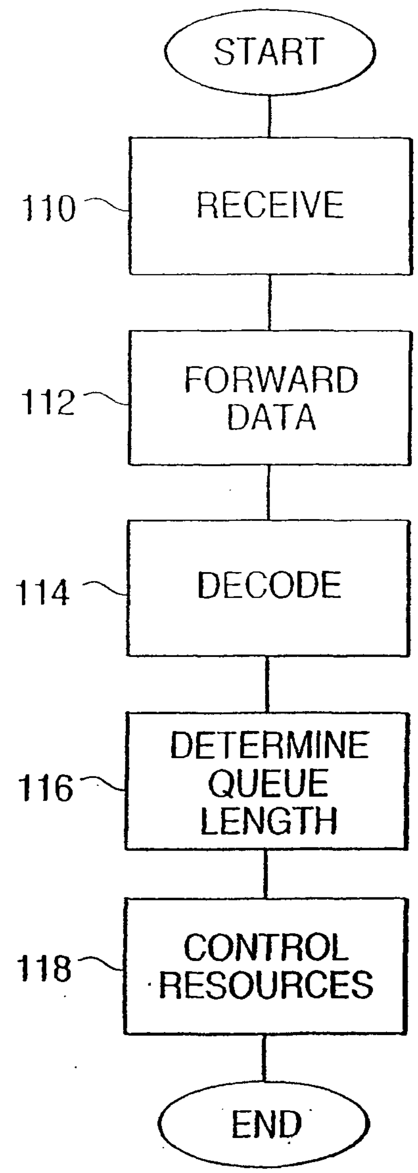

START
QUEUE LENGTH DETERMINED
100
ENCODE
102
INSERT IN PACKET
104
TRANSMIT
106
END

FIG. 5


START
RECEIVE
110
FORWARD DATA
112
DECODE
114
DETERMINE QUEUE LENGTH
116
CONTROL RESOURCES
118
END

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(54) **Method for allocating resources in the uplink of a wireless communication network and corresponding radio terminal**

(57) The invention relates notably to a method for allocating resources in the uplink of a wireless communication network supporting real-time packet data services, said wireless communication network comprising a centralized resource allocation module (13) and a plurality of radio terminals (11).
According to the invention, the method comprises the steps of:

- generating and storing real-time data blocks at said radio terminals (11);
- generating and storing frames encapsulating real-time data blocks or portions of real-time data block at said radio terminals;
- including in each of said frames generated by said radio terminal an indication on the number of stored real-time data blocks;
- transmitting said frames in the uplink of said wireless communication network upon authorization from said resource allocation module (13);
- fowarding said indication to said centralized resource allocation module (13); and
- allocating resource to said radio terminal (11) depending on said indication (22).

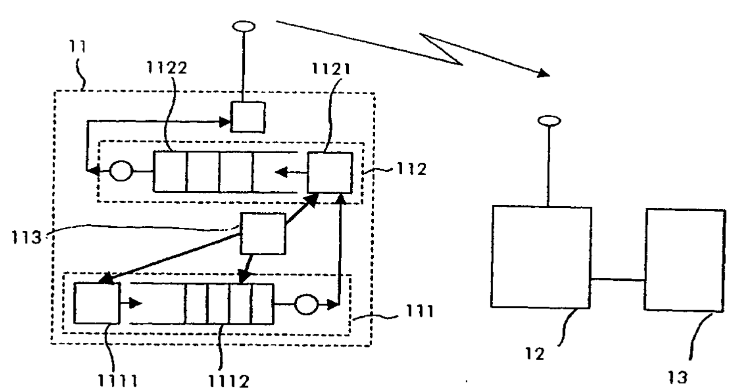

Fig 1

EP 1 261 222 A1

Description

Background of the Invention

[0001] The present invention relates to radio communication and more precisely to a method for allocating resources in the uplink of a wireless communication network supporting real-time packet data services.

[0002] In wireless communication networks, resource allocation for traffic data may be performed by a centralized resource allocation module. This is especially the case in GPRS (General Packet Data Services) or EDGE (Enhanced Data rate for GSM Evolution) networks.

[0003] Usually, a radio terminal which has traffic data to send requires the allocation of resources to the centralized resource allocation module. The latter, by taking into account a plurality of resource allocation requests from different mobile users and specific parameters contained in the resource allocation request message (i.e. user type) allocates resources to the mobile users.

[0004] The general term resources should be understood in the framework of the present invention as radio resources i.e. either a frequency channel and / or a time slot of a frame that is / are reserved for a radio terminal to communicate with the wireless radio network. Frequency channels, respectively time slots, are usually resources used in FDMA, respectively TDMA networks. A resource can be a code in CDMA networks, it may also be a combination of frequency channel, time slot and code.

[0005] The present invention deals especially with packet-oriented wireless communication networks which support real-time data services. Such real time data services may consist in the transmission of packetized voice or video. Such real-time data services require that the transmission delay and the delay between the reception of two consecutive data frames are bounded for ensuring an acceptable quality of service. These strict requirements are sometimes difficult to fulfill since the resource allocation module cannot react as fast as necessary on each resource allocation request message.

[0006] Moreover, if the wireless communication network supports simultaneously real-time and non real time data services, the resource allocation module is even more demanded.

[0007] Several solutions can improve the resource allocation mechanism in wireless communication networks supporting real-time data services.

[0008] For example, a combination of circuit-oriented resource allocation and packet-oriented resource allocation helps the real-time requirements to be fulfilled. Upon reception of a resource allocation request message from a radio terminal having real-time data to transmit, the resource allocation module grants resources for a predefine time period or for a predefined number of real-time data frames.

[0009] A such mechanism is, for example, described in the ETSI standard GSM 04.60 and implemented by means of Temporary Block Flow (TBF). A temporary block flow is a physical connection between a transmitter and a receiver of the wireless communication network supporting the unidirectional transfer of a predefined number of layer-2 frames on traffic channels. A TBF is opened by the resource allocation module upon receipt of a "packet channel request" message from a radio terminal. Before the termination of the TBF, the radio terminal may send a further "packet channel request message if further layer-2 frames should be transmitted. In such a case, the resource allocation can be performed right on time so that there is no delay between the termination of one TBF and the opening of a further TBF.

[0010] A further mechanism is provided for in order to better estimate when a TBF should terminate and then further optimize the resource allocation. This mechanism, called countdown procedure, consists in indicating in a field of the header of each layer-2 frame, short before the termination of the TBF the exact number of layer-2 frames, the countdown value, which remain to be sent before the termination of the TBF. The countdown value is decremented each time a new frame is transmitted on the radio interface.

[0011] The countdown procedure is especially appropriate for acknowledged non-real time packet data service where lost or badly received frames are retransmitted. When a frame has to be retransmitted, the countdown value is not decremented. The transmitter alone knows if a frame is retransmitted and informs the resource allocation module of such a situation by not decreasing the countdown value.

[0012] On the contrary, the unacknowledged mode is used for real-time packet data services i.e. lost or badly received frames are not retransmitted at the initiative of the layer 2 protocol in order not to delay the whole transmission by retransmitting frames. The correction or compensation of lost or badly received frames is dealt with at higher protocol levels. To this extend the countdown procedure does not improve the resource allocation for real time packet data services.

[0013] A particular object of the present invention is to provide a method for optimizing the resource allocation procedure for real-time packet data services.

[0014] Another object of the invention is to provide a radio terminal and a resource allocation module implementing a such method.

Summary of the Invention

[0015] These objects, and others that appear below, are achieved by a method for allocating resources in the uplink of a wireless communication network according to claim 1, a radio terminal according to claim 6 and a resource allocation module according to claim 7.

[0016] According to the present invention, a distinction is made between the step of generating and storing real-time data block and the step of generating, storing and transmitting frames encapsulating real time data blocks corresponding to a layer-two protocol. According to the invention, each frame comprises an indication destined to the resource allocation module on the number of stored real time data blocks waiting for transmission.

[0017] The present invention has the advantage to give to the resource allocation module an upstream indication which reflects the behavior of the real-time data block source and not the behavior of the layer-2 frame buffer as known in prior art. This indication better takes in consideration the characteristics of the real-time data blocks source and provides to the resource allocation module with a faster reactivity. As a consequence, the method according to the present invention contributes to optimize the number of simultaneous mobile users on the radio link and better ensures real time requirements for voice or video traffic.

[0018] In a preferred embodiment, this method is used in relation with the radio link control protocol RLC as specified in ETSI GSM04.60, the indication on the number of stored real time data blocks being contained in the Countdown Value field of the RLC frame header. This method is preferably used in GPRS (General Packet Data Services) or EDGE (Enhanced Data rate for GSM Evolution) networks.

[0019] Further advantageous features of the invention are defined in the dependent claims.

Brief Description of the Drawings

[0020] Other characteristics and advantages of the invention will appear on reading the following description of a preferred embodiment given by way of non-limiting illustrations, and from the accompanying drawings, in which:

- Figure 1 shows a simplified radio communication system where the method according to the present invention can be used;
- Figure 2 shows an header of a frame according to the present invention;
- Figure 3 illustrates an embodiment of the resource allocation module according to the present invention.

Detailed Description of the Invention

[0021] Figure 1 represents a simplified radio communication system where the method according to the present invention can be used. The radio communication system comprises a radio terminal 11, a radio communication channel, a base station 12 connected to a centralized resource allocation module 13.

[0022] The simplified radio communication network is preferably a GERAN (GSM/EDGE Radio Access Network) functioning in a packet switched mode supporting real time services as voice or video services.

[0023] According to the present invention, radio terminal 11 comprises a first module 111 for generating and storing real time data blocks. First module 111 comprises a real time data block source 1111 and a real time data block queue 1112. The real time data blocks contains preferably packetized voice or video data.

[0024] First module 111 is connected to a second module 112 for generating and storing frames encapsulating real time data blocks or portions of real time data blocks. Second module 112 comprises a frame generator 1121 and a frame queue 1122. The output of frame queue 1122 is connected to a transmission module which transmit frames on the radio interface upon reception of a transmit authorization from resource allocation module 13. Second module 112 supports a layer-2 communication protocol which deals with the transmission of layer 2 frames encapsulating real time data blocks.

[0025] According to the present invention, radio terminal 11 further comprises a counting module 113 for counting the number of real time data blocks waiting for transmission in real time data block queue 1112. Counting module 113 forwards to an indication on the number of real time data block to frame generator 1121. This indication is preferably included in a field of each frame header generated at frame generator 1121.

[0026] The size of this field can be chosen arbitrary. A mapping should be established between the number of real time data blocks waiting for transmission and the indication on the number of real time data blocks contained in the header field. It may be a one to one mapping or any more appropriate mapping as will be immediately clear for a person skilled in the art.

[0027] Upon reception of a frame from radio terminal 11 at base station 12, the header of the frame is extracted an the indication on the number of real time data blocks waiting for transmission at first module 111 is forwarded to resource management module 13.

[0028] In a preferred embodiment, second module 112 supports, as layer-2 communication protocol, the Radio Link Control Protocol as specified in the standard ETSI GSM04.60. This protocol is preferably used in the unacknowledged mode to be able to fulfil real time constraints. Preferably, the field Countdown Value specified in the in the standard ETSI GSM04.60 is used for carrying the indication on the number of real time data blocks waiting for transmission at first module 111. The Countdown Value field as specified in the standard ETSI GSM04.60 comprises four bits and can as a consequence take 16 different values.

[0029] However, any other field of the frame header may be chosen to carry the indication provided that the position of this field is predefined and known at the radio terminal as well as at the radio network entity dedicated to extract the indication out of the header.

[0030] Preferably, the choice of the unacknowledged mode of transmission unambiguously indicates that the field Countdown Value contains the number of real-time packet blocks according to the present invention.

[0031] In a further embodiment of the present invention, counting module 113 also takes into account the number of real time data blocks being currently generated at the real time data block source 1111. This has the advantage to better anticipate the sudden generation of real time data blocks. In this embodiment, counting module adds the number of real time data blocks currently being generated at source 1111 and the number of data blocks stored at queue 1112. A weighting factor may be applied to the real time data blocks currently being generated at data block source 1111. Preferably, this weighting factor should be smaller than one.

[0032] Alternatively, some values may be assigned to specific configurations of the real time data block queue 1112. For example a predefined value may indicate the real time data block queue 1112 is empty but that a real time data block is being constructed at the real time data block source 1111. Another predefined value may indicate that the real time data block queue 1112 is empty and no real time data block is under construction at real time data block source 1111 i.e. that the corresponding radio terminal has entered a silence period.

[0033] Figure 2 represents a frame header containing an indication according to the present invention.

[0034] A frame 20 as generated by frame generator 1121 comprises in header 21 a field 22 containing an indication on the number of real time data blocks waiting for transmission at first module 111 and a payload field containing several real time data blocks 23 or portions of real time data blocks. This frame should be transmitted upon reception of a transmit authorization received at radio terminal 11 from resource allocation module 13. The format of this frame is determined by the layer 2 protocol used on the radio interface in a preferred embodiment, the format of the frame is given by the RLC protocol as specified in ETSI GSM04.60.

[0035] Figure 3 shows an embodiment of a resource allocation module 30 according to the present invention.

[0036] Resource allocation module 30 comprises a storage medium 31 connected to a processing unit 32 which is further connected to a authorization transmission module 33.

[0037] Storage medium 31 is preferably organized in the form of a table containing as many entries as radio terminals connected to the radio communication network. Each entry contains a field corresponding to an identifier of the radio terminal and a field corresponding to an indication on the number of real time data blocks waiting for transmission at the corresponding radio terminal. Further fields corresponding to the usual parameters required at the resource allocation module 30 for determining the priority of each radio terminal to send frames should or may be contained in storage medium 31. These fields will not be further detailed in the framework of this invention but are well known for a person skilled in the art.

[0038] The field containing an indication on the number of real time data blocks waiting for transmission at radio terminal 11 is filled each time the base station receives a frame from this radio terminal. The indication on the number of real-time data blocks contained in the header of the frame is extracted and copied to the corresponding field in the storage medium 31 at resource allocation module. The extraction of the indication may be performed at any other entity of the radio communication network, for example at the the base station, the RNC or at the resource allocation module itself.

[0039] The processing unit 32 is dedicated to calculate the priority of the different radio terminals to transmit frames on the radio interface according to a predefined, usually complex, algorithm. The usual algorithms used in the state of the art should be modified to take into account the features of the present invention. The algorithm should take into account the indication on the number of real time data blocks waiting for transmission at the first module 111 of each radio terminal.

[0040] Preferably, if this number is higher than a predefined threshold, the corresponding terminal should be given a higher transmit priority. A corrective term corresponding to the number of real time data blocks waiting for transmission at the first module of the corresponding radio terminal should weight with a predefined weighting factor the term used in prior art resource allocation algorithm.

[0041] Other ways to take into account the indication of the number of real time data blocks in the resource allocation algorithm will be clear for a person skilled in the art.

[0042] Usually, a transmit authorization is generated for each time slot by authorization transmission module 33 and transmitted on a predefined broadcast channel to the radio terminals. Other ways to the transmit authorizations to the radio terminals may be envisaged having no influence on the method according to the present invention.

[0043] The method according to the present invention helps to fulfill the real time requirements of real time data flows in that it enables the resource allocation module to take into account traffic which are not already registered in the layer 2 protocol since the real time data blocks not already encapsulated in layer 2 frames cannot be taken into account with usual prior art methods. Moreover, the method according to the present invention improves also the capacity of the radio network since the optimized resource allocation enables the network to accept more simultaneous users i.e. increases the spectrum efficiency of the radio communication network.

Claims

1. Method for allocating resources in the uplink of a wireless communication network supporting real-

time packet data services, said wireless communication network comprising a centralized resource allocation module (13)and a plurality of radio terminals (11), said method being **characterized in that** it comprises the steps of:

- generating and storing real-time data blocks at said radio terminals (11);
- generating and storing frames encapsulating real-time data blocks or portions of real-time data block at said radio terminals;
- including in each of said frames generated by said radio terminal an indication (22) on the number of stored real-time data blocks;
- transmitting said frames in the uplink of said wireless communication network upon authorization from said resource allocation module (13),
- forwarding said indication to said centralized resource allocation module (13); and
- allocating resource to said radio terminal (11) depending on said indication (22).

2. Method according to claim 1, **characterized in that** said indication further takes into account real-time radio blocks that are being generated at said first module.

3. Method according to claim 1, **characterized in that** said frames are generated and transmitted according to a layer-two radio link protocol, the header (21) of said frames comprising a field containing said indication (22).

4. Method according to claim 1, **characterized in that** said layer-two protocol is the Radio Link Control (RLC) protocol as specified in ETSI GSM04.60, said indication being located in the Countdown Value field of the RLC frame header.

5. Method according to claim 2, **characterized in that** said real-time radio block contain packetized voice.

6. Radio terminal (11) to be used in a wireless communication network supporting real-time packet data services, said radio terminal (11) comprising a data block source (1111) associated to a data block queue (1112) for generating and storing real-time data blocks and a frame generator (1121) associated to a frame queue (1122) for generating and storing frames encapsulating real-time data blocks or portions of real-time data block, said frames being transmitted in the uplink of said wireless communication network upon authorization from a resource allocation module (13), said radio terminal (11) being **characterized in that** it further comprises:

- a counting module (113) for generating an indication on the number of stored real-time data blocks at said first module (111);
- an interface between said counting module (113) and said second module (112) for forwarding said indication to said second module (112);
- a frame generator (1121) for including said indication in each frame transmitted by said radio terminal (11).

7. Resource allocation module (13) to be used a wireless communication network supporting real-time packet data services for allocating resources in the uplink to radio terminals (11), said resource allocation module (13) sending authorization to transmit frames, said frames comprising real time data blocks or portions of real time data blocks, said resource allocation module (13) being **characterized in that** it comprises:

- a storage medium (31) for storing an indication on the number of stored real-time data blocks at each of said radio terminals (11);
- processing unit (32) for determining the amount of resources to be allocated to each of said radio terminals (11) depending on said indication.

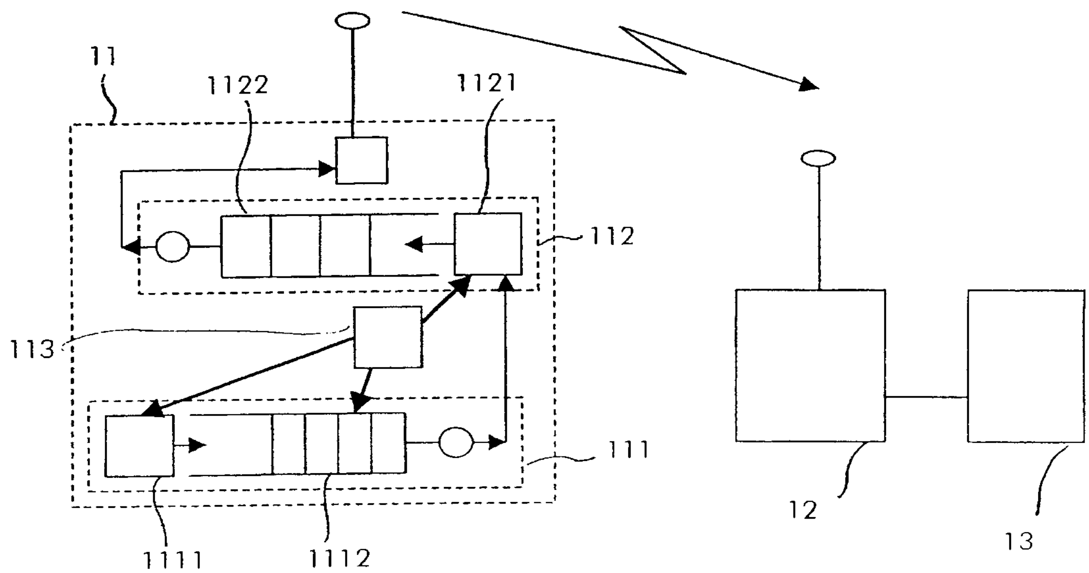

Fig 1

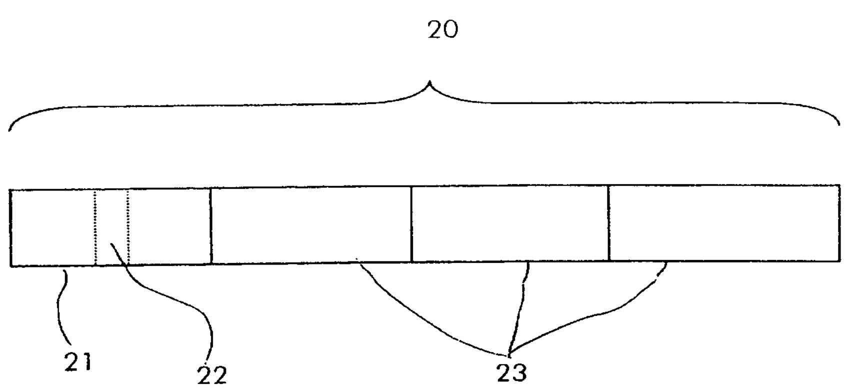

Fig 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 44 0144

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	EP 1 006 695 A (NOKIA MOBILE PHONES LTD) 7 June 2000 (2000-06-07) * the whole document * ---	1-7	H04Q7/22
A	EP 1 043 902 A (LUCENT TECHNOLOGIES INC) 11 October 2000 (2000-10-11) * the whole document * ---	1-7	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	22 November 2001	Quaranta, L

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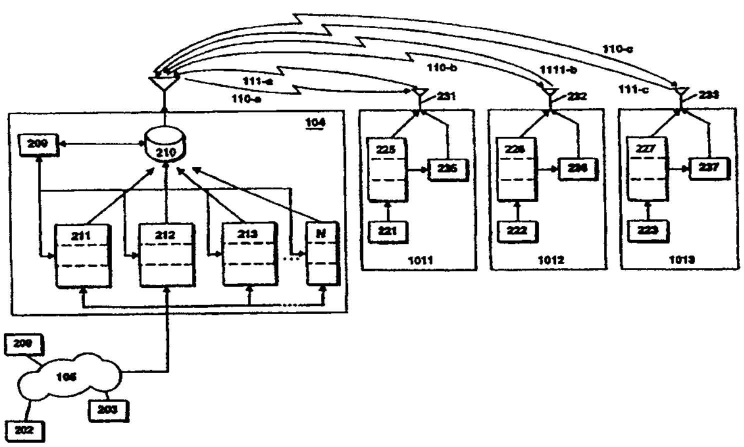

(57) Abstract

A technique for providing high speed data service over standard wireless connections via an unique integration of protocols and existing cellular signaling, such as is available with Code Division Multiple Access (CDMA) type systems through more efficient allocation of access to CDMA channels. For example, when more users exist than channels, the invention determines a set of probabilities for which users will require channel access at which times, and dynamically assigns channel resources accordingly. Channel resources are allocated according to a buffer monitoring scheme provided on forward and reverse links between a base station and multiple subscriber units. Each buffer is monitored over time for threshold levels of data to be transmitted in that buffer. For each buffer, a probability is calculated that indicates how often the specific buffer will need to transmit data and how much data will be transmitted. This probability takes into account the arrival rates of data into the buffer, as well as which thresholds within the buffer are exceeded, as well as which resources in the form of channels are already allocated to the subscriber unit.

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DYNAMIC BANDWIDTH ALLOCATION IN CDMA SYSTEM

BACKGROUND OF THE INVENTION

The increasing use of wireless telephones and personal computers has led to a corresponding demand for advanced telecommunication services that were once thought to only be meant for use in specialized applications. In the 1980's, wireless voice communication became widely available through the cellular telephone network. Such services were at first typically considered to be the exclusive province of the business person because of expected high subscriber costs. The same was also true for access to remotely distributed computer networks, whereby until very recently, only business people and large institutions could afford the necessary computers and wireline access equipment. As a result of the widespread availability of both technologies, the general population now increasingly wishes to not only have access to networks such as the Internet and private intranets, but also to access such networks in a wireless fashion as well. This is particularly of concern for the users of portable computers, laptop computers, hand-held personal digital assistants and the like who would prefer to access such networks without being tethered to a telephone line.

There still is no widely available satisfactory solution for providing low cost, high speed access to the Internet, private intranets, and other networks using the existing wireless infrastructure. This situation is most likely an artifact of several unfortunate circumstances. For one, the typical manner of providing high speed data service in the business environment over the wireline network is not readily adaptable to the voice grade service available in most homes or offices. Such standard high speed data services also do not lend themselves well to efficient transmission over standard cellular wireless handsets. Furthermore, the existing cellular network was originally designed only to deliver voice services. As a result, the emphasis in present day digital wireless communication schemes lies with voice, although certain schemes such as CDMA do provide some measure of asymmetrical behavior for the accommodation of data transmission. For example, the data rate on an IS-95 forward traffic channel can be adjusted in increments from 1.2 kilobits per second (kbps) up to 9.6 kbps for so-called

Rate Set 1 and in increments from 1.8 kbps up to 14.4 kbps for Rate Set 2. On the reverse link traffic channel, however, the data rate is fixed at 4.8 kbps.

The design of such existing systems therefore typically provides a radio channel which can accommodate maximum data rates only in the range of 14.4 kilobits per second (kbps) at best in the forward direction. Such a low data rate channel does not lend itself directly to transmitting data at rates of 28.8 or even 56.6 kbps that are now commonly available using inexpensive wire line modems, not to mention even higher rates such as the 128 kbps which are available with Integrated Services Digital Network (ISDN) type equipment. Data rates at these levels are rapidly becoming the minimum acceptable rates for activities such as browsing web pages. Other types of data networks using higher speed building blocks such as Digital Subscriber Line (xDSL) service are just now coming into use in the United States. However, their costs have only been recently reduced to the point where they are attractive to the residential customer.

Although such networks were known at the time that cellular systems were originally deployed, for the most part, there is no provision for providing higher speed ISDN- or xDSL-grade data services over cellular network topologies. Unfortunately, in wireless environments, access to channels by multiple subscribers is expensive and there is competition for them. Whether the multiple access is provided by the traditional Frequency Division Multiple Access (FDMA) using analog modulation on a group of radio carriers, or by newer digital modulation schemes the permit sharing of a radio carrier using Time Division Multiple Access (TDMA) or Code Division Multiple Access (CDMA), the nature of the radio spectrum is that it is a medium that is expected to be shared. This is quite dissimilar to the traditional environment for data transmission, in which the wireline medium is relatively inexpensive to obtain, and is therefore not typically intended to be shared.

Other considerations are the characteristics of the data itself. For example, consider that access to web pages in general is burst-oriented, with asymmetrical data rate transmission requirements. In particular, the user of a remote client computer first specifies the address of a web page to a browser program. The browser program then sends this web page address data, which is typically 100 bytes or less in length, over the network to a server computer. The server computer then responds with the content of the requested web page, which may include anywhere from 10 kilobytes to several megabytes of text, image, audio, or even video data. The user then may spend at least several seconds or even several minutes reading the content of the page before requesting that another page be downloaded. Therefore, the required forward channel data rates, that is, from the base station to the subscriber, are typically many times greater than the required reverse channel data rates.

In an office environment, the nature of most employees' computer work habits is typically to check a few web pages and then to do something else for extended period of time, such as to access locally stored data or to even stop using the computer altogether. Therefore, even though such users may expect to remain connected to the Internet or private intranet continuously during an entire day, the actual overall nature of the need to support a required data transfer activity to and from a particular subscriber unit is actually quite sporadic.

Furthermore, prior art wireless communication systems provide a continuous bandwidth to individual subscribers. That is, in such networks, during a communication session the bandwidth available at all times is constant and has been designed, as noted above, primarily for voice grade use.

SUMMARY OF THE INVENTION

Prior art methodologies for transmission of data over wireless networks suffer numerous problems. As noted above, the bandwidth available for a single subscriber unit channel is typically fixed in size. However, data communications tend to be bursty in nature, often requiring a need for large amounts of bandwidth at certain times, while requiring very little amounts, or even none, at other times. These wide swings in bandwidth requirements can be very close together in time.

For example, when browsing a web site using HyperText Transfer Protocol (HTTP), the user of a web browser typically selects pages by selecting or clicking a single link to a page causing the client computer to send a small page request packet to the web server. The request packet in the receive link direction requires very little bandwidth. However, in response to the request, the server typically delivers one or more web pages ranging in size from 10 to 100 kilobits (kB) or more to the client in the forward link direction. To receive the pages, the bandwidth requirements are much greater than to request the pages. The optimum bandwidth needed to acceptably receive the pages is rarely realized due to the inefficiency of the present wireless protocols that only offer maximum data rates of about 9600 bps under optimal conditions. This results in the server having to hold back some of the requested data until the network can "catch up" with the data delivery and also results in frustrated users having slow response and page loading times. In essence, the bandwidth to send a request is more than is needed, and the bandwidth to receive the pages is not enough to deliver the data at acceptable rates.

Another problem with prior art systems is that the time frame between when the small page request message leaves the wireless network and becomes wirebound, and when the pages of requested data enter the wireless portion of the data communications session on the return link is often quite long. This time-from-request to time-of-receipt delay is a function of how congested the network and server are during that time. The invention is based in part on the observation that bandwidth is being wasted during periods of time when waiting for data from the wireline network. Prior art wireless communications systems maintain the constant availability of the full bandwidth of the 9600 bps wireless connection for that entire data communication session, even though the wireless client may be waiting for return pages. This bandwidth which is effectively unused is therefore wasted because there is no way to allocate the channel resources in use for this data communication session to another session needing more bandwidth. That is, if other concurrent wireless data communications sessions are taking place for other subscriber units, these concurrent sessions have no way in the prior art systems to take advantage of any unused bandwidth allocated to the client merely waiting for return pages, as in this example.

The present invention provides high speed data and voice service over standard wireless connections via an unique integration of protocols and existing cellular signaling, such as is available with Code Division Multiple Access (CDMA) type systems. The invention achieves high data rates through more efficient allocation of access to the CDMA channels.

Specifically, the invention provides a scheme for determining an efficient allocation of N fixed rate data channels amongst M users. The invention addresses the problem of how to allocate these channels in the most effective manner between users competing for channel use. For example, when more users exist than channels, the invention determines a set of probabilities for which users will require channel access at which times, and assigns channel resources accordingly. The invention can also dynamically take away or deallocate channels (i.e., bandwidth) from idle subscribers and provide or allocate these freed-up channels to subscribers requiring this bandwidth.

Channel resources are allocated according to a buffer monitoring scheme provided on forward and reverse links between a base station and multiple subscriber units. Data buffers are maintained for each connection between a base station and a subscriber unit. Each buffer is monitored over time for threshold levels of data to be transmitted in that buffer. In essence, the thresholds measure the "fullness" of buffers over time for each respective subscriber unit monitored. For each buffer, a probability is calculated that indicates how often a specific buffer for a specific subscriber will need to transmit data and how much data will be transmitted. This probability takes into account the arrival rates of data into the buffer, as well as which thresholds within the buffer are exceeded, as well as which resources in the form of channels are already allocated to the subscriber unit. Based on this probability, channel resources for data transmission can be either allocated or deallocated to subscriber units depending upon a forecasted need.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views.

Fig. 1 is a block diagram of an example wireless communication system making use of a bandwidth management scheme according to the invention.

Fig. 2 is a diagram showing how channels are assigned within a given radio frequency (RF) channel.

Fig. 3 is a block diagram illustrating the internal components of a base station and subscriber units that provide the dynamic bandwidth allocation mechanism.

Fig. 4 illustrates the structure of the buffers used in either the base station or subscriber units.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Turning attention now to the drawings more particularly, Fig. 1 is a block diagram of a system 100 for providing high speed data service over a wireless connection by seamlessly integrating a digital data protocol such as, for example, Integrated Services Digital Network (ISDN) with a digitally modulated wireless service such as Code Division Multiple Access (CDMA).

The system 100 consists of two different types of components, including subscriber units 101-1, 101-2, and 101-3 (collectively subscribers 101) as well as one or more base stations 104 to provide the functions necessary in order to achieve the desired implementation of the invention. The subscriber units 101 provide wireless data and/or voice services and can connect devices such as, for example, laptop computers, portable computers, personal digital assistants (PDAs) or the like through base station 104 to a network 105 which can be a Public Switched Telephone Network (PSTN), a packet switched computer network, or other data network such as the Internet or a private intranet. The base station 104 may communicate with the network 104 over any number of different efficient communication protocols such as primary rate ISDN, or other LAPD based protocols such as IS-634 or V5.2, or even TCP/IP if network 105 is an Ethernet network such as the Internet. The subscriber units 101 may be mobile in nature and may travel from one location to another while communicating with base station 104.

Fig. 1 illustrates one base station 104 and three mobile subscriber units 101 by way of example only and for ease of description of the invention. The invention is applicable to systems in which there are typically many more subscriber units communicating with one or more base stations.

It is also to be understood by those skilled in the art that Fig. 1 may be a standard cellular type communication system such as a CDMA, TDMA, GSM or other system in which the radio channels are assigned to carry between the base stations 104 and subscriber units 101. This invention, however, applies more particularly to non-voice transmissions, and preferably to digital data transmissions of varying bandwidths. Thus, in a preferred embodiment, Fig. 1 is a CDMA-like system, using code division multiplexing principles for the air interface. However, it is also to be understood that the invention is not limited to using standardized CDMA protocols such as IS-95, or the newer emerging CDMA protocol referred to as IS-95B. The invention is also applicable to other multiple access techniques.

In order to provide data and voice communications between the subscriber units 101 and base station 104, wireless transmission of data over a limited number of radio channel resources is provided via forward communication channels 110-a through 110-c, and reverse communication channels 111-a through 111-c. The invention provides dynamic bandwidth management of these limited channel resources on an as needed basis for each subscriber unit 101. It should also be understood that data signals travel bidirectionally across the CDMA radio channels 110 and 111, i.e., data signals originating at the subscriber units 101 are coupled to the network 105, and data signals received from the network 105 are coupled to the subscriber units 101.

Fig. 2 provides an example of how dynamic allocation of radio bandwidth may take place in an example system 100. First a typical transceiver within a subscriber unit 101 or the base station 104 can be tuned on command to any 1.25 MegaHertz (MHZ) channel within a much larger bandwidth, such as up to 30 MHZ in the case of the radio spectrum allocated to cellular telephony; this bandwidth is typically made available in the range of from 800 to 900 MHZ in the United States. For PCS type wireless systems, a 5 or 10 MHZ bandwidth is typically allocated in the range from about 1.8 to 2.0 GigaHertz (GHz). In addition, there are typically two matching bands active simultaneously, separated by a guard band, such as 80 MHZ; the two matching bands form a forward and reverse full duplex link between the base station 104 and the subscriber units 101.

For example, within the subscriber unit 101 and the base station 170, transmission processors (i.e., transceivers) are capable of being tuned at any given point in time to a given 1.25 MHZ radio frequency channel. It is generally understood that such 1.25 MHZ radio frequency carrier provides, at best, a total equivalent of about a 500 to 600 kbps maximum data rate transmission speed within acceptable bit error rate limitations.

In the prior art, it was thus generally understood that in order to support an ISDN type like connection which may contain information at a rate of 128 kbps that, at best, only about (500 kbps/128 kbps) or only three (3) ISDN subscriber units could be supported at best.

In contrast to this, the present invention subdivides the available approximately 500 to 600 kbps data rate among a relatively large number of channels and then provides a way to determine how to allocate these channels to best transmit data between the base station 104 and each of the subscriber units 101, and vice versa. In the illustrated example in Fig. 2, the bandwidth is divided into sixty-four (64) subchannels 300, each providing an 8 kbps data rate. It should be understood herein that within a CDMA type system, the subchannels 300 are physically implemented by encoding a data transmission with one of a number of different assignable codes. For example, the subchannels 300 may be defined within a single CDMA radio frequency (RF) carrier by using different orthogonal Walsh codes for each defined subchannel 300. (The subchannels 300 are also referred to as "channels" in the following discussion, and the two terms are used interchangeably herein).

As mentioned above, the channels 300 are allocated only as needed. For example, multiple channels 300 are granted during times when a particular subscriber unit 101 is requesting that large amounts of data be transferred. In this instance and in the preferred embodiment, the single subscriber unit 101 may be granted as many as 20 of these channels in order to allow data rates of up to 160 kbps (20 * 8 kbps) for this individual subscriber unit 101. These channels 300 are then released during times when the subscriber unit 101 is relatively lightly loaded. The invention determines the way in which the limited number of channels are divided at any moment in time among the subscriber units 101.

Before discussing how the channels 300 are preferably allocated and deallocated, it will help to understand the general architecture of relevant parts of a typical subscriber unit 101 and base station 104 in greater detail. Turning attention now to Fig. 3, the base station 104 accepts data from incoming data sources 201 through 203. Each data source 201 through 203 represents any type of data source that is sending data to one or more of the subscriber units 101. For example, data source 202 may be web server software on network 105 serving web pages to a client web browser operating in conjunction with subscriber unit 101-1, while data source 203 may be an ISDN terminal on network 105 that is sending voice and data to subscriber unit 101-3.

For each subscriber unit 101 that is in communication with this particular base station 104, the base station 104 establishes and allocates a respective data buffer 211 through 213. Data buffers 211 through 213 store the data that is to be transmitted to their respective subscriber units 101. That is, in a preferred embodiment, there is a separate data buffer in the base station 104 for each respective subscriber unit 101. As subscriber units enter into and exit out of communication sessions or connections with base station 104, the number of buffers may change. There is always a one-to-one correspondence between the number of buffers 211 through 213 allocated to the number of subscriber units 101 communicating with base station 104. The buffers 211 through 213 may be, for example, queues or other memory structures controlled by software, or may be hardware controlled fast cache memory.

As data is queued up in the buffers 211 through 213, transmission processor 210 transmits the data from the base station 104 to the respective subscriber units 101. In the case of forward link transmission (from the base station 104 to the subscriber units 101), a selection of a limited number of forward link channels 110a through 110c are used. As will be explained, the invention is able to accommodate greater bandwidth for one particular subscriber unit 101, as more and more data is queued at the base station 104. That is, as the transmission processor 210 in the base station 104 accepts data from each buffer 211 through 213 for transmission to that buffers' respective subscriber unit 101, the transmission processor 210 uses only the allocated number of forward link 110 resources assigned to that particular respective subscriber unit. To determine how these channel resources are assigned, the invention provides a channel resource assignor 209 which implements a unique algorithm according to the invention that monitors buffer usage to determine an urgency characteristic of each subscriber unit 101 in order to dynamically assign an optimum number of channel resources to be allocated to each subscriber unit.

In the reverse direction, each subscriber unit 101 also contains a respective data source 221 through 223 that provides data to data buffers 225 through 227. The data stored in buffers 225 through 227 is data to be transmitted on one or more of the reverse links 111a-c back to the base station 104, for eventual transmission to processes or devices on network 105 that are connected at a network session layer with the subscriber units 101. Each subscriber unit 101 also contains a transmission processor 231 through 233 for controlling the transmission of data from buffers 225 through 227 back to base station 104. As in the base station 104, the transmission processors 231 through 233 only use an allocated number of reverse channel 111a-c resources assigned to that particular respective subscriber unit 101.

In a preferred embodiment of the invention, the channel resource assignor 209 in the base station also monitors the usage of buffers 225 through 227 within subscriber units 101. This is accomplished via buffer monitors 235 through 237 in each subscriber unit 101 which periodically report buffer characteristics back to base station 104. The buffer characteristics reports may be piggybacked onto the regular transmission of data on the reverse links 111a-c. Upon receipt of this buffer characteristic information, the channel resource assignor 209 then determines an urgency factor representing the relative need for each subscriber unit 101 to transmit data on the reverse links 111a-c from their respective buffers 225 through 227. Using these urgency factors, the channel resource assignor 209 can then dynamically assign an optimum number of channel resources which each subscriber unit may use on the reverse links 111a-c. This channel assignment information sent back to the subscriber units 101 on the forward links 110, so that the transmission processors 231 through 233 know their currently allocated channels at all times.

The channel resource assignor 209 is thus a bandwidth management function thus includes the dynamic management of the bandwidth allocated to a particular network layer session connection. Before a further description of the channel assignor 209 is given, it should be first understood that no matter what bandwidth allocation is given to a particular subscriber unit 101, a network layer communication session will be maintained even though wireless bandwidth initially allocated for transmission is reassigned to other connections when there is no information to transmit. One manner of maintaining network layer communication sessions during periods of reduced allocation of bandwidth for a particular subscriber unit is discussed in detail in the above-referenced co-pending patent applications, the entire contents of which are hereby incorporated by reference in their entirety.

In general, bandwidth assignments are made for each network layer session based upon measured short term data rate needs as determined by buffer statistics. One or more channels are then assigned based upon these measurements and other parameters such as amount of data in the buffer, the present resources allocated to a subscriber unit, and probabilities of a requirement of a subscriber unit to transmit data or priority of service as assigned by the service provider. In addition, when a given session is idle, a connection is preferably still maintained end to end, although with a minimum number of channel resources allocated, such as a single subchannel being assigned. This single subchannel may eventually be dropped after a predetermined minimum idle time is observed.

Fig. 4 illustrates a buffer 360 in detail. Buffer 360 can be any one of the buffers 211 through 213 or 225 through 227 in either the subscriber units 101 or base station 104. The buffer 360 accepts data 365 and stores this data while awaiting transmission on forward links 110 from the base station 104 to a respective subscriber unit 101, or on reverse links 111 from one of the subscriber units to the base station 104. Each buffer has associated with it L thresholds, which in this example are labeled 1, 2,...L and number 361, 362 and 363 respectively. These L thresholds are an indication of how much data is currently stored in the buffer 360. That is, the thresholds are "characteristics" in the sense that they provide an indication of how much buffer memory is currently in use.

As data 365 enters and fills buffer 360, until transmission of this data takes place, the data may fill buffer 360 so much so as to cross certain of the thresholds 361 through 363. For instance, in Fig. 4, data blocks 365-a through 365-d have just filled buffer 360 enough to approach the first threshold 361. The last block of data 365-n exists between thresholds 361 and 362 and so the buffer 360 has stored data in an amount exceeding the first threshold 361. In other words, buffer 360 as shown has a threshold level of "1", corresponding to the first threshold 361.

As explained above, the channel resource assignor 209 in base station 104 obtains an indication of the threshold level for each buffer 225 through 227 in each respective subscriber unit 101-1 through 101-3. By determining how much data is in each buffer, the resulting data arrival rates of data to each buffer, and the resources currently allocated to transmit data from a buffer, an urgency factor for each data source attempting to transmit on the reverse links 111 is computed. A similar computation takes place for each data transmitter on the forward links 110.

More particularly, an urgency factor is calculated for each buffer based on these buffer characteristics, that indicates the relative need to empty the buffer for that particular receiver as compared to the buffers in other receivers. Given urgency factors for each buffer having data queued for transmission to a waiting receiver, the invention is able to determine how to allocate the available channels to best transmit this data.

The urgency factor for buffer 360, for example, is based on statistical information gathered for the accumulation of data 365. The statistical information is used to compute probabilities of when data 365 exceeds or does not exceed certain of the L discrete data thresholds 361, 362 and 363. Thus, as data 365 enters buffer 360 and exceeds the first threshold 361, the urgency factor for that buffer, and hence for the receiver associated with that buffer (i.e., for example, one of the subscriber units 101 for which data 365 in buffer 360 is destined) increases.

The urgency factor for buffer 360 is also based upon conditional probabilities of how much time has passed since buffer 360 has had data 365 transmitted from the buffer to its intended receiver, as well as how much time has passed since data 365 has been received at the buffer 360 for storage until transmission may occur. The urgency factor depends partly on the history of the time that the data level in the buffer exists between each threshold in the buffer and on the number of times each threshold, including the maximum buffer capacity, is exceeded.

The urgency factor is also based on how close data 365 is to the last threshold L 363, which indicates that the buffer is reaching maximum capacity. The urgency factor therefore also accounts for the probability of exceeding the capacity of buffer 360, based on exceeding the maximum threshold L 363.

The channel resource allocator 209 therefore calculates an urgency factor, U, for each of M buffers, where M is the total number of buffers used in the reverse 111 and forward 110 links. The urgency factor for the buffers servicing the forward links 110 are calculated independently of urgency factors for the other buffers servicing the reverse links 111, and the buffers servicing each transmission direction of a particular connection between a particular one of the subscriber units 101 and the base station 104 are independent of one another.

At any given time, a given buffer J has a number of channels, N_J, which is the number of channels already allocated to that particular buffer J. Accordingly, N_J must range from $1 < N_J < N_{MAX}$, where N_{MAX} is the maximum number of channel resources 300 that may be assigned to any one particular buffer, and hence to any one link. In the preferred embodiment, N_{MAX} can be as high as 20 channels, with each channel operating at approximately 8.55 kilobits per second (kbps) or at 13.3 kbps, depending upon a rate selection as determined by which CDMA standard is used. Thus, if a particular buffer is assigned the maximum number of channels to accommodate data transfers for high bandwidth applications, instantaneous data rates may be achieved as high as from about 171 kbps to 260 kbps.

The urgency factor U for a given buffer is equal to the sum of weighted conditional probabilities. Each conditional probability represents the chance of exceeding the last threshold L, within a time frame, T_s, given that the data in the buffer has already exceeded a particular threshold E_i. The time frame T_s corresponds to the maximum time needed to reallocate a resource. The probabilities for an urgency factor

U for a single buffer are all computed in a similar manner, but are based upon different thresholds within that buffer. Thus, as the probabilities for each threshold change with the various demands for service, the urgency factor for that particular buffer also changes.

In a preferred embodiment, the probability of exceeding a particular threshold E_L in time T_s given that another threshold E_i is exceeded is given by:

$$P_{EL}(T_S \mid E_j) = \frac{P_{EL}(E_i) \cdot P_{EL}(T_S)}{P_{EL}(E_j)}$$

Threshold E_i is used in the above equation when computing the probability of exceeding a threshold E_L in a time period T_s given that the data level in the buffer has already crossed threshold E_j. Since this is an indirect computation, it may be derived from the formula:

$$\frac{\sum \left(P_{EL} \text{ within } T_S \text{ of } E_i \right) / \sum \left(E_i \text{ for } T_S \right)}{\sum \left(E_L / E_i \right)}$$

The probabilities that make up the urgency factor U for a particular buffer are also weighted before they are summed, such as

$$U = \sum_i P_{EL}(T_S \mid E_i) \cdot W_i(N)$$

The weight $W_i(N)$ for each probability is selected to optimize the resource allocation. For example, the weight is selected based upon which threshold is crossed and therefore effects the urgency factor for that buffer by increasing the weight of the summed probabilities used to compute that urgency factor for that buffer.

Once an urgency factor U for each buffer has been computed, the channel resource assignor 209 determines how to allocate the available channels among the buffers. This is accomplished in a preferred embodiment by determining which buffer has the highest urgency factor and which one has the lowest. Next, the highest and lowest urgency factors must exceed respective high and low urgency thresholds. If this is true, one resource channel is deallocated from the buffer with the lowest urgency factor and is reallocated to the buffer with the highest urgency factor. In this manner, the channel resources for buffers may change over time based upon the urgency factors of the buffers.

Also, when N_j is 1, there is only one channel allocated to a particular buffer. In this state, the assigned channel resource may be reallocated (i.e., taken away) to another buffer if there is no data in buffer and if the probability of exceeding the buffer capacity within the time it takes to reassign this initial resource, $P_{EL}(T_S \mid E_0)$, is less than the probability of reaching the buffer overflow limit $P(E_L)$, which is a predetermined constant.

EQUIVALENTS

While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. Those skilled in the art will recognize or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments of the invention

CLAIMS

What is claimed is:

1. A system for allocating and deallocating channel resources from a limited number of channel resources used to transmit data from a transmitter to a receiver, the system comprising:

a transmitter having an input receiving data to be transmitted to at least one receiver, the transmitter including at least one buffer storing the data to be transmitted to a respective at least one receiver;

a transmission processor within the transmitter accepting data from the at least one buffer for transmission to that buffers respective at least one receiver using an allocated number of channel resources assigned to that respective at least one receiver; and

a channel resource assignor monitoring usage of the at least one buffer to determine the urgency of data to be transmitted to that buffers respective at least one receiver in order to dynamically assign an optimum number of channel resources to be allocated to the respective at least one receiver.

2. The system of claim 1, wherein

the at least one buffer comprises a plurality of buffers in the base station, each one of the plurality of buffers associated with a respective one of the plurality of subscribers;

each one of the plurality of buffers having an associated plurality of thresholds, each threshold associated with a level of data stored in that one of the plurality of buffers; and

wherein the channel resource assignor computes an urgency factor associated with each buffer based upon a statistical information gathered for the accumulation of data at the associated plurality of thresholds for that buffer, the urgency factor representing a relative need for each transmitter associated with each buffer to transmit data, and wherein the urgency factor for each buffer is used to determine the optimum number of channel resources to be allocated to the receiver associated with that buffer.

3. The system in claim 2, wherein the statistical information used to compute the urgency factor associated with a buffer includes statistics based upon threshold levels of data in the buffer, current resources allocated to the receiver associated with that buffer, and data arrival rates of data to that buffer.

4. The system in claim 2, wherein the statistical information used to compute the urgency factor associated with the buffer includes conditional probabilities of how much time has passed since the buffer has had data transmitted from the buffer to its intended receiver, as well as how much time has passed since data has been received at that input of the transmitter associated with that buffer.

5. The system of claim 2, wherein the urgency factor for a given buffer is based upon a sum of weighted conditional probabilities, each conditional probability representing the chance of exceeding a threshold E_L in the buffer, within a time frame T_s which corresponds to a maximum time needed to reallocate a channel resource to another buffer, given that data in the buffer has already exceeded a particular threshold E_i, each conditional probability for each threshold in a buffer given by the formula:

$$P_{EL}(T_S \mid E_i) = \frac{P_{EL}(E_i) \cdot P_{EL}(T_S)}{P_{EL}(E_j)}$$

which is derived from the formula:

$$\frac{\sum \left(P_{EL} \text{ within } T_S \text{ of } E_i \right) / \sum \left(E_i \text{ for } T_S \right)}{\sum \left(E_L / E_i \right)}$$

6. The system of claim 5, wherein the conditional probabilities that make up the urgency factor U for a particular buffer are weighted before they are summed, according to the formula:

$$U = \sum_i P_{EL} (T_S \mid E_i) \cdot W_i(N)$$

wherein weight W_i is selected based upon which threshold N is crossed by data currently in the buffer.

7. The system of claim 2 wherein the channel resource assignor determines how to allocate the available channels among the buffers by determining if the buffer having the highest urgency factor U exceeds a respective high threshold and if the buffer having the lowest urgency factor U exceeds a respective low threshold, and if so, deallocating one resource channel is from the buffer with the lowest urgency factor and reallocating the one resource channel to the buffer with the highest urgency factor.

8. The system of claim 7, wherein, for a buffer, if the channel resource assignor determines that N_j is 1, representing that there is only one channel resource allocated to a the buffer, the one channel resource may be reallocated to another buffer if there is no data in the buffer and if the probability of exceeding the buffer capacity within the time it takes to reassign this initial resource, $P_{EL} (T_S \mid E_0)$, is less than the probability of reaching the buffer overflow limit $P(E_L)$.

9. The system of claim 1, wherein the transmitter including at least one buffer is located in a base station operating a Code Division Multiple Access communication protocol

and the at least one receiver comprises a plurality of subscriber units, each subscriber unit operating the Code Division Multiple Access communication protocol and the transmitter communicates with the receiver using a number of channel resources selected from the limited number of channel resources assigned to a forward link.

10. The system of claim 2, wherein the transmitter including at least one buffer is located in a base station operating a Code Division Multiple Access communication protocol and the at least one receiver comprises a plurality of subscriber units, each subscriber unit operating the Code Division Multiple Access communication protocol and the transmitter communicates with the receiver using a number of channel resources selected from the limited number of channel resources assigned to a forward link.

11. The system of claim 6, wherein the transmitter including at least one buffer is located in a base station operating a Code Division Multiple Access communication protocol and the at least one receiver comprises a plurality of subscriber units, each subscriber unit operating the Code Division Multiple Access communication protocol and the transmitter communicates with the receiver using a number of channel resources selected from the limited number of channel resources assigned to a forward link.

12. The system of claim 1, wherein the transmitter including at least one buffer is located in a subscriber unit operating a Code Division Multiple Access communication protocol and the at least one receiver is located in a base station operating the Code Division Multiple Access communication protocol and the transmitter communicates with the receiver using a number of channel resources selected from the limited number of channel resources assigned to a reverse link.

13. The system of claim 2, wherein the transmitter including at least one buffer is located in a subscriber unit operating a Code Division Multiple Access communication

protocol and the at least one receiver is located in a base station operating the Code Division Multiple Access communication protocol and the transmitter communicates with the receiver using a number of channel resources selected from the limited number of channel resources assigned to a reverse link.

14. The system of claim 6, wherein the transmitter including at least one buffer is located in a subscriber unit operating a Code Division Multiple Access communication protocol and the at least one receiver is located in a base station operating the Code Division Multiple Access communication protocol and the transmitter communicates with the receiver using a number of channel resources selected from the limited number of channel resources assigned to a reverse link.

15. A method for allocating and deallocating channel resources from a limited number of channel resources used to transmit data from a transmitter to a receiver, the method comprising the steps of:

receiving, at a transmitter, data to be transmitted to at least one receiver, the transmitter having an input and at least one buffer;

storing the data to be transmitted to a respective at least one receiver in the at least one buffer;

accepting data at a transmission processor within the transmitter from the at least one buffer for transmission to that buffers respective at least one receiver using an allocated number of channel resources assigned to that respective at least one receiver; and

monitoring usage of the at least one buffer by a channel resource assignor to determine the urgency of data to be transmitted to that buffers respective at least one receiver in order to dynamically assign an optimum number of channel resources to be allocated to the respective at least one receiver.

16. The method of claim 15, wherein the at least one buffer comprises a plurality of buffers in the base station, each one of the plurality of buffers associated with a respective one of the plurality of subscribers and each one of the plurality of buffers has an associated plurality of thresholds, each threshold associated with a level of data stored in that one of the plurality of buffers, the method further including the steps of:

computing an urgency factor associated with each buffer based upon a statistical information gathered for the accumulation of data at the associated plurality of thresholds for that buffer, the urgency factor representing a relative need for each transmitter associated with each buffer to transmit data, and wherein the urgency factor for each buffer is used to determine the optimum number of channel resources to be allocated to the receiver associated with that buffer.

17. The method of claim 16, further including the step of basing the statistical information used to compute the urgency factor associated with a buffer on statistics including threshold levels of data in the buffer, current resources allocated to the receiver associated with that buffer, and data arrival rates of data to that buffer.

18. The method of claim 16, further including the step of basing the statistical information used to compute the urgency factor associated with the buffer on conditional probabilities of how much time has passed since the buffer has data transmitted from the buffer to its intended receiver, as well as how much time has passed since data has been received at that input of the transmitter associated with that buffer.

19. The method of claim 16, further including the step of basing the urgency factor for a given buffer upon a sum of weighted conditional probabilities, each conditional probability representing the chance of exceeding a threshold E_L in the buffer, within a time frame T_s which corresponds to a maximum time needed to reallocate a channel

resource to another buffer, given that data in the buffer has already exceeded a particular threshold E_i, each conditional probability for each threshold in a buffer given by the formula:

$$P_{EL}(T_S \mid E_i) = \frac{P_{EL}(E_i) \cdot P_{EL}(T_S)}{P_{EL}(E_j)}$$

which is derived from the formula:

$$\frac{\sum (P_{EL} \text{ within } T_S \text{ of } E_i) / \sum (E_i \text{ for } T_S)}{\sum (E_L / E_i)}$$

20. The method of claim 19, further including the steps of weighting the conditional probabilities that make up the urgency factor U for a particular buffer before they are summed, according to the formula:

$$U = \sum_i P_{EL}(T_S \mid E_i) \cdot W_i(N)$$

and selecting the weight W_i based upon which threshold N is crossed by data currently in the buffer.

21. The method of claim 16 further including the steps of:

determining how to allocate the available channels among the buffers by determining if the buffer having the highest urgency factor U exceeds a respective high threshold and if the buffer having the lowest urgency factor U exceeds a respective low threshold, and if so, deallocating one resource channel is from the buffer with the lowest urgency factor and reallocating the one resource channel to the buffer with the highest urgency factor.

22. The method of claim 21 further comprising the steps of:

for a buffer, if the channel resource assignor determines that N_J is 1, representing that there is only one channel resource allocated to a the buffer, the one channel resource may be reallocated to another buffer if there is no data in the buffer and if the probability of exceeding the buffer capacity within the time it takes to reassign this initial resource, $P_{EL}(T_S \mid E_0)$, is less than the probability of reaching the buffer overflow limit $P(E_L)$.

23. The method of claim 15, wherein the transmitter including at least one buffer is located in a base station operating a Code Division Multiple Access communication protocol and the at least one receiver comprises a plurality of subscriber units, each subscriber unit operating the Code Division Multiple Access communication protocol and the transmitter communicates with the receiver using a number of channel resources selected from the limited number of channel resources assigned to a forward link.

24. The method of claim 15, wherein the transmitter including at least one buffer is located in a subscriber unit operating a Code Division Multiple Access communication protocol and the at least one receiver is located in a base station operating the Code Division Multiple Access communication protocol and the transmitter communicates with the receiver using a number of channel resources selected from the limited number of channel resources assigned to a reverse link.

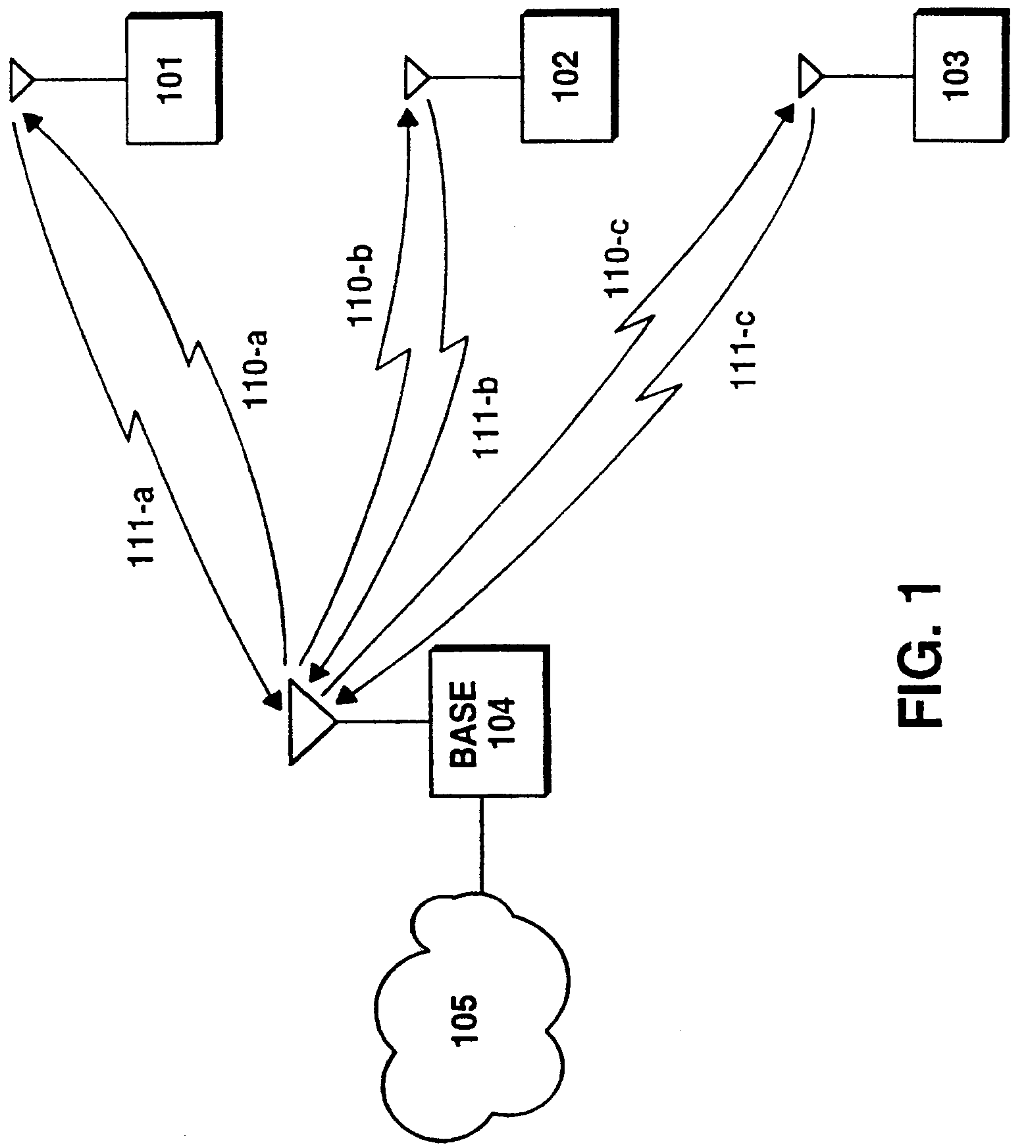

FIG. 1

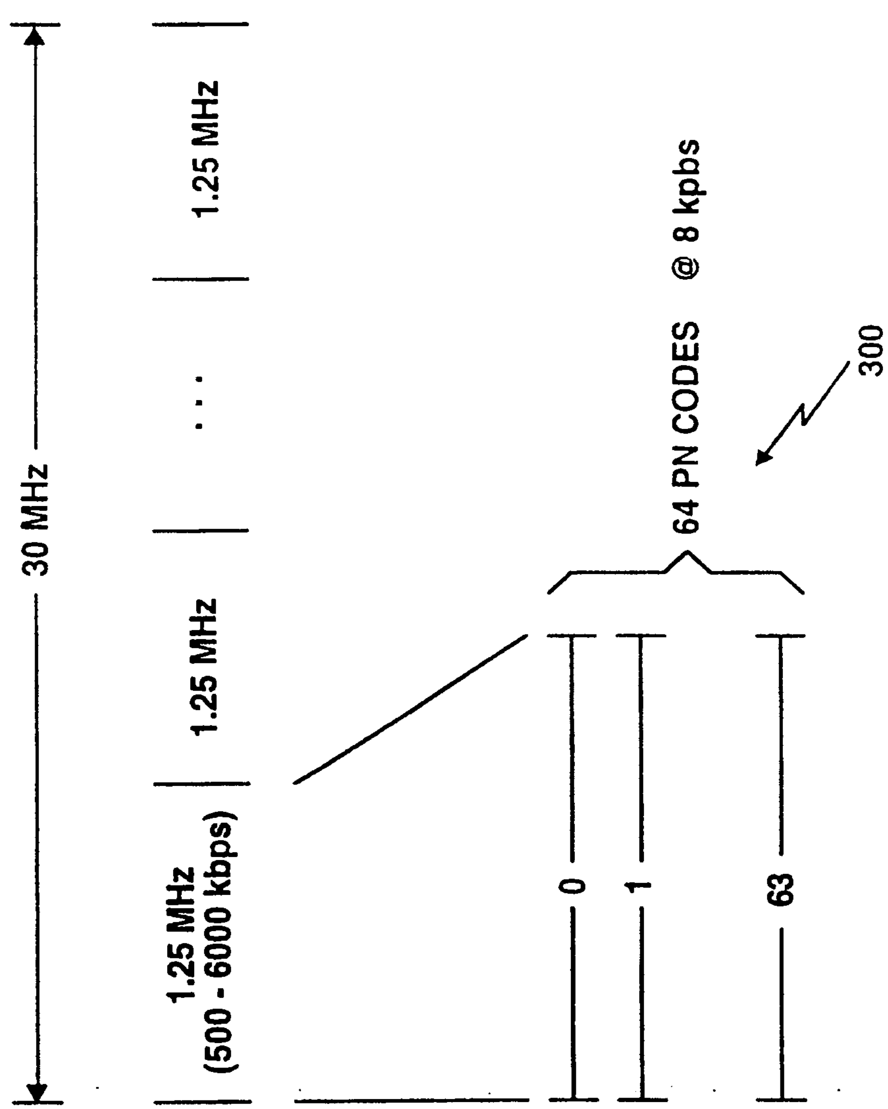

FIG. 2

SUBSTITUTE SHEET (RULE 26)

3/4

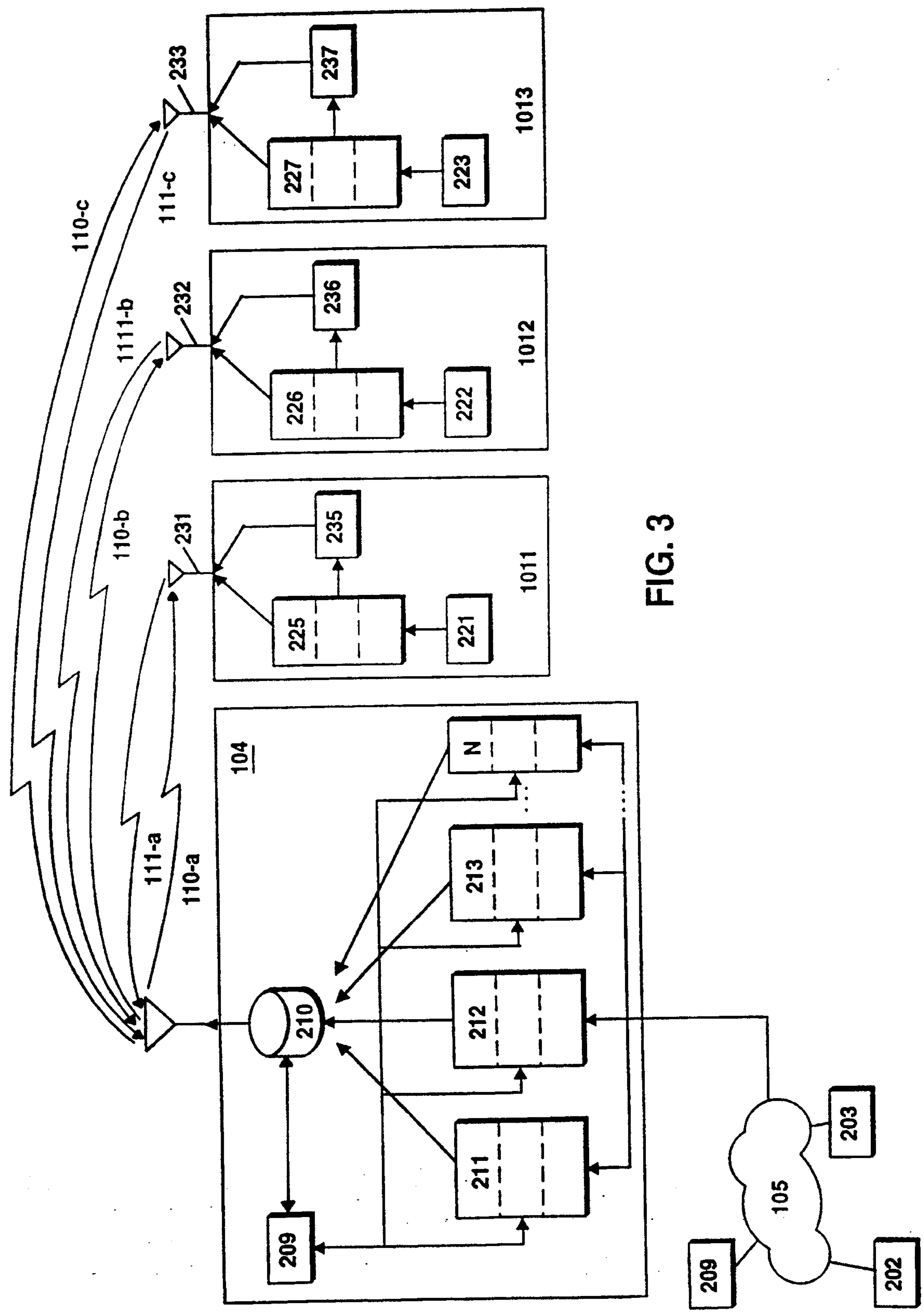

FIG. 3

SUBSTITUTE SHEET (RULE 26)

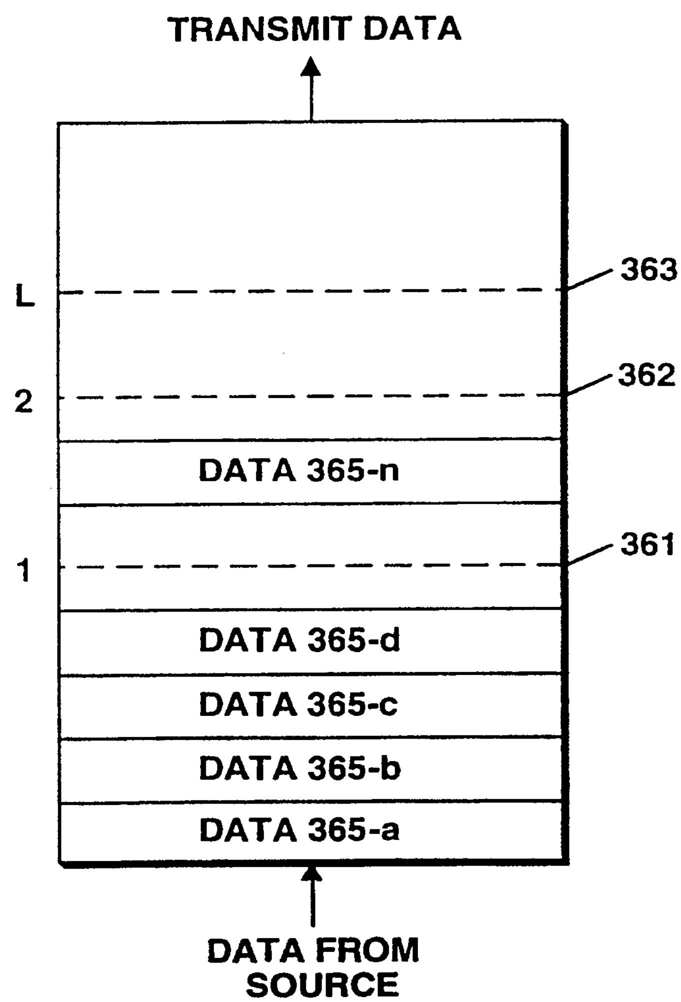
TRANSMIT DATA
L
363
2
362
DATA 365-n
1
361
DATA 365-d
DATA 365-c
DATA 365-b
DATA 365-a
DATA FROM
SOURCE

FIG. 4

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(54) **Hybrid automatic repeat request combining method and system in orthogonal frequency division multiplexing system**

(57) The present invention provides a HARQ (Hybrid Automatic Repeat Request) combining method in an OFDM (Orthogonal Frequency Division Multiplexing) system, which adopts improved Chase combining method weighted by SNR and variance of SNR to realize HARQ combining. The method can improve system performance in processing power and time delay, particularly in low SNR environment, and will not make the system more complex.

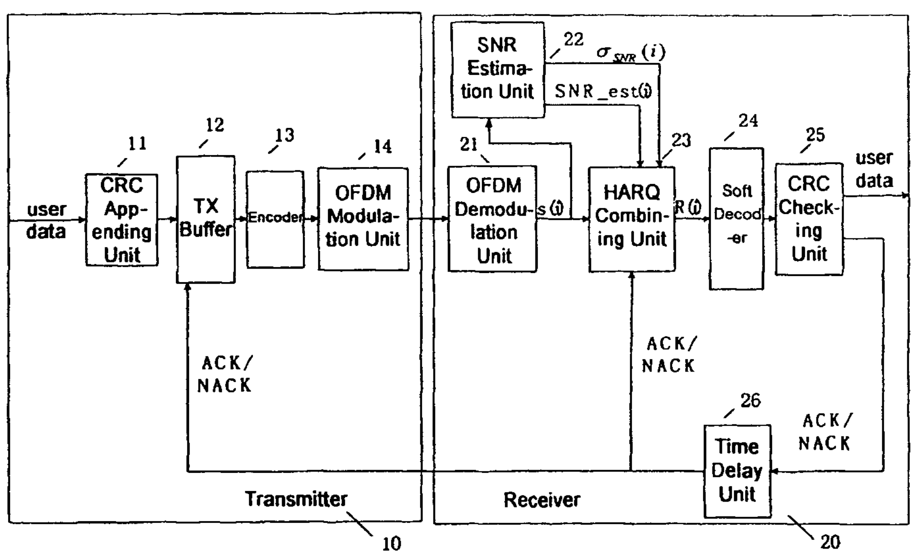

Fig.1

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Description

FIELD OF THE INVENTION

[0001] The present invention generally relates to a mobile communication system and particularly to a HARQ (Hybrid Automatic Repeat Request) combining method in an OFDM (Orthogonal Frequency Division Multiplexing) system.

BACKGROUND OF THE INVENTION

[0002] Existing simple combining techniques use Chase combining weighted by SNR (signal-to-noise ratio) to realize HARQ combining. Here, SNR is an average value over a period of time (for example, a data frame).

[0003] There are two cases in relatively low SNR environment: 1) variance of SNR may be relatively high over the same period of time; 2) variance of SNR may be relatively low over the same period of time. The first case indicates that time selective fading of the signal is very serious. The effect of fast fading in time domain may be neglected and the performance of HARQ combining at the receiver side may be reduced if only Chase combining weighted by SNR is simply adopted to realize HARQ combing.

SUMMARY OF THE INVENTION

[0004] The object of the present invention is to provide a HARQ combining method in an OFDM system, which can solve problems existing in the prior art, improve system performance in throughput and time delay, and reduce the system retransmission times at the same time.

[0005] The HARQ combining method in an OFDM system according to the present invention comprises the following steps:

a. A transmitter transmitting data to a receiver in a unit of frame, then the receiver weighting the received data based on its SNR and variance of SNR and storing the weighted data as final data in a buffer of a HARQ combining unit, and later, the receiver processing the stored final data to determine whether the received data frames are correct;

b. If the data frames are correct, the receiver outputting the final data and feeding back an ACK indicator respectively to the HARQ combining unit of the receiver and the transmitter, and if the data frames are not correct, the receiver feeding back a NACK indicator respectively to the HARQ combining unit of the receiver and the transmitter;

c. When the HARQ combining unit of the receiver and the transmitter receives an ACK indicator, the process returning to step a, until all data has been transmitted;

d. When the HARQ combining unit of the receiver and the transmitter receives a NACK indicator, the transmitter retransmitting original data to the receiver, then the HARQ combining unit of the receiver weighting the received retransmission data based on its SNR and variance of SNR, and combining the weighted retransmission data with the data stored in the buffer of the HARQ combining unit, and at the same time, storing the combined data as final data in the buffer of the HARQ combining unit, then the receiver processing the combined final data to determine whether the combined data frames are correct, and returning to step b.

[0006] In step a, before the transmitter transmits data to the receiver in a unit of frame, the data needs to undergo some processes including CRC appending, encoding and OFDM modulating in turn, and at the same time storing the data after CRC appending and before encoding in a TX buffer as final data in order to facilitate possible retransmission. In step a, before the receiver weights the received data based on its SNR and variance of SNR, the receiver has to OFDM-demodulate the received data. In step a, the receiver processes the stored final data, including in turn soft decoding and CRC checking, and then obtaining an ACK or NACK indicator based on the determining whether the received data is correct by CRC checking.

[0007] In step b, the ACK or NACK indicator fed back to the transmitter is inputted to the TX buffer. When said TX buffer receives an ACK indicator, it will store new data as final data in itself, whereas when said TX buffer receives a NACK indicator, it will hold original final data unchanged.

[0008] In step d, before the HARQ combining unit of the receiver weights the received retransmission data based on its SNR and variance of SNR, the receiver has to OFDM-demodulate the received retransmission data. In step d, the receiver SNR-estimates the OFDM-demodulated retransmission data to obtain its SNR and variance of SNR. In Step d, the receiver processes the combined final data, including in turn soft decoding and CRC checking, and then obtaining an ACK or NACK indicator based on the determining whether the combined data frames are correct by CRC checking.

[0009] Here, in the receiver of the present invention, the processes for weighting the received data and weighted combining the retransmission data can be realized according to the following formula:

$$\begin{cases} R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}{\sum_{i=0}^{N_{retrans}} \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}, & SNR\_est(i) < SNR_{threshold} \text{ and } \sigma_{SNR}(i) > \sigma_{threshold} \\ R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * SNR\_est(i)}{\sum_{i=0}^{N_{retrans}} SNR\_est(i)}, & SNR\_est(i) \geq SNR_{threshold} \text{ or } \sigma_{SNR}(i) \leq \sigma_{threshold} \end{cases},$$

where i indicates the i-th retransmission, and $i \geq 0$;
$N_{retrans}$ indicates the retransmission times of a transmission block, and $1 \leq N_{retrans} \leq N_{\max}$;
$N_{\max}$ indicates the maximum retransmission times of a transmission block;
$R(i)$ indicates the data after the i-th combining;
$S(i)$ indicates the data before the i-th combining;
$SNR\_est(i)$ indicates SNR of the i-th estimation;
$SNR_{threshold}$ indicates the threshold of SNR;
$\sigma_{SNR}(i)$ indicates variance of SNR of the i-th estimation;
$\sigma_{threshold}$ indicates the threshold of variance of SNR.

[0010] The receiver in the OFDM system of the present invention comprises:

a SNR estimation unit for SNR-estimating the demodulated data to obtain estimated SNR and variance of SNR and outputting them;

a HARQ combining unit for receiving the output from the SNR estimation unit, weighting inputted demodulated data based on inputted SNR and variance of SNR, and storing the weighted data as final data in a buffer of said HARQ combining unit, then determining whether to execute the combining based on determining whether the received data frames are correct: if the received data frames are correct, not executing the combining; if the received data frames are not correct, weighting the inputted demodulated retransmission data based on its SNR and variance of SNR, and combining the weighted retransmission data with the data stored in the buffer of said HARQ combining unit and storing the combined data as final data in the buffer of said HARQ combining unit.

[0011] The present invention implements a hybrid automatic repeat request combining method in an OFDM system by means of improved Chase combining weighted by SNR and variance of SNR. The method improves system performance in throughput and time delay, particularly in low SNR environment, and will not make the system more complex.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The present invention will now be further described in combination with the attached drawings and exemplary embodiments of the present invention.

Fig. 1 is a schematic illustrating relevant structure of the receiver and transmitter for performing the HARQ combining method of the present invention in an OFDM system;

Fig. 2 is a simulation curve chart of SNR - Bit Error Ratio (BER) in which the HARQ combining method of the present invention is compared with normal Chase combining method and non-weighted data combining method;

Fig. 3 is a simulation curve chart of SNR - System Throughput in which the HARQ combining method of the present invention is compared with normal Chase combining method and non-weighted data combining method; and

Fig. 4 is a simulation curve chart of SNR - Time Delay in which the HARQ combining method of the present invention is compared with normal Chase combining method and non-weighted data combining method.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] With reference to the attached drawings and preferred embodiments, the present invention will now be further described.

[0014] Fig. 1 is a schematic illustrating related structure of the receiver and transmitter for performing the HARQ combining method of the present invention in an OFDM system. As shown in Fig. 1, at the side of Transmitter 10, firstly, CRC Appending Unit 11 of Transmitter 10 appends CRC to inputted user data in unit of frame and stores the appended user data with CRC bit as final user data in TX Buffer (transmitter buffer) 12. Then, TX Buffer 12 transmits the stored user data to Encoder 13, which encodes the user data inputted from TX Buffer 12 and outputs the result to OFDM Modulation Unit 14. And later, OFDM Modulation Unit 14 transmits the OFDM-modulated user data to a transmission unit of Transmitter 10 (not shown in Fig. 1) , which transmits the user data to radio channels (not shown in Fig. 1).

[0015] At the side of Receiver 20, firstly, after a receiving unit of Receiver 20 (not shown in Fig. 1) receives the user data transmitted from Transmitter 10 from radio channels, OFDM Demodulation Unit 21 OFDM-demodulates the received user data and inputs the result, i.e., user data ***S*(0)** to HARQ Combining Unit 23 and SNR Estimation Unit 22, respectively. SNR Estimation Unit 22 SNR-estimates the user data ***S*(0)** to get estimation values of SNR and variance of SNR, i.e., ***SNR_est*(0)** and $\sigma_{SNR}(0)$, of the user data ***S*(0)**. Then ***SNR_est*(0)** and $\sigma_{SNR}(0)$ are inputted together into HARQ Combining Unit 23. HARQ Combining Unit 23 weights the user data ***S*(0)** based on estimated SNR and Variance of SNR, i.e., ***SNR_est*(0)** and $\sigma_{SNR}(0)$ to get weighted user data ***R*(0)**, and stores the result, i.e., weighted user data ***R*(0)** as final user data in the buffer of HARQ Combining Unit 23. And later, HARQ Combining Unit 23 inputs the user data ***R*(0)** to Soft Decoder 24, in which the inputted user data ***R*(0)** is soft decoded and outputted to CRC Checking Unit 25. CRC Checking Unit 25 determines whether the user data frames received by Receive 20 are correct and then gets an ACK or NACK indicator accordingly.

[0016] If CRC Checking Unit 25 determines the user data received by receiver 20 are correct, CRC Checking Unit 25 will output the user data after CRC checking and issue an ACK indicator, which is fed back respectively to HARQ Combining Unit 23 of Receiver 20 and TX Buffer 12 of Transmitter 10. There should be a certain time delay before HARQ Combining Unit 23 of Receiver 20 and TX Buffer 12 of Transmitter 10 receive the ACK indicator, respectively, so the ACK indicator issued from CRC Checking Unit 25 of Receiver 20 is delayed by Time Delay Unit 26 of Receiver 20 before fed back to HARQ Combining Unit 23 of Receiver 20 and TX Buffer 12 of Transmitter 10, respectively.

[0017] When TX Buffer 12 of Transmitter 10 and HARQ Combining Unit 23 of Receiver 20 receive an ACK indicator, the operating procedures for transmitting user data at the side of the transmitter and for receiving user data at the side of the receiver are repeated. That is, TX Buffer 12 of Transmitter 10 gets new user data after CRC appending (in unit of frame), and stores it as final user data. Then the stored user data is transmitted to radio channels (not shown in Fig. 1) via a transmission unit (not shown in Fig. 1) after encoded and OFDM modulated by Transmitter 10. Receiver 20 receives the new user data transmitted by Transmitter 10 from radio channels (not shown in Fig. 1) and processes the received new user data, including OFDM demodulating, SNR estimating and weighting in turn, and at the same time storing weighted new user data as final user data in the buffer of HARQ Combining Unit 23. And later, the stored user data is soft decoded and CRC checked to determine whether the received new user data frames are correct. If the received new user data frames are correct, Receiver 20 outputs the user data after CRC checking and feeds back an ACK indicator to HARQ Combining Unit 23 of Receiver 20 and TX Buffer 12 of Transmitter 10 simultaneously. Thus, all these processes form a loop.

[0018] If CRC Checking Unit 25 determines the received user data frames are not correct, CRC Checking Unit 25 of Receiver 20 will issue a NACK indicator. In the same way, the NACK indicator is also delayed by Time Delay Unit 26 and fed back to HARQ Combining Unit 23 of Receiver 20 and TX Buffer 12 of Transmitter 10, respectively.

[0019] When HARQ Combining Unit 23 of Receiver 20 and TX Buffer 12 of Transmitter 10 receive a NACK indicator, TX Buffer 12 of Transmitter 10 does not get new user data, and retransmits the stored final user data to Encoder 13 and OFDM Modulation Unit 14 to encode and modulate it. After that, the user data is transmitted to radio channels (not shown in Fig. 1) via the transmission unit (not shown in Fig. 1). After receiving the user data retransmitted by Transmitter 10 from radio channels (not shown in Fig.1), Receiver 20 OFDM-demodulates the retransmission user data to get retransmission data ***S*(1)** and inputs the retransmission data ***S*(1)** into SNR Estimation Unit 22 and HARQ Combining Unit 23, respectively. SNR Estimation Unit 22 SNR-estimates the retransmission data ***S*(1)** to get its estimation values of SNR and Variance of SNR, i.e., ***SNR_est*(1)** and $\sigma_{SNR}(1)$, and inputs the estimated ***SNR_est*(1)** and $\sigma_{SNR}(1)$ together into HARQ Combining Unit 23. HARQ Combining Unit 23 weights the inputted retransmission data ***S*(1)** based on its ***SNR_est*(1)** and $\sigma_{SNR}(1)$, then gets user data ***R*(1)** by combining the weighted retransmission data and final user data ***S*(0)** stored in the buffer of HARQ Combining Unit 23, and at the same time stores the combined user data ***R*(1)** as final user data in the buffer of HARQ Combining Unit 23.

[0020] Then, HARQ Combining Unit 23 inputs the combined user data $R(1)$ into Soft Decoder 24 to decode it. Soft Decoder 24 outputs soft-decoded data to CRC Checking Unit 25 to determine whether the received retransmission user data is correct. If the received retransmission user data is not correct, Receiver 20 feeds back a NACK indicator to HARQ Combining Unit 23 of Receiver 20 and TX Buffer Unit 12 of Transmitter 10, respectively. When HARQ Combining Unit 23 of Receiver 20 and TX Buffer Unit 12 of Transmitter 10 receive the NACK indicator, the operating procedures for retransmitting user data at the side of the transmitter and for receiving retransmitted user data at the side of the receiver are repeated. That is, after encoded and OFDM modulated by Transmitter 10, the final user data in TX Buffer 12 is retransmitted to radio channels (not shown in Fig. 1) via the transmission unit (not shown in Fig. 1). After receiving the user data retransmitted by Transmitter 10 from radio channels (not shown in Fig. 1), Receiver 20 gets retransmission data $S(2)$ by OFDM demodulation, and then gets $SNR\_est(2)$ and $\sigma_{SNR}(2)$ by SNR-estimating the retransmission data $S(2)$. HARQ Combining Unit 23 weights the inputted retransmission data $S(2)$ based on inputted $SNR\_est(2)$ and $\sigma_{SNR}(2)$, and then combines the weighted retransmission data with the final user data $S(1)$ in the buffer of HARQ Combining Unit 23 to get user data $R(2)$, which is stored as final user data in the buffer of HARQ Combining Unit 23. And later, $R(2)$ is soft decoded and CRC-checked by Receiver 20 to determine whether the received new retransmission user data is correct. If the received retransmission user data is not correct, Receiver 20 feeds back a NACK indicator respectively to HARQ Combining Unit 23 of Receiver 20 and TX Buffer 12 of Transmitter 10, thus constituting a loop. The loop will go on until the received new retransmission user data is correct. Then Receiver 20 outputs the retransmission user data and feeds back an ACK indicator respectively to HARQ Combining Unit 23 of Receiver 20 and TX Buffer 12 of Transmitter 10 simultaneously.

[0021] The above weighted combining process can be realized according to the following formula:

$$\begin{cases} R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}{\sum_{i=0}^{N_{retrans}} \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}, & SNR\_est(i) < SNR_{threshold} \quad and \quad \sigma_{SNR}(i) > \sigma_{threshold} \\ R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * SNR\_est(i)}{\sum_{i=0}^{N_{retrans}} SNR\_est(i)}, & SNR\_est(i) \geq SNR_{threshold} \quad or \quad \sigma_{SNR}(i) \leq \sigma_{threshold} \end{cases},$$

Where i indicates the i-th retransmission and $i \geq 0$;
$N_{retrans}$ indicates the retransmission times of a transmission block, and $1 \leq N_{retrans} \leq N_{\max}$;
$N_{\max}$ indicates the maximum retransmission times of a transmission block;
$R(i)$ indicates the data after the i-th combining;
$S(i)$ indicates the data before the i-th combining;
$SNR\_est(i)$ indicates the SNR of the i-th estimation;
$SNR_{threshold}$ indicates the threshold of SNR;
$\sigma_{SNR}(i)$ indicates variance of SNR of the i-th estimation;
$\sigma_{threshold}$ indicates the threshold of variance of SNR.

[0022] According to above detailed description of the embodiment, the HARQ (Hybrid Automatic Repeat Requests) combining method in an OFDM (Orthogonal Frequency Division Multiplexing) System of the present invention can be summarized as the following steps:

a. A transmitter transmits data to a receiver in a unit of frame, then the receiver weights the received data based on its SNR and variance of SNR and stores the weighted data as final data in a buffer of a HARQ combining unit, and later, the receiver processes the stored final data to determine whether the received data frames are correct;

b. If the data frames are correct, the receiver will output the final data and feed back an ACK indicator respectively to the HARQ combining unit of the receiver and the transmitter, and if the data frames are not correct, the receiver will feed back a NACK indicator respectively to the HARQ combining unit of the receiver and the transmitter;

c. When the HARQ combining unit of the receiver and the transmitter receive an ACK indicator, the process returns to step a, until all data has been transmitted;

d. When the HARQ combining unit of the receiver and the transmitter receive a NACK indicator, the transmitter retransmits original data to the receiver, then the HARQ combining unit of the receiver weights the received retransmission data based on its SNR and variance of SNR, and combines the weighted retransmission data with the data stored in the buffer of the HARQ combining unit, and at the same time, stores the combined data as final data in the buffer of the HARQ combining unit, then the receiver processes the combined final data to determine whether the combined data frames are correct, after that, the process returns to Step b.

[0023] At the same time, from the above embodiment the receiver in the OFDM system of the present invention will be achieved, which includes:

a SNR estimation unit for SNR-estimating the demodulated data to obtain estimated SNR and variance of SNR and outputting them;

a HARQ combining unit for receiving the output from the SNR estimation unit, weighting inputted demodulated data based on its SNR and variance of SNR, and storing the weighted data as final data in a buffer of said HARQ combining unit, then determining whether to execute the combining based on the determination whether the received data frames are correct: if the received data frames are correct, not executing the combining; if the received data frames are not correct, weighting the inputted demodulated retransmission data based on its SNR and variance of SNR and combining the weighted retransmission data with the data in the buffer of said HARQ combining unit, and at the same time, storing the combined data as final data in the buffer of said HARQ combining unit.

[0024] The transmitter and other function modules of the receiver in the OFDM system can be realized by existing technologies. Thus, their description are omitted here.

[0025] Herein, in the receiver of the present invention, the process of the HARQ combining unit for weighting the received data and weighted combining the retransmission data based on its SNR and variance of SNR respectively can be realized according to the following formula:

$$\begin{cases} R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}{\sum_{i=0}^{N_{retrans}} \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}, & SNR\_est(i) < SNR_{threshold} \quad and \quad \sigma_{SNR}(i) > \sigma_{threshold} \\ R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * SNR\_est(i)}{\sum_{i=0}^{N_{retrans}} SNR\_est(i)}, & SNR\_est(i) \geq SNR_{threshold} \quad or \quad \sigma_{SNR}(i) \leq \sigma_{threshold} \end{cases},$$

Where i indicates the i-th retransmission and $i \geq 0$;
$N_{retrans}$ indicates the retransmission times of a transmission block, and $1 \leq N_{retrans} \leq N_{max}$;
N_{max} indicates the maximum retransmission times of a transmission block;
R(i) indicates the data after the i-th combining;
$S(i)$ indicates the data before the i-th combining;
$SNR\_est(i)$ indicates the SNR of the i-th estimation;
$SNR_{threshold}$ indicates the threshold of SNR;
$\sigma_{SNR}(i)$ indicates variance of SNR of the i-th estimation;
$\sigma_{threshold}$ indicates the threshold of variance of SNR.

[0026] Figures 2, 3, and 4 show the simulation curve chart of SNR-BER (Bit Error Ratio), SNR-Throughput and SNR-Time Delay according to comparing examples of the present invention, respectively. As show in Figures 2-4, curves a1, a2, and a3 indicate the simulation curves when employing non-weighted combining method, curves b1, b2, and b3 indicate the simulation curves when employing normal Chase combining method weighted by SNR, and curves c1, c2, and c3 indicate the simulation curves when employing improved Chase combining method weighted by SNR and variance of SNR of the present invention.

[0027] The simulation curves shown in Figures 2-4 are obtained in the following simulation environments: in an OFDM system; the carrier frequency is 3.2GHz; the channel is an outdoor multipath channel A with AWGN+UMTS; the mobile speed is 120km/h; coding mode is 1/3 Turbo coding; modulation mode is 16QAM; CRC is 24-bit; channel estimation and SNR estimation are ideal; the simulation point is 10240*150; and the maximum retransmission times are set to 5. According to Figures 2, 3, and 4, the improved Chase combining method weighted by SNR and variance of SNR of the present invention improves not only the performance of BER, but also system performance in throughput and time delay. And in relatively low SNR (less than 11dB) environment, the improvement of system performance in throughput and time delay of the method is remarkable. Thus, the improved Chase combining method weighted by SNR and variance of SNR of the present invention has more advantages, particularly in low SNR environment, which is the common condition in mobile communication systems.

[0028] As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof except as defined in the appended claims.

Claims

1. A Hybrid Automatic Repeat Request (HARQ) combining method in an Orthogonal Frequency Division Multiplexing (OFDM) system, comprising steps of:

    a. a transmitter transmitting data to a receiver in a unit of frame, then the receiver weighting the received data based on its SNR and variance of SNR and storing the weighted data as final data in a buffer of a HARQ combining unit, and later, the receiver processing the stored final data to determine whether the received data frames are correct;

    b. if the data frames are correct, the receiver outputting the final data and feeding back an ACK indicator respectively to the HARQ combining unit of the receiver and the transmitter, and if the data frames are not correct, the receiver feeding back a NACK indicator respectively to the HARQ combining unit of the receiver and the transmitter;

    c. when the HARQ combining unit of the receiver and the transmitter receiving an ACK indicator, the process returning to step a, until all data has been transmitted;

    d. when the HARQ combining unit of the receiver and the transmitter receiving a NACK indicator, the transmitter retransmitting original data to the receiver, then the HARQ combining unit of the receiver weighting the received retransmission data based on its SNR and variance of SNR, and combining the weighted retransmission data with the data stored in the buffer of the HARQ combining unit, and at the same time, storing the combined data as final data in the buffer of the HARQ combining unit, then the receiver processing the combined final data to determine whether the combined data frames are correct, after that, the process returning to step b.

2. The HARQ combining method according to Claim 1, wherein in said step a, before the transmitter transmits data to the receiver in unit of frame, the data needs to undergo processes of CRC appending, coding and OFDM modulating in turn, and at the same time storing the data after CRC appending and before coding as final data in a TX buffer in order to facilitate possible retransmission.

3. The HARQ combining method according to Claim 2, wherein in said step a, before the receiver weights the received data based on its SNR and variance of SNR, the receiver has to OFDM-demodulate the received data.

4. The HARQ combining method according to Claim 3, wherein in said step a, the receiver processes stored final data including soft decoding and CRC checking in turn, and then obtaining an ACK or NACK indicator based on the determination whether the received data is correct by CRC checking.

5. The HARQ combining method according to Claim 1, wherein in said step b, the ACK or NACK indicator fed back to the transmitter is inputted to the TX buffer, and if said TX buffer receives an ACK indicator, it will store new data as final data in itself, and if said TX buffer receives a NACK indicator, it will hold the final data unchanged.

6. The HARQ combining method according to Claim 4, wherein in said step d, before the HARQ combining unit of the receiver weights the received retransmission data based on its SNR and variance of SNR, the receiver has to OFDM-demodulate the received retransmission data.

7. The HARQ combining method according to Claim 6, wherein in said step d, the SNR and variance of SNR of the retransmission data are obtained by the receiver by SNR-estimating the received OFDM-demodulated retrans-

mission data.

8. The HARQ combining method according to Claim 7, wherein in said step d, the receiver processes the combined final data including soft decoding and CRC checking in turn, and then obtaining an ACK or NACK indicator based on the determination whether the combined data frames are correct by CRC checking.

9. The HARQ combining method according to Claim 1, wherein the process of said Receiver for weighting the received data and weighted combining said retransmission data is implemented according to the following formula:

$$\begin{cases} R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}{\sum_{i=0}^{N_{retrans}} \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}, & SNR\_est(i) < SNR_{threshold} \quad and \quad \sigma_{SNR}(i) > \sigma_{threshold} \\ R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * SNR\_est(i)}{\sum_{i=0}^{N_{retrans}} SNR\_est(i)}, & SNR\_est(i) \geq SNR_{threshold} \quad or \quad \sigma_{SNR}(i) \leq \sigma_{threshold} \end{cases},$$

where i indicates the i-th retransmission, and $i \geq 0$; $N_{retrans}$ indicates the retransmission times of a transmission block, and $1 \leq N_{retrans} \leq N_{max}$;
N_{max} indicates the maximum retransmission times of a transmission block;
$R(i)$ indicates the data after the i-th combining;
$S(i)$ indicates the data before the i-th combing;
$SNR\_est(i)$ indicates the SNR of the i-th estimation;
$SNR_{threshold}$ indicates the threshold of SNR;
$\sigma_{SNR}(i)$ indicates variance of SNR of the i-th estimation;
$\sigma_{threshold}$ indicates the threshold of variance of SNR.

10. A receiver in an OFDM system, comprising:

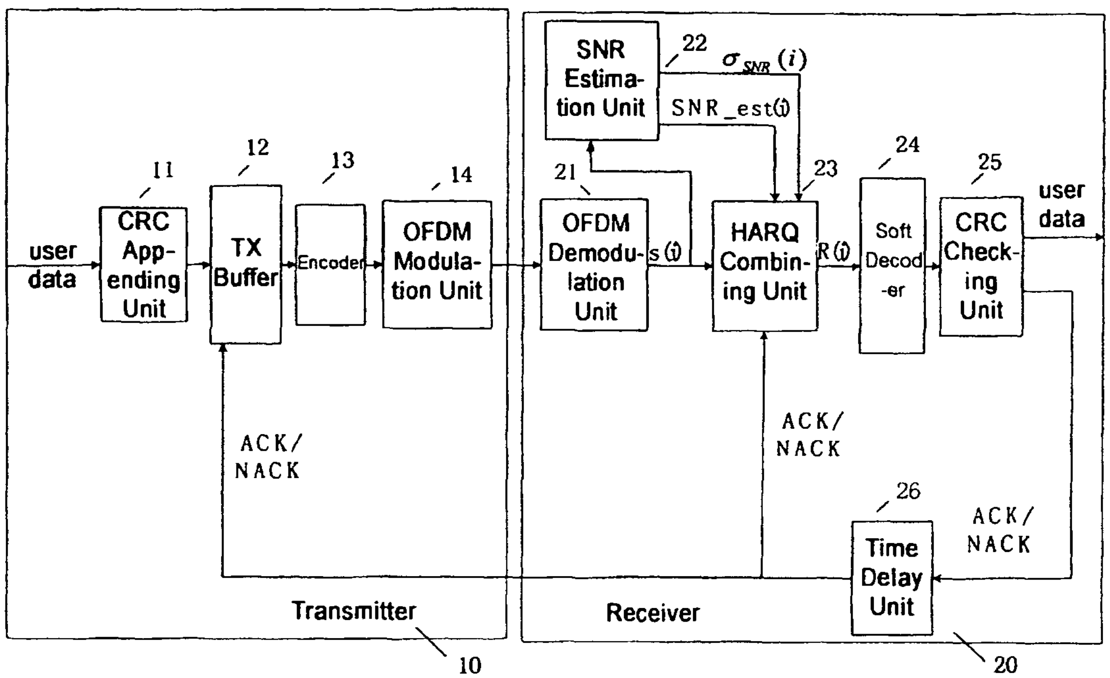
a SNR estimation unit for SNR-estimating demodulated data to obtain estimated SNR and variance of SNR and outputting them;

a HARQ combining unit for receiving the output from the SNR estimation unit, weighting inputted demodulated data based on inputted SNR and variance of SNR, and storing the weighted data as final data in a buffer of said HARQ combining unit, then determining whether to execute the combining based on the determination whether the received data frames are correct: if the received data frames are correct, not executing the combination; if the received data frames are not correct, weighting the inputted demodulated retransmission data based on its SNR and variance of SNR , combining the weighted retransmission data with the data in the buffer of said HARQ combining unit, and storing the combined data as final data in the buffer of said HARQ combining unit.

11. The receiver according to Claim 10, wherein the processes for weighting the demodulated data and weighted combining said inputted demodulated retransmission data is implemented according to the following formula:

$$
\begin{cases}
R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}{\sum_{i=0}^{N_{retrans}} \dfrac{SNR\_est(i)}{\sigma_{SNR}(i)}}, & SNR\_est(i) < SNR_{threshold} \quad and \quad \sigma_{SNR}(i) > \sigma_{threshold} \\
R(i) = \dfrac{\sum_{i=0}^{N_{retrans}} s(i) * SNR\_est(i)}{\sum_{i=0}^{N_{retrans}} SNR\_est(i)}, & SNR\_est(i) \geq SNR_{threshold} \quad or \quad \sigma_{SNR}(i) \leq \sigma_{threshold}
\end{cases},
$$

where i indicates the i-th retransmission, and $i \geq 0$; $N_{retrans}$ indicates the retransmission times of a transmission block, and $1 \leq N_{retrans} \leq N_{\max}$;
$N_{\max}$ indicates the maximum retransmission times of a transmission block;
$R(i)$ indicates the data after the i-th combining;
$S(i)$ indicates the data before the i-th combining;
$SNR\_est(i)$ indicates the SNR of the i-th estimation;
$SNR_{threshold}$ indicates the threshold of SNR;
$\sigma_{SNR}(i)$ indicates the variance of SNR of the i-th estimation;
$\sigma_{threshold}$ indicates the threshold of Variance of SNR.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-er
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user
data
ACK/
NACK
26
Time
Delay
Unit
ACK/
NACK
Receiver
20

Fig.1

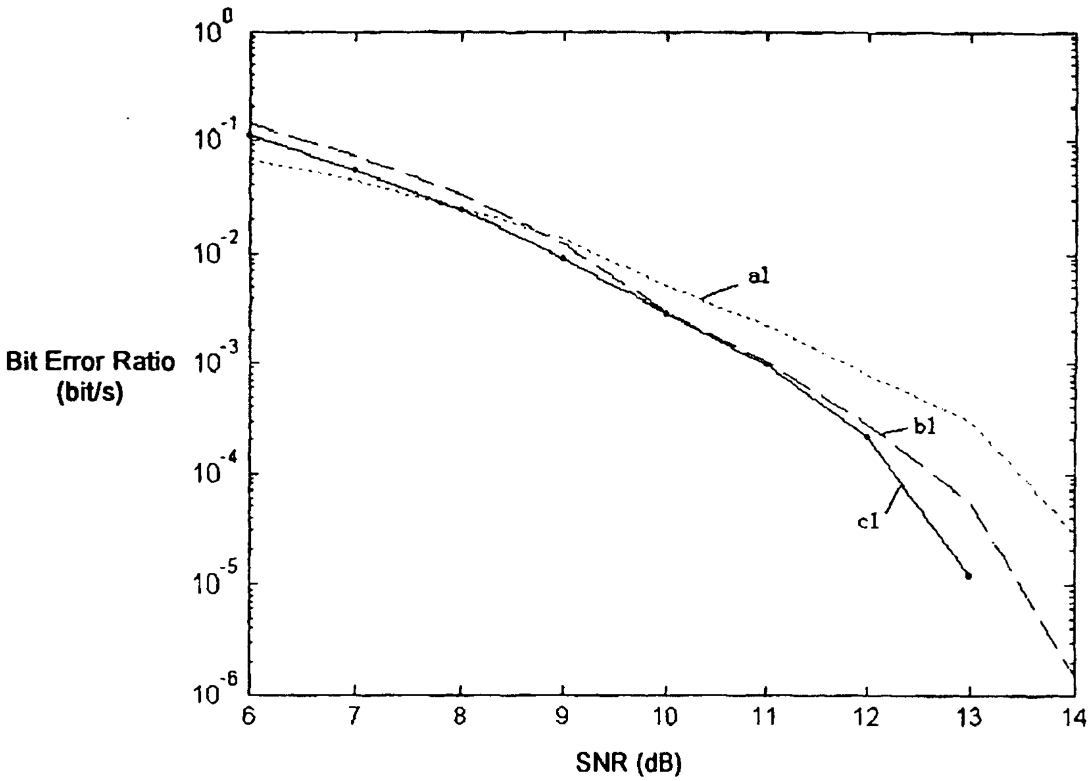
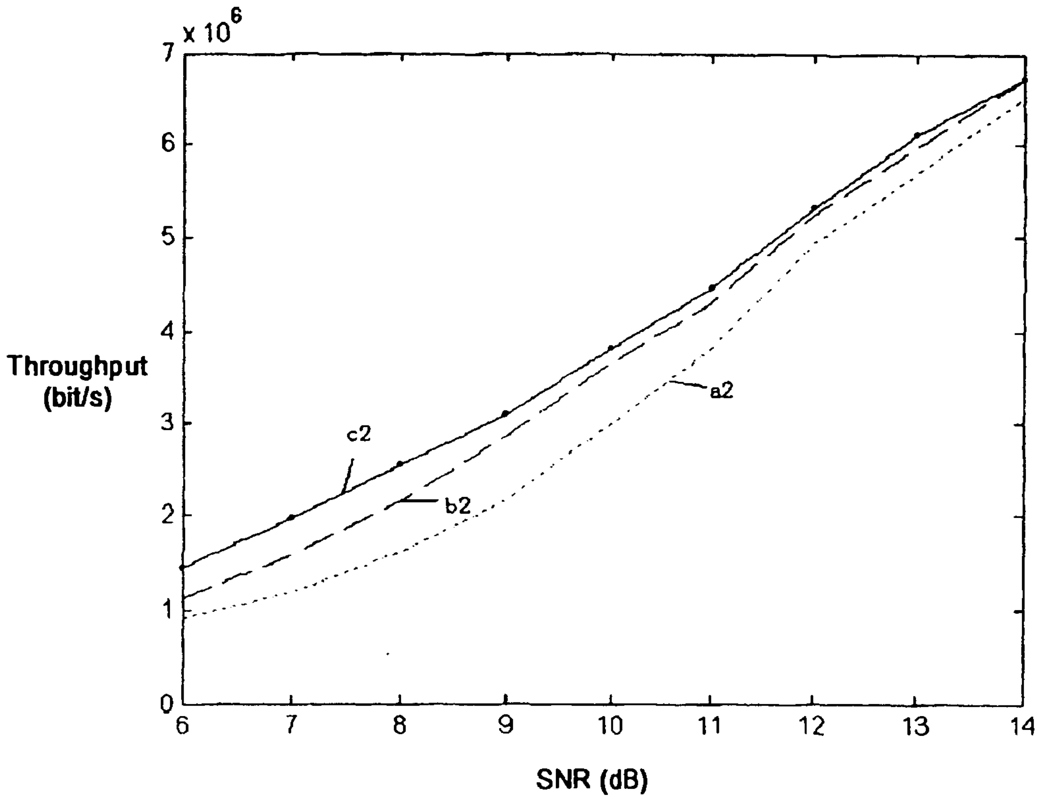


Fig.2


x 10^6
Throughput (bit/s)
SNR (dB)
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a2
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11
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13
14

Fig.3

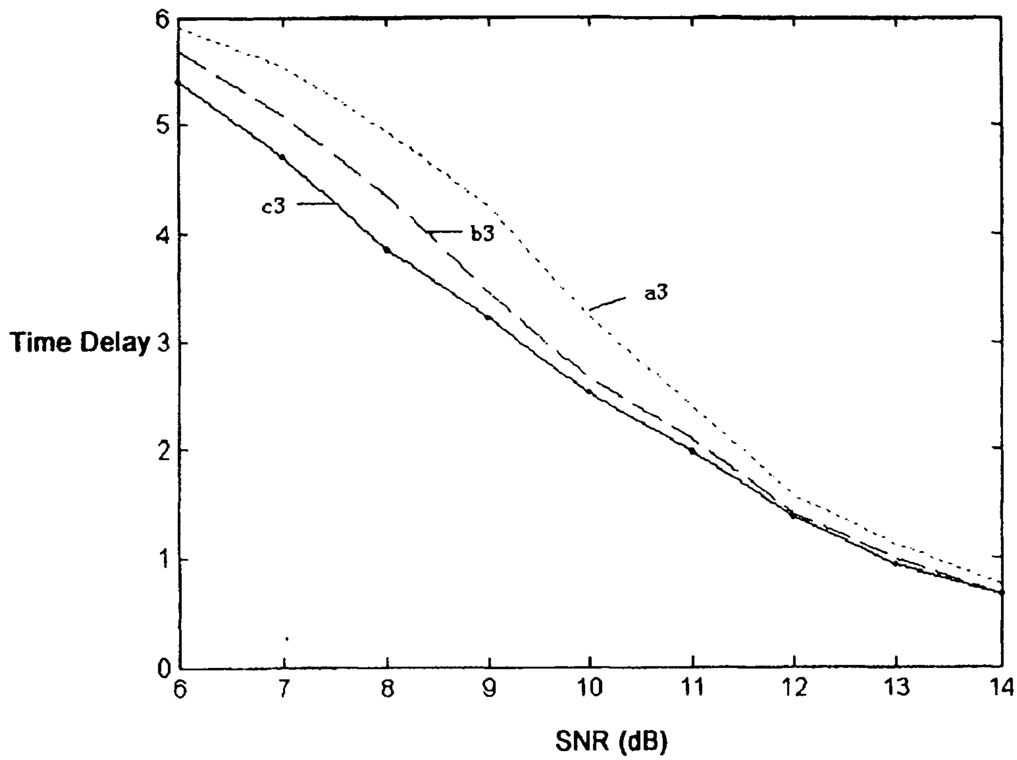

Fig.4

Reverse high-speed packet data physical layer enhancements in cdma2000 1×EV-DV

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Abstract
The rapid growth of Internet-based applications calls for design of a high-speed wireless packet data communication system. This anticipated increase in future mobile wireless packet data services has challenge the current 3G standardization bodies to respond with evolved 3G system specifications capable of providing increased data throughput. In response to such a need, 3GPP2 recently completed the enhanced reverse link standardization effort of the CDMA technology flagship, cdma2000® by completing the definition of the 1×EV-DV 1× system. 1×EV-DV achieves higher data throughput while simultaneously providing coexisting and backward-compatible voice services within the same spectrum. This feature of 1×EV-DV allows wireless operators to manage the voice and data loading in their system more efficiently. This article describes the physical layer reverse link enhancements in cdma2000 revision D that are necessary to support 1×EV-DV.

Index Terms
Available to subscribers and IEEE members.

References
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Citing Documents
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Reverse High-Speed Packet Data Physical Layer Enhancements in cdma2000 1xEV-DV

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ABSTRACT

The rapid growth of Internet-based applications calls for design of a high-speed wireless packet data communication system. This anticipated increase in future mobile wireless packet data services has challenged the current 3G standardization bodies to respond with evolved 3G system specifications capable of providing increased data throughput. In response to such a need, 3GPP2 recently completed the enhanced reverse link standardization effort of the CDMA technology flagship, cdma2000®, by completing the definition of the 1xEV-DV 1x system. 1xEV-DV achieves higher data throughput while simultaneously providing coexisting and backward-compatible voice services within the same spectrum. This feature of 1xEV-DV allows wireless operators to manage the voice and data loading in their system more efficiently. This article describes the physical layer reverse link enhancements in cdma2000 Revision D that are necessary to support 1xEV-DV.

INTRODUCTION

The development of third-generation (3G) systems such as cdma2000 provides connectivity to packet data networks via cellular systems while increasing voice capacity. As one would expect, many of the rapidly growing Internet applications and services are finding their way into the mobile wireless domain and taking advantage of 3G system offerings such as rich multimedia content. Real-time streaming video and music, and online interactive gaming are just a few examples of services whose popularity is growing beyond expectations. Hence, services of this nature are pushing the technology envelope for wireless data transfer to achieve a better end user experience.

In response to growing mobile wireless packet data demands and higher data throughput, the Third Generation Partnership Project Two (3GPP2) recently completed the enhanced reverse link standardization effort of the cdma2000 1x Evolution for High-Speed Integrated Data and Voice (1xEV-DV) system [1]. At the outset, the goals for 1xEV-DV were clear:

- Increase the bit rate over the radio.
- Improve packet-switched bearer services by providing support for various quality of service (QoS) classes.

Furthermore, users' ability to communicate over a packet-switched bearer service while simultaneously engaging in a voice call (or other teleservice) was deemed important. With this guidance, the 3GPP2 developed a specification for 1xEV-DV that achieves higher data throughput while simultaneously providing coexisting and backward-compatible voice services within the same RF spectrum. This feature of 1xEV-DV allows wireless operators to utilize their spectrum more efficiently, and provides a means to balance the voice and data load in their system based on their specific needs.

This article is organized as follows. We give an overview of recent reverse link enhancements made to the 1xEV-DV systems. We provide a simple operational overview, and the article is concluded with some summary remarks.

1XEV-DV OVERVIEW

1xEV-DV is an enhancement to cdma2000's data carrying capability designed to deliver rates significantly higher than prior revisions of cdma2000 (Release 0 and Revisions A and B). 1xEV-DV achieves higher data throughput while simultaneously providing coexisting and backward-compatible voice services within the same radio frequency (RF) spectrum. This feature of 1xEV-DV allows wireless operators to utilize their spectrum more efficiently, and provides a means to balance the voice and data load in their system based on their specific needs.

The enhanced 1xEV-DV reverse link employs common technologies that were used in the development of the 1xEV-DV forward link. Both the forward and reverse links in the 1xEV-DV system employ channel-sensitive scheduling via adaptive modulation and encoding with higher-order modulation. The 1xEV-DV system uses concatenation of forward error correction (FEC) coding and an automatic repeat request (ARQ) protocol commonly known as hybrid ARQ

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Revision D of cdma2000 targeted improved data carrying capability on the reverse link. To support this new capability, four channels were added to the reverse link: the reverse packet data channel, reverse packet data control channel, reverse secondary pilot channel, and reverse request channel

(HARQ) on both the forward and reverse links. HARQ operating at the physical layer facilitates shorter round-trip delays than those associated with higher-layer retransmission schemes employed in the Radio Link Protocol (RLP). These physical layer technologies coupled with upper layer enhancements work together as a team to achieve the best possible end user experience.

Before proceeding, one must consider that 1xEV-DV was designed in two phases:

- cdma2000 Revision C (1xEV-DV) [3] focused on both improved data rates and QoS reliability on the forward link
- Revision D of cdma2000 (1xEV-DV) [1] targets reverse link improved data rates and QoS reliability.

Since the focus of this article is on the recent reverse link enhancements to cdma2000, readers interested in the forward link enhancements and 1xEV-DV performance are encouraged to visit [2–6]. With this in mind, the system overview is subdivided into three subsections to provide insight into some of the reverse link design philosophy, and the reverse and forward link physical layer channels and their purpose in the system operation.

Reverse Link Design Philosophies

In designing the 1xEV-DV forward link for high-speed data, the limiting resources were the remaining power and orthogonal codes once the voice needs were met. In reverse link case, the most limiting resource is the total received power at the base transceiver station (BTS). The ratio of the total received power over the thermal noise power at the BTS is called rise-over-thermal (ROT). Because thermal noise power is a constant given the bandwidth, temperature, and receiver noise figure, ROT is a direct measure of the total received power. In the reverse link of cdma2000 systems, the interference a mobile experiences is the total received power except its own. As ROT rises, a mobile needs to transmit with more power to overcome the increased interference, which in turn creates more interference to other users. Because the mobile power amplifier and battery usually have limited capacity, it is essential to control the ROT in order to maintain good system performance and user experience. Two schools of thought surfaced regarding the radio resource management of the high-speed reverse link: rate control and scheduling. Rate control works much like traditional power control in today's CDMA systems; an up or down command instructs a mobile station (MS) to either increase or decrease its data rate by one step, respectively, depending on the command. Strict scheduling, on the other hand, implies that the network schedules the time, duration, and data rates an MS uses during its transmission. Both of these design philosophies have specific pros and cons. Examination of these control philosophies in 3GPP2 revealed that the pros of one control philosophy are the cons of the other. Consider for the moment some aspects of the rate control and strict scheduling philosophies.

A system employing pure rate control typically would utilize more code-division multiplexing (CDM) of users, thus generating more interference and ROT, whereas for a pure scheduled controlled system, less interference may be achievable through more time-division multiplexing (TDM) of users [7]. Likewise, for a rate-controlled system, it is possible the network would respond more slowly to fast channel and system dynamics, where this is not necessarily the case for a scheduled system. Rate control does permit less fluctuation in the total ROT [8], so a rate-controlled system can operate with less ROT headroom, thereby achieving larger capacity utilization on the average. However, a scheduled system employing TDM creates larger ROT fluctuations and thus has to operate with more headroom to accommodate the larger ROT fluctuations. Another aspect of rate control is that it is less sensitive than scheduled systems to imperfect knowledge of the channel and MS buffer conditions due to its CDM nature. Recognizing these strengths and weaknesses of the two approaches, 3GPP2 realized that the optimum solution most likely falls somewhere in between. As a result, the system can employ either approach, or a hybrid scheduled and rate-controlled approach. These control mechanisms offer wide flexibility in addressing many different data services, each requiring different levels of QoS. The decision that the improved reverse link should be able to flexibly operate using various control methods led to the definition of the necessary physical layer channels.

Reverse Link Enhancements

Revision D of cdma2000 targeted improved data carrying capability on the reverse link. To support this new capability, four new channels were added to the reverse link: the reverse packet data channel (R-PDCH), reverse packet data control channel (R-PDCCH), reverse secondary pilot channel (R-SPICH), and reverse request channel (R-REQCH).

Increasing Bit Rates — The R-PDCH is the new reverse link data bearing traffic channel. The R-PDCH has a fixed packet duration of 10 ms, and can transmit any of a set of fixed packet sizes of 192, 408, 792, 1560, 3096, 4632, 6168, 9240, 12,312, 15,384, and 18,432 bits. The R-PDCH also employs a four-channel stop-and-go HARQ with up to three transmissions. The timing of retransmissions is fixed relative to the initial transmission timing. The fixed packet duration and fixed timing HARQ ease the control logic and receiver design at the BTS. The 10 ms packet duration coupled with the many packet sizes and HARQ achieve flexible high-rate data transmissions ranging from 6.4 kb/s to 1.8432 Mb/s. The R-PDCH can undergo soft handoff (SHO). The system also enables channel-sensitive scheduling (a.k.a. link adaptation) via adaptive modulation with binary phase shift keying (BPSK), quaternary PSK (QPSK), and 8PSK and adaptive coding with quasi-complementary turbo code (QCTC) [9].

The R-PDCCH was introduced to avoid the problem of blind detection and decoding at the BTS. The R-PDCCH carries information corresponding to the packet format on the R-PDCH (i.e., the encoder packet size, subpacket identifi-

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er, SPID, for HARQ, and the boost bit to indicate whether or not the MS used boosted transmit power). The boost bit is typically associated as a means of addressing services that may be delay-intolerant. The R-PDCCH also contains the mobile status indicator bit (MSIB), which indicates whether the MS has enough power and data to increase the transmission rate on the R-PDCH. This information is used in the radio resource management algorithms at the BTS to achieve fast rate adaptation to channel condition and buffer status.

In general, high-data-rate transmission on the reverse link requires higher received pilot signal-to-noise ratio (SNR) for channel estimation to achieve optimized system performance [10]. The data rate of the R-PDCH can change rapidly due to rate control or scheduling. This requires the received pilot SNR to adapt to the data rate change of the R-PDCH on a frame basis. Notice that the received reverse pilot channel (R-PICH) is power controlled to compensate for channel fluctuation with an SNR target set by the outer loop power control. Hence, rapid power adjustments on the R-PICH can destabilize the outer loop power control mechanism. The R-SPICH was introduced to provide additional pilot SNR to optimize coherent detection of high-data-rate transmission on the reverse link. Introduction of the two-level (on or off) R-SPICH alleviates the outer loop problem by continuing to operate the R-PICH as normal, and the additional power needed for coherent demodulation of the high-speed data is placed on the R-SPICH. The presence or absence of the R-SPICH indicates that either high-rate or low-rate data was transmitted and ensures that detection can be performed quickly and reliably. When the R-SPICH is detected quickly, the combined R-PICH and R-SPICH can be used to improve the performance of the inner loop power control and demodulate the other channels. Hence, the R-SPICH serves three primary purposes:

- Facilitate simple and fast detection
- Improve reverse link power control
- Improve coherent demodulation performance

As stated earlier, the system can employ a rate-controlled, scheduled, or hybrid scheduled and rate-controlled radio resource management approach to offer wide flexibility in addressing the many different data services, each requiring different levels of QoS.

Quality of Service — QoS was less of an issue in the forward link in the air interface since the network contains all QoS-related information for service delivery on the forward link to the MS. In the reverse link, QoS is more of an issue since the MS originates services requiring different QoS levels, but the network controls access to the wireless radio resource. Thus, the network needs to know the QoS-related information for reverse link services. To address QoS origination issues, Revision D introduces many features such as the autonomous transmission mode, boost method [11], and energy reduction method [12] along with a new physical layer reverse link channel, the reverse request channel (R-REQCH).

The autonomous transmission mode permits the MS to start data transmission at any given time up to a preauthorized maximum data rate. The autonomous mode allows the MS to start up a service at any time while simultaneously reducing delay. This is a critical part of the QoS picture, especially the delay aspect, since the network cannot predict when the MS needs to initiate data transmission. When the MS initiates data transmission in autonomous mode, it may be transitioned into controlled mode for the duration of the data transmission period followed by transitioning back into the autonomous mode. Once the MS is engaged in a data traffic session, features such as the boost or energy reduction method can be employed during the session. These methods give the system designer tools to trade off power for delay. Consider as an example the case where a designer may use these two methods to achieve different system optimization. Specifically, let us assume that the boost method and energy reduction method in the presence of HARQ are used to address delay-intolerant and delay-tolerant services, respectively.

HARQ is employed on the R-PDCH, but HARQ introduces delay albeit significantly faster than ARQ operating at the upper layers. For delay-intolerant data services such as voice over IP (VoIP) or online gaming, it is desirable to terminate the HARQ instance early (i.e., achieve successful data transmission while minimizing the number of retransmissions). This can be achieved by simply increasing the MS's transmitter power for each transmission. The MS setting the boost bit on the R-PDCCH indicates use of the boost method/mode. The MS can transmit in the boost mode by either reducing the packet size or increasing the transmission power. However, this feature may generate a larger ROT when the MS transmits with a higher power level in the boost mode. Should the MS use smaller packets jointly with the boost mode, the ROT may be preserved. While the boost mode used in this example can reduce the delay at the cost of higher ROT when increasing transmitter power, the energy reduction mode can be used to achieve the opposite effect.

Typically for HARQ operation, the same transmitter power is used for each retransmission of a data packet. HARQ employs both soft combining of a packet retransmission with the corresponding earlier packet transmission and incremental redundancy. It stands to reason that it is not necessary to retransmit a packet using the same transmitter power provided the BTS has stored the energy associated with the earlier transmission. Thus, this particular use of the energy reduction mode allows the MS to retransmit the packet at lower power. This feature results in reduced ROT, and the cost is higher delay since it is most probable that full termination of the HARQ instance is required. Thus, the energy reduction mode in this example is used as a means of addressing services that may be delay-tolerant such as FTP. Stated another way, the boost method typically employs higher transmit power early in the HARQ instance, and the energy reduction mode typically employs reduced transmit power later in the HARQ

The system can employ a rate-controlled, scheduled, or a hybrid scheduled and rate-controlled radio resource management approach to offer wide flexibility in addressing the many different data services, each requiring different levels of quality of service.

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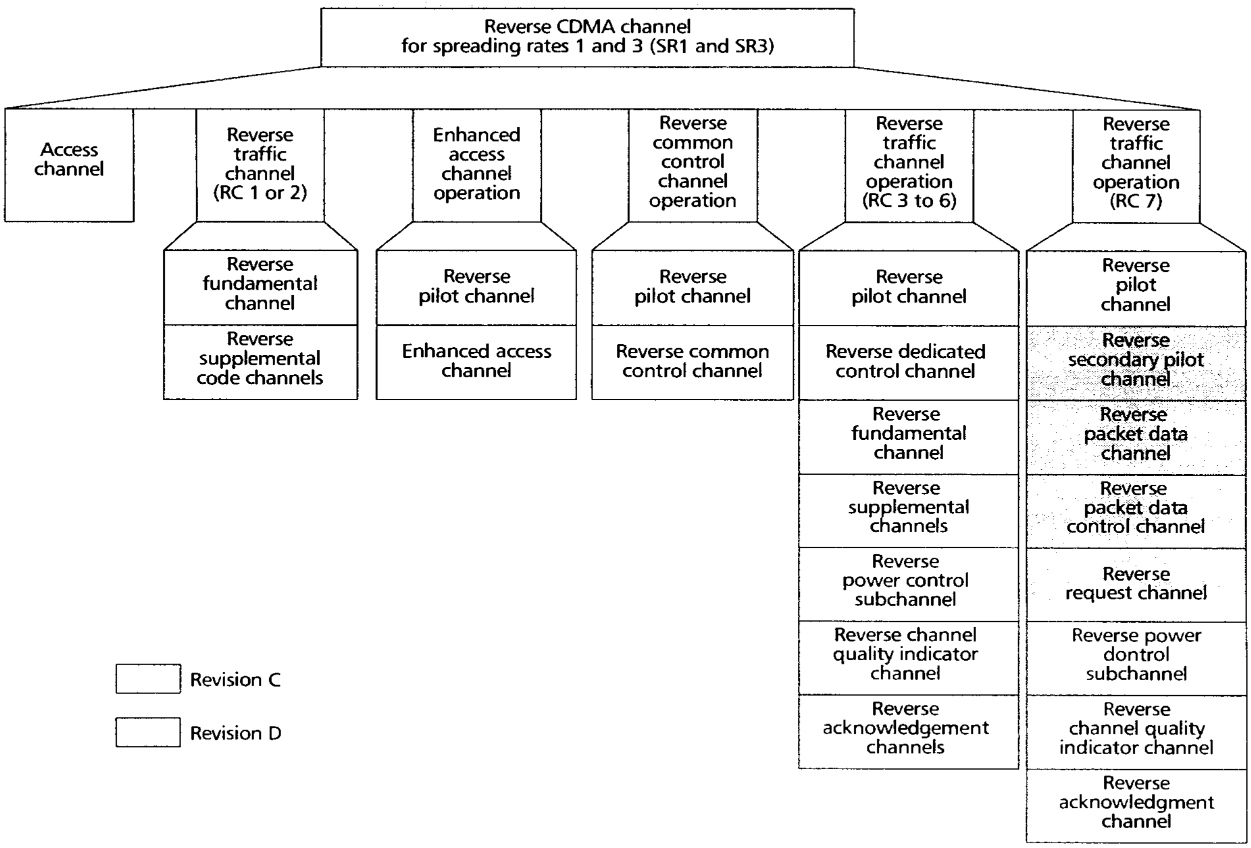


■ **Figure 1.** *IS-2000 reverse link physical layer channels.*

instance. However, it should be noted that the energy reduction mode could also be configured to reduce delay in a similar manner as the boost method. The remaining piece of the QoS picture is addressed with the introduction of the R-REQCH.

The R-REQCH allows the MS to provide the network with information pertaining to the MS's buffer status and available transmitter power to achieve effective radio resource management. The R-REQCH is event-triggered. To take into account all possible dynamic conditions during an R-PDCH data session, three types of requesting triggers can be configured by the BS:

- When data traffic arrives
- When specific buffer watermark (i.e., threshold) levels are crossed
- When the MS transmitting power level changes

The MS keeps monitoring its buffer status and transmitting power level accordingly. When any event is triggered, a corresponding request message containing the event code and power headroom will be sent over the R-REQCH to the BS. The general expectation is that the R-REQCH will be transmitted at a lower periodicity than the R-PDCH or R-PDCCH. Thus, the R-REQCH coupled with the autonomous transmission mode, boost method, and energy reduction method provides the 1xEV-DV system great flexibility to address QoS from different perspectives.

Figure 1 depicts the reverse link channels in IS-2000 and highlights the new 1xEV-DV channel additions. As one would expect, corresponding new physical layer channels were created to support the improved data carrying capability in the opposite direction (e.g., the improved reverse link required new forward link channels).

Forward Link Enhancements to Support Reverse Link High-Speed Packet Data Transmission

As noted earlier, the enhanced 1xEV-DV reverse link supports higher data rate transmissions, HARQ, and flexible radio resource management control techniques. New channels were added to the 1xEV-DV forward link to control these new features: the forward acknowledgment channel (F-ACKCH), forward grant channel (F-GCH), and forward indicator control channel (F-ICCH).

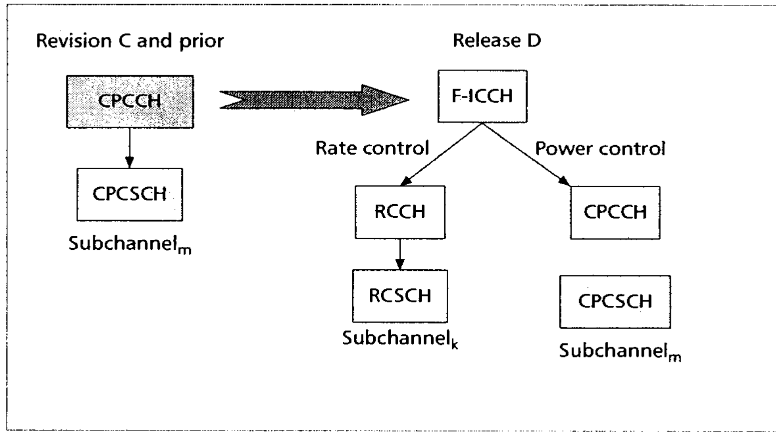
The F-ACKCH was added to support reverse link HARQ control by providing synchronous acknowledgments to the received reverse link data packet transmissions. The F-ACKCH uses on-off keying (OOK) where an "on" indicates acknowledgment of the received packet. The F-

ACKCH is theoretically capable of addressing 192 different users within a sector. To preserve energy and interference generated on the forward link, the system has an option of operating without acknowledgment of the last transmission of the HARQ sequence. Hence, the HARQ sequence is restarted regardless if the last transmission was properly received or not at the BTS. This new HARQ sequence is usually the transmission of a new packet, but it may also be the transmission of the old packet that is not received properly if the system is operating with acknowledgment of the last transmission of the HARQ sequence.

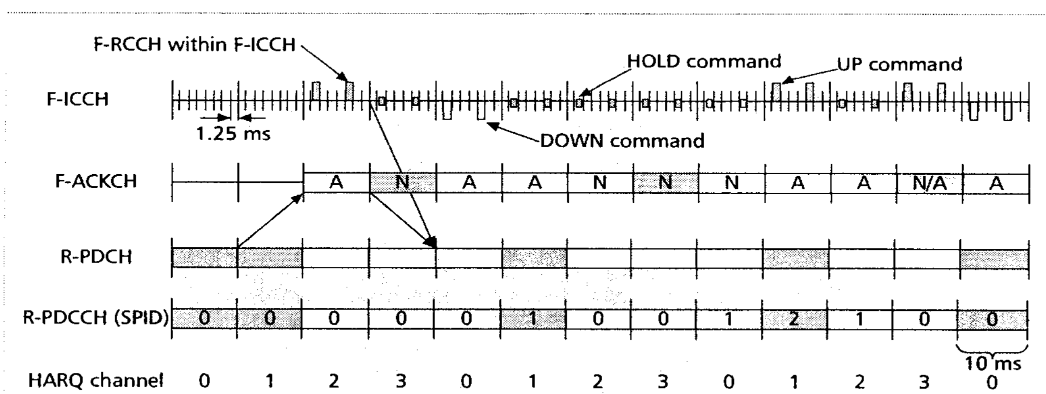
To support both rate control and scheduling, 1xEV-DV Revision D introduces the forward grant channel (F-GCH). The F-GCH is a reverse link control channel that carries the user's medium access control (MAC) ID, maximum packet size the MS can use, an indicator flag determining whether or not the grant applies to all ARQ channels, and a persistence flag indicating whether the grant message is a single or multiple grant of reverse link resources to the MS. All MSs monitor the F-GCH within the sector served by the F-GCH. The F-GCH is used to grant an MS access to the network above a predetermined autonomous transmission rate. The F-GCH can be used to quick start the MS transmission by adjusting the MS initial data transmission rate to avoid or limit the effects of ramp-up delay caused by rate control. Based on the F-GCH parameters, the F-GCH design has the flexibility to support rate and/or scheduling control or a hybrid combination of the two. However, another forward link channel was required to achieve efficient rate control.

As stated earlier, rate control is analogous to power control. With this in mind, the forward rate control channel (F-RCCH) was incorporated in the creation and definition of the forward indicator control channel (F-ICCH) to facilitate dedicated (per user) or common (per group, where the group may be all users of a sector) rate control. The F-ICCH is a control channel used by the BTS that contains one or two time-division multiplexed channels. In Revision C of cdma2000, the F-ICCH was simply the common power control channel (CPCCH). In Revision D the F-ICCH was introduced, and consists of both the CPCCH and F-RCCH (Fig. 2). The F-RCCH is the set of rate control subchannels (RCSCHs) that can be used to control individual or multiple MSs within an F-ICCH. The F-RCCH uses a double form of OOK to achieve rate control: a positive "on" implies increase in rate, a negative on implies a decrease in data rate, and off implies hold or keep the data rate constant. Common rate control (CRC) requires that multiple MSs within a sector listen and follow the same rate control commands, whereas dedicated rate control (DRC) implies that each MS receives individual rate control commands. Hence, usage of the F-GCH and F-RCCH together or separately enables different MAC operating mechanisms such as scheduling control, common rate control, dedicated rate control, and autonomous control.

Figure 3 depicts exemplary operation of R-PDCH variable rate operation and physical layer channel timing relationships between with four-channel HARQ and single-bit repetition of the rate control command for each 10 ms frame. This timing assumes that the F-GCH has given a multiple grant to the MS across all of the HARQ channels. A, N, and N/A denote terminology on



■ **Figure 2.** *Relation of CPCCH and F-ICCH between Revisions C and D of IS-2000.*



■ **Figure 3.** *Timing diagram for R-PDCH variable rate operation with four-channel HARQ and single-bit repetition of rate control.*

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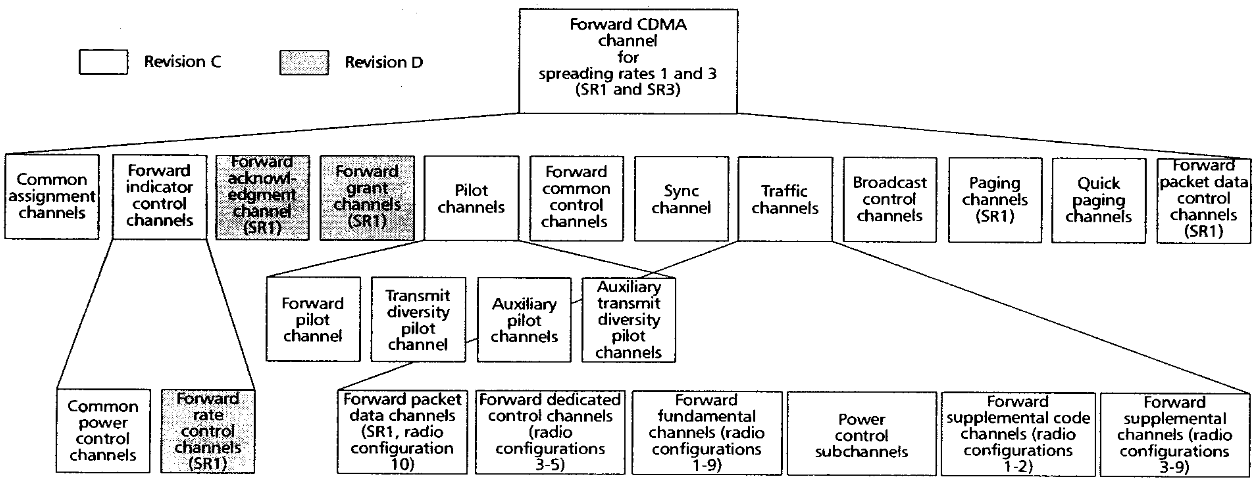
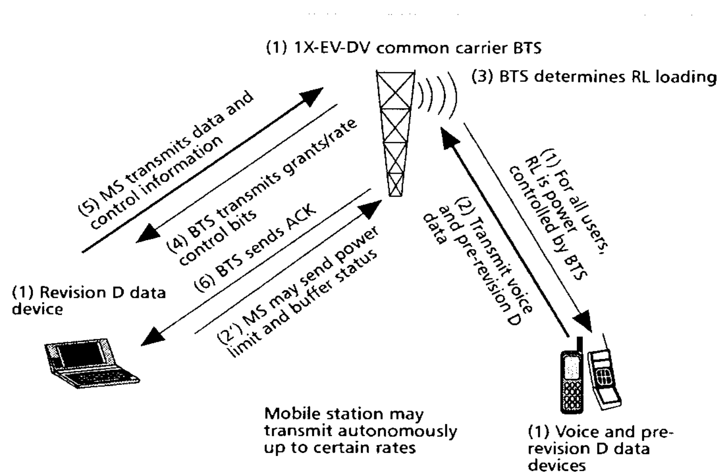


■ **Figure 4.** *IS-2000 forward link physical layer channels.*



■ **Figure 5.** *Conceptual description of 1xEV-DV reverse link operation.*

the F-ACKCH of acknowledge, negative acknowledge, and not applicable, respectively. The timing of the F-RCCH coincides with the timing of the F-ACKCH.

Figure 4 depicts the forward link channels in IS-2000 and highlights the new 1xEV-DV channels that were added.

1xEV-DV Reverse Link Operational Overview

Given the description and purpose of the new reverse and forward link channels, a simplified operational overview of the 1xEV-DV system reverse link is presented, as shown in Fig. 5. Several details are omitted from this example due to space limitations, but it is important to note that conceptually the system operation is straightforward.

First, we assume there are both Revision D and pre-Revision D (legacy) MSs present within a sector, and they are already registered onto the network. Revision D compliant MSs utilize the enhanced high-data-rate reverse link, while the legacy MSs interoperate with the BTS according to the revision of IS-2000 with which they are compliant. Both the legacy and Revision D MSs have their reverse links power controlled by the BTS. The BTS measures the R-PICH of each MS and controls the received signal-to-interference-plus-noise ratio (SINR) of the R-PICH to a target level by sending power control bits to the MS through either the power control subchannel embedded within a dedicated forward link channel to this MS such as the F-FCH, or the F-CPCCH when there is no dedicated forward link channel available. The SINR target level of each MS's R-PICH can be set by the BTS according to its proprietary outer loop power control algorithm. Assuming the network enables the autonomous transmission mode, a Revision D compliant MS may at any time initiate data transmission on the R-PDCH up to a predefined maximum rate with the accompanying R-PDCCH carrying transmission format information. It may also send indications of its power limit and buffer status on the R-REQCH. Upon receipt of the MS's data and control information at the BTS, the BTS determines the loading on the reverse link. The BTS determines whether or not to grant the MS data rates, via the F-GCH, exceeding the maximum autonomous rate based on the reverse link loading, the buffer status, the power limit, and priority of this MS and other MSs competing for resources, and so on. Once the MS receives a grant via the F-GCH, the MS transmits data on the R-PDCH and transmission format information on the R-PDCCH along with periodic R-REQCH updates. The grants via the F-GCH to an MS are sporadic to limit forward link overhead. The MS follows the rate control bits on the F-RCCH in between F-GCH messages addressed to it. The MS may or may not transmit the R-SPICH depending on the reverse link data transmission rate. Meanwhile, the BTS either acknowledges (ACK) or negatively acknowledges (NAK) the MS's data transmissions via the F-ACKCH to assist the reverse link HARQ operation, and the MS responds accordingly by either retransmitting the current packet or starting a new transmission if necessary.

With additional features such as the boost method and the energy reduction method for further tuning and optimization of the illustrated operations, the enhanced 1xEV-DV reverse link system can provide both optimized system throughput and QoS.

SUMMARY

IS-2000 Revision D completes a significant block upgrade to the flagship of code-division multiple access technology, cdma2000. In this articl the essential elements of the high-speed reverse link enhancements made in IS-2000 Revision D were briefly presented and discussed along with a simple operational overview. The 1xEV-DV system is designed to provide real-time circuit-switched services and high-data-rate packet data services in the same RF carrier. 1xEV-DV flexibly incorporates many technologies and features, targeting significantly improved throughput and QoS to enhance data application provisioning and the end user data experience. At the same time, the system is carefully designed to be fully backward-compatible with previous revisions of cdma2000 and does not negatively impact the operations of legacy mobile stations. Due to the capability of 1xEV-DV to support both voice and data services in the same RF carrier, it allows wireless operators to utilize their spectrum more efficiently, and provides a means to dynamically adapt the voice and data load in their systems based on their specific needs.

Currently, the 3GPP2 is investigating new technologies to double the existing voice capacity, increase data throughput and coverage, and reduce end-to-end delay in the air interface as part of the ongoing cdma2000 evolution.

Due to the capability of 1xEV-DV to support both voice and data services in the same RF carrier, it allows the wireless operators to utilize their spectrum more efficiently and provides a means to dynamically adapt the voice and data load in their system based on their specific needs.

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Packet synchronization and identification for incrementalredundancy transmission in FH-CDMA systems

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Abstract
Incremental redundancy transmission is an efficient data communication technique in a frequency hopping coc division multiple access system. However, there are some difficulties in practical implementation of this technique such as synchronization of packets of different sizes and identification between regular and subpackets. This paper describes these problems and suggests practical solutions to avoid the loss of synchronization and decoding ambiguity during transmission of messages

Index Terms
Available to subscribers and IEEE members.

References
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Citing Documents
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PACKET SYNCHRONIZATION AND IDENTIFICATION FOR INCREMENTAL REDUNDANCY TRANSMISSION IN FH-CDMA SYSTEMS*

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ABSTRACT

Incremental redundancy transmission is an efficient data communication technique in a frequency hopping code division multiple access system. However, there are some difficulties in practical implementation of this technique such as synchronization of packets of different sizes and identification between regular and subpackets. This paper describes these problems and suggests practical solutions to avoid the loss of synchronization and decoding ambiguity during transmission of messages.

INTRODUCTION

Recently, it has been shown that incremental redundancy transmission technique (IRT) may be applied to frequency hopping code division multiple access (FH-CDMA) to reduce the interference between simultaneous users as well as to increase the power of forward error correction (FEC) [1]. However, there are two major difficulties to be resolved before the IRT may be realized in practice for wireless CDMA systems. These are: synchronization and identification of packets associated with the IRT.

Unlike the conventional retransmission technique, the IRT uses packets of two or more different sizes which may cause a loss of packet synchronization and an ambiguous decoding of packets. For proper resolution of these problems, we suggest: special packet formats, a transmission technique using the minislot concept [2], and a twofold decoding technique.

In the subsequent sections, the IRT used in the FH-CDMA system will be briefly introduced and the problems and suggested solutions of packet synchronization and identification will be described.

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IRT IN FH-CDMA SYSTEMS

The IRT has been introduced by several authors for communication channels which utilize the receiver memory and FEC codes [3,4,5]. The basic operation of IRT may be described as follows.

Initially, the transmitter sends a packet of information data with minimum amount of redundancy for error detection. If the transmission is successful, the transmitter sends the next packet. However, if it is not successful, the transmitter sends a smaller packet of redundancy to enhance the error correcting capability of the decoder at the receiver. The initial packet is called a regular packet and the smaller one is called a subpacket. The transmitter has a set of subpackets for additional redundancy transmissions in case the decoding fails subsequently. The IRT procedure continues until either the packet is successfully decoded or all subpackets are exhausted, when a higher level protocol will decide the next step to be taken.

The main idea of the IRT is to use only the required amount of redundancy for a successful transmission of given information to maximize the use of available channel resource and to improve channel throughput. Since the IRT is known as an adaptive procedure, it is most effective on a statistically unknown, fluctuating channel for which an estimation of the channel state is imperfect or not available.

The IRT is especially effective when it is applied to the FH-CDMA system [1]. This is the result of a minimization of wasted traffic by utilizing the receiver memory [6] and a reduced contribution to the channel traffic (or the offered load) by backlogged users trying transmission of subpackets upon failure of the initial regular packet. The effect may be clearly visualized by the timing diagrams in Figure 1.

In conventional retransmission systems, all users always transmit regular packets as long as there are packets to send regardless of new or retransmissions. This is illustrated by Figure 1.a. On the other hand, in systems with IRT, the backlogged

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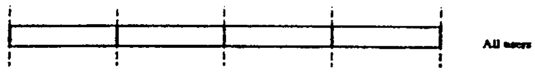
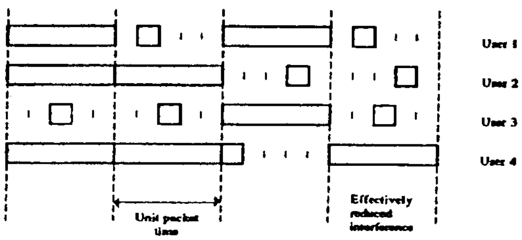


(a) Conventional transmission.



(b) IRT transmissions.

Figure 1. An example pattern of packet transmissions of FH-CDMA systems with the conventional and incremental redundancy transmission (IRT) techniques.

users transmit shorter subpackets one in every unit packet interval which corresponds to the regular packet length, as illustrated by Figure 1.b. The subpackets may be placed at arbitrary time instants within the unit packet interval according to each user's transmission rule. This randomness helps reduce the average channel traffic in effect and, accordingly, the amount of interference between simultaneously transmitting users.

Consider, for example, the last unit time interval in Figure 1. If there are four simultaneous users, the average channel traffic is exactly 4 packets/unit time for the conventional system. But it is only slightly more than 1 packet/unit time for the IRT system because the load by subpackets is almost uniformly distributed over the interval due to the randomness of their positions. As a result, the system throughput has increased and the subscription capacity has been expanded several times that of a conventional retransmission system [1].

Once we have obtained a theoretical result, the next question arises as to how it may be realized for practical applications. In view of the unique transmission rule of IRT, the problems of most concern are the synchronization of receiver circuit to the incoming packets of different sizes and identification between the regular packet and the subpacket. Even though the size of subpackets may vary, we assume that all subpackets are of the same size in the following discussion for convenience.

SYNCHRONIZATION

The synchronization of the receiver clock to the incoming packets may be divided into two parts [7]: the acquisition of the initial signal and the tracking of an accurate timing to maintain the already acquired synchronization for subsequent receptions.

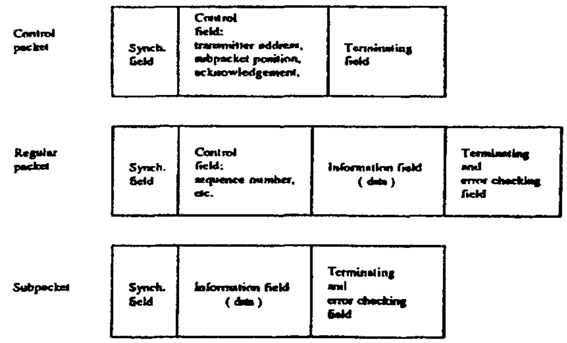
The acquisition of the initial synchronization may be obtained in an ordinary manner, e.g., by using a special synchronization pattern in the header of each packet. However, the tracking has a slight complication because the following packets may be either regular or subpackets. Moreover, the receiver may not expect the exact position of subpackets since the transmitter has a freedom to randomize the position of subpackets.

We suggest, therefore, use of the following packet formats and transmission rule to resolve the above difficulty. In Figure 2.a, three types of packet formats are suggested for use in a system with IRT.

The control packet is used for the initial call set-up before any information may be sent. This packet consists of three fields: synchronization, control, and termination. The synchronization field is used for initial acquisition. The control field contains data which represent the address (or phone number) of the transmitter, the exact position of subpackets within a unit time interval for the current call session, and other information required for proper call set-up like the acknowledgement. The terminating field may contain bits for error protection and unique stop pattern. This packet may be repeatedly sent until a successful communication link is established, when an acknowledgement is sent from receiver to transmitter.

Regular packets are transmitted following a successful call set-up. The regular packet contains synchronization, control, data, and terminating fields. The control field may include a sequence number for an orderly decoding of the regular packets.

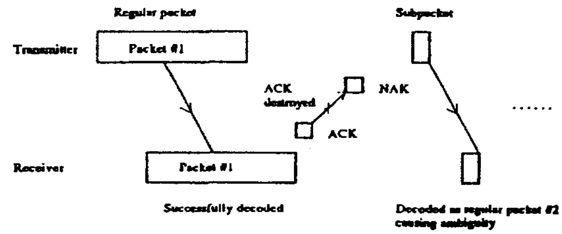
In case of decoding failure, the receiver requests a retransmission and the transmitter will send subpackets. The subpacket consists of synchronization, redundancy data, and terminating fields. Control



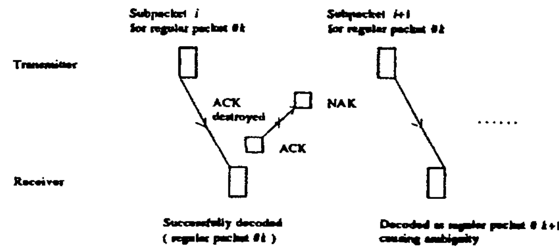
(a) Suggested packet formats.

(b) Minislot technique for packet synchronisation.

Figure 2. Suggested packet formats and minislot concept.



(a) After successful decoding of a regular packet.



(b) After successful decoding of a subpacket.

Figure 3. Two possibilities causing decoding ambiguity in systems using an IRT technique.

bits may be kept minimal since there will be no repetition of a subpacket or acknowledgement for individual subpacket. However, a minimum amount of synchronization bits is required for keeping track of an accurate timing.

The subpacket synchronization may be made more practical by using the minislot concept, which is often used for slot reservation protocol in time division multiple access (TDMA) systems [2]. With the minislot technique, a unit time interval is divided into an integral number of subintervals which may be called minislots. Each minislot is uniquely numbered and a specific one is used throughout the call session for transmission of subpackets. The minislot designation may vary randomly from one session to another and from one user to another to ensure uniform distribution of interference by subpacket transmissions. However, the receiver may expect subpackets at just the right time since the location is known by the control information at the time of call set-up.

An example is shown in Figure 2.b. Here, a regular packet is followed by four subpackets due to initial decoding failure. It may be noted that all four subpackets are placed in the fourth minislot for consistency. The propagation delay is not included in this diagram.

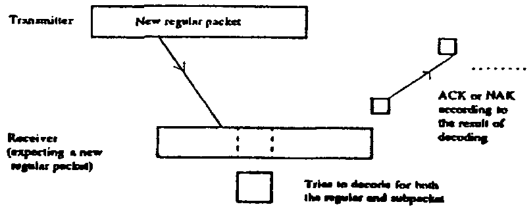
IDENTIFICATION

A proper operation of systems with IRT heavily depends on reliability of the feedback channel delivering acknowledgement signals. As in general automatic repeat request (ARQ) systems, a damaged acknowledgement (ACK) may cause decoding ambiguity as illustrated in Figure 3 where two possibilities are shown.

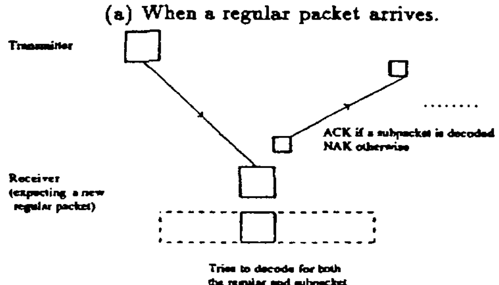
In both cases, the same type of decoding ambiguity arises. That is, a subpacket arrives while the receiver is expecting the next regular packet containing new information. This causes the receiver to consider the subpacket as if it was a regular packet disrupted due to the channel imperfection.

To avoid this confusion, a twofold decoding must be performed whenever receiver expects a new regular packet. This may be illustrated by Figure 4.

Here, the receiver not only tries to decode a regular packet but also tries decoding of a subpacket. This is possible because the receiver can recognize regular and subpackets by their synchronization



(a) When a regular packet arrives.



(b) When an unexpected subpacket arrives.

Figure 4. Twofold decoding technique to avoid decoding ambiguity in systems using an IRT technique.

patterns. An unexpected subpacket also can be more easily recognized because the receiver can predict its exact contents based on the prior correct reception.

If the decoded packet is a regular packet, the receiver continues normal decoding. But if it is a subpacket, which was actually unnecessary, the receiver issues an ACK automatically requesting transmission of a new regular packet.

It is very unlikely that a subpacket will be decoded as a regular packet or vice versa since the synchronization patterns are found at different time instants in the unit interval. Also, if the synchronization pattern of a regular packet is made different from that of a subpacket, the receiver can decode packets almost without ambiguity.

There also exists a possibility of a NAK turning into an ACK which may cause decoding difficulties. However, it is known that the probability of this event is negligible in a practical situation where unique ACK patterns are used. Thus we may omit this from our consideration.

CONCLUSION

The problem of packet synchronization and identification is discussed and possible resolutions are suggested in implementing the incremental redundancy transmission technique in FH-CDMA systems. Special packet formats, a subpacket positioning technique, and a twofold decoding technique are introduced for proper synchronization and unambiguous decoding of packets. These may be realized at a slightly added complexity of the receiver circuit.

REFERENCES

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Electronic Acknowledgement Receipt

EFS ID:	4492332
Application Number:	12159841
International Application Number:	
Confirmation Number:	3203
Title of Invention:	METHOD OF TRANSMITTING/RECEIVING A PAGING MESSAGE IN A WIRELESS COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Young Dae Lee
Customer Number:	35884
Filer:	Puya Partow-Navid/Adrian Lee
Filer Authorized By:	Puya Partow-Navid
Attorney Docket Number:	2101-3515
Receipt Date:	19-DEC-2008
Filing Date:	
Time Stamp:	14:26:07
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Filed (SB/08)	IDS-1.pdf	607995 1910b4816e8e440be07813b4ea966c1f3df324b5	no	4

Warnings:

Information:

A U.S. Patent Number Citation or a U.S. Publication Number Citation is required in the Information Disclosure Statement (IDS) form for autoloading of data into USPTO systems. You may remove the form to add the required data in order to correct the Informational Message if you are citing U.S. References. If you chose not to include U.S. References, the image of the form will be processed and be made available within the Image File Wrapper (IFW) system. However, no data will be extracted from this form. Any additional data such as Foreign Patent Documents or Non Patent Literature will be manually reviewed and keyed into USPTO systems.

2	Foreign Reference	Ref-1.pdf	7588382 08afe715d52f8e1fe421892cf1a514e43de6b551	no	146

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Total Files Size (in bytes):	8196377

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New Applications Under 35 U.S.C. 111
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National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Customer No. 035884

PATENT DOCKET NO. 2101-3515

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:
Young Dae LEE et al.

Serial No.: 12/159,841
Filed: July 1 ,2008
For: METHOD OF TRANSMITTING/RECEIVING A PAGING MESSAGE IN A WIRELESS COMMUNICATION SYSTEM

Art Unit: 2617
Examiner: Not Yet Assigned
Confirmation No. 3203

TRANSMITTAL OF MISSING PARTS

Mail Stop Missing Parts
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Filed herewith is a signed Declaration and Power of Attorney for the above-identified application per the Patent Office "Notification of Missing Requirements Under 35 U.S.C. 371" dated August 22, 2008.

The Commissioner is hereby authorized to charge the fee of $130 for the late declaration surcharge as set forth in 37 CFR 1.16(e) of a non-small entity and any deficiency fees associated with this communication or credit any overpayment to Deposit Account No. 502290.

Respectfully submitted,

LEE, HONG, DEGERMAN, KANG & WAIMEY

Date: October 22, 2008

By: [signature]
Harry S. Lee
Registration No. 56,814

Customer No. 035884

ATTORNEY'S DOCKET NO. 2101-3515

DECLARATION
and POWER OF ATTORNEY

☒ ORIGINAL
☐ CONTINUATION-IN-PART
☐ DIVISIONAL

As a below named inventor, I declare that the information given herein is true, that I believe that I am the original, first and sole inventor (if only one name is listed as 1 below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD OF TRANSMITTING/RECEIVING A PAGING MESSAGE IN A WIRELESS COMMUNICATION SYSTEM

the specification of which is attached hereto unless the following box is checked:

☒ was filed on July 1, 2008 as United States Application Number 12/159,841 .

My residence, post office address and citizenship are as stated below next to my name. I acknowledge my duty to disclose information, which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations § 1.56(a). I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I hereby claim foreign priority benefits under Title 35, United States Code, § 119 OR 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate, or any PCT international application having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

COUNTRY	APPLICATION NUMBER	DATE OF FILING Month Day Year	PRIORITY CLAIMED UNDER 35 U.S.C. 119
KOREA	10-2007-0000936	January 4, 2007	YES
PCT	PCT/KR2007/000078	January 5, 2007	YES

I hereby claim the benefit under Title 35, United States Code, §119 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

60/757,063	January 5, 2006	Provisional
60/783,250	March 16, 2006	Provisional
60/784,680	March 21, 2006	Provisional
60/797,402	May 2, 2006	Provisional
(Application Serial No.)	(Filing Date)	(Status)

POWER OF ATTORNEY: As a named Inventor, I hereby appoint the following attorney(s) and/or Agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

THE ATTORNEYS ASSOCIATED WITH CUSTOMER NO. 035884

SEND CORRESPONDENCE TO:	Jonathan Y. Kang, Esq. **LEE, HONG, DEGERMAN, KANG & SCHMADEKA** At the address associated with **Customer No. 35884**	TELEPHONE NO.: FAX NO.:	(213) 623-2221 (213) 623-2211/8601

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I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 1 [signature]	**SIGNATURE OF INVENTOR 2** [signature]
DATE 15/07/2008	**DATE** 15/07/2008
SIGNATURE OF INVENTOR 3 [signature]	**SIGNATURE OF INVENTOR 4** [signature]
DATE 15/07/2008	**DATE** 15/07/2008

Electronic Patent Application Fee Transmittal

Application Number:	12159841
Filing Date:	
Title of Invention:	METHOD OF TRANSMITTING/RECEIVING A PAGING MESSAGE IN A WIRELESS COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Young Dae Lee
Filer:	Harry Sung Lee/Joan Ramirez
Attorney Docket Number:	2101-3515

Filed as Large Entity

U.S. National Stage under 35 USC 371 Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Oath/decl > 30 months from priority date	1617	1	130	130
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
		Total in USD ($)		**130**

Electronic Acknowledgement Receipt

EFS ID:	4160857
Application Number:	12159841
International Application Number:	
Confirmation Number:	3203
Title of Invention:	METHOD OF TRANSMITTING/RECEIVING A PAGING MESSAGE IN A WIRELESS COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Young Dae Lee
Customer Number:	35884
Filer:	Harry Sung Lee/Joan Ramirez
Filer Authorized By:	Harry Sung Lee
Attorney Docket Number:	2101-3515
Receipt Date:	22-OCT-2008
Filing Date:	
Time Stamp:	19:31:54
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$130
RAM confirmation Number	4006
Deposit Account	502290
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. 1.492 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		2101_3515_Transmit_Missing_Parts_Dec_Power.pdf	283418 7ecc834db3e2286d42c2734ea982cd7256232f09	yes	3

Multipart Description/PDF files in .zip description

Document Description	Start	End
Miscellaneous Incoming Letter	1	1
Oath or Declaration filed	2	3

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2	Fee Worksheet (PTO-06)	fee-info.pdf	30458 26d1358bd9bc6cdd43a4f631d9af1340a0a18f26	no	2

Warnings:

Information:

Total Files Size (in bytes):	313876

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New Applications Under 35 U.S.C. 111
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National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

DO/ EO WORKSHEET

ANITA JOHNSON, Patent Application Specialist/ National Stage Division

U.S. Appl. No. 12 - 159,841 International Appl. No. PCT/ KR2007/000078

Application filed by : ☐ 20 months ☑ 30 months

WIPO PUBLICATION INFORMATION :

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Publication Date : 12 Jul 2007

Not Published : ☐ U.S. only designated ☐ EP request

Published : ☐ EP request

INTERNATIONAL APPLICATION PAPERS IN THE APPLICATION FILE :

☒ International Application *(RECORD COPY)*

☐ Article 19 Amendments

☐ PCT/IPEA/409 IPER : ☐ EP ☐ JP ☐ SE ☐ AU ☐ US ☐ FR ☐ CN ☐ ES ☐ RU ☐ AT ☐ KR ☐ ___

☐ Annexes to 409

☐ PCT/ISA/237 : ☐ EP ☐ JP ☐ SE ☐ AU ☐ US ☐ FR ☐ CN ☐ ES ☐ RU ☐ AT ☐ KR ☐ ___

☐ PCT/IPEA/409 or PCT/ISA/237 was NOT AVAILABLE at the time of paralegal review

☐ PCT/IB/306

☐ Request form PCT/RO/101

☐ PCT/ISA/210 - Search Report : ☐ EP ☐ JP ☐ SE ☐ AU ☐ US ☐ FR ☐ CN ☐ ES ☐ RU ☐ AT ☐ KR ☐ ___ ☐ NONE

☐ Search Report References

☒ Priority Document (s) No. 5

☐ N/A

☐ Priority Document was NOT AVAILABLE at the time of paralegal review

☐ Other : ____________

RECEIPTS FROM THE APPLICANT *(other than checked above)* :

☒ Basic National Fee *(or authorization to charge)*

☒ Description ☒ Claims ☒ Abstract

☒ Drawing Figure(s) - (# of drwgs. 8)

☐ Translation of Article 19 Amendments

☐ entered ☐ not entered :

☐ not a page for page substitution

☐ replaced by Article 34 Amendment

☐ Annexes to 409

☐ entered ☐ not entered :

☐ not a page for page substitution

☐ no translation ☐ other : ________

☐ Application Data Sheet

☐ Power of Attorney

☐ Change of Address

☐ Preliminary Amendment(s) Filed on :

1. ☐ same as 371 request date 2. ________ 3. ________

☐ Information Disclosure Statement(s) Filed on :

1. ☐ same as 371 request date 2. ________ 3. ________

☐ Assignment Document (forwarded to Assignment Branch)

☐ Assignee Statement Under 37 CFR 3.73(b)

☐ Assignee PG Publication Notice

☐ Substitute Specification Filed on :

1. ☐ same as 371 request date 2. ________ 3. ________

☐ Verified Small Status Statement

☐ Oath/ Declaration (executed)

☐ Oath/ Declaration ☐ unsigned ☐ no citizenship ☐ other

☐ DNA Diskette ☐ Sequence Listing

☐ Other : ____________

NOTES : ☐ I.A. used as Specification ☐ Other :

35 U.S.C. 371 - Receipt of Request (PTO-1390)	mo. 7 / day / / yr. 2008
Date Acceptable Oath/ Declaration Received	☐ Same as 371 Req. Date; ☐ mo. / day / yr. 200
Date of Completion of requirements under 35 U.S.C. 371	☐ Same as 371 Req. Date; ☐ Same as OATH Date; ☐ mo. / day / yr. 200
Date of Completion of DO/ EO 903 - Notification of Acceptance	
Date of Completion of DO/ EO 905 - Notification of Missing Requirements	
Date of Completion of DO/ EO 909 - Notification of Abandonment	
Date of Completion of DO/ EO 916 - Notification of Defective Response	
Date of Completion of DO/ EO 922 - Notification to Comply w/ Requirements for Patent Applications Containing Nucleotide and/or Amino Acid Sequence Disclosures	
Date of Completion of DO/ EO 923	

4

MULTIPLE DEPENDENT CLAIM FEE CALCULATION SHEET (FOR USE WITH FORM PTO-875)	SERIAL NO. 12-159,841	FILING DATE
	APPLICANT(S)	

CLAIMS

	AS FILED		AFTER 1st AMENDMENT		AFTER 2nd AMENDMENT	
	IND.	DEP.	IND.	DEP.	IND.	DEP.
1	1					
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TOTAL IND.	3	↓		↓		↓
TOTAL DEP.	12 ←		←		←	
TOTAL CLAIMS	15					

	AS FILED		AFTER 1st AMENDMENT		AFTER 2nd AMENDMENT	
	IND.	DEP.	IND.	DEP.	IND.	DEP.
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TOTAL CLAIMS						

PTO-1360 (REV. 11/04)

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PATENT APPLICATION FEE DETERMINATION RECORD

Effective December 8, 2004

Application or Docket Number: 12-159,841

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)	SMALL ENTITY TYPE RATE	FEE	OR	OTHER THAN SMALL ENTITY RATE	FEE
S. NATIONAL STAGE FEES							
SIC FEE	SMALL ENT. = $ 150	LARGE ENT. = $ 300	BASIC FEE		OR	BASIC FEE	310
AMINATION FEE	Satisfies PCT Article 33(1)-(4) = $ 50 / $ 100	All other situations = $ 100 / $ 200	EXAM. FEE			EXAM. FEE	210
ARCH FEE	U.S. is ISA = $ 50 / $ 100 ALL other countries = $ 200 / $ 400	ALL other situations = $ 250 / $ 500	SEARCH FEE			SEARCH FEE	510
E FOR EXTRA SPEC. PGS.	minus 100 =	/ 50 =	X $ 125 =			X $ 250 =	
TAL CHARGEABLE CLAIMS	15 minus 20 =	*	X $ 25 =		OR	X $ 50 =	
EPENDENT CLAIMS	3 minus 3 =	*	X $ 100 =		OR	X $ 200 =	
TIPLE DEPENDENT CLAIM PRESENT		☒	+ $ 180 =		OR	+ ~~$ 360~~ =	370
			TOTAL		OR	TOTAL	1400

the difference in column 1 is less than zero, enter "0" in column 2

CLAIMS AS AMENDED - PART II

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
Total	*	Minus	**	=	X $ 25 =		OR	X $ 50 =	
Independent	*	Minus	***	=	X $ 100 =		OR	X $ 200 =	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐	+ $ 180 =		OR	+ $ 360 =	
					TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE	ADDITIONAL FEE	OR	RATE	ADDITIONAL FEE
Total	*	Minus	**	=	X $ 25 =		OR	X $ 50 =	
Independent	*	Minus	***	=	X $ 100 =		OR	X $ 200 =	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐	+ $ 180 =		OR	+ $ 360 =	
					TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
If the "Highest Number Previously Paid For" IN THIS SPACE is less than '20', enter "20".
If the "Highest Number Previously Paid For" IN THIS SPACE is less than '3', enter "3".
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U.S. APPLICATION NUMBER NO.	FIRST NAMED APPLICANT	ATTY. DOCKET NO.
12/159,841	Young Dae Lee	2101-3515

35884
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INTERNATIONAL APPLICATION NO.	
PCT/KR2007/000078	
I.A. FILING DATE	PRIORITY DATE
01/05/2007	01/05/2006

CONFIRMATION NO. 3203
371 FORMALITIES LETTER

OC000000031715332

Date Mailed: 08/22/2008

NOTIFICATION OF MISSING REQUIREMENTS UNDER 35 U.S.C. 371 IN THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)

The following items have been submitted by the applicant or the IB to the United States Patent and Trademark Office as an Elected Office (37 CFR 1.495):

- Priority Document
- Copy of the International Application filed on 07/01/2008
- Copy of the International Search Report filed on 07/01/2008
- U.S. Basic National Fees filed on 07/01/2008
- Priority Documents filed on 07/01/2008

The applicant needs to satisfy supplemental fees problems indicated below.

The following items **MUST** be furnished within the period set forth below in order to complete the requirements for acceptance under 35 U.S.C. 371:

- Oath or declaration of the inventors, in compliance with 37 CFR 1.497(a) and (b), identifying the application by the International application number and international filing date.
- To avoid abandonment, a surcharge (for late submission of filing fee, search fee, examination fee or oath or declaration) as set forth in 37 CFR 1.492(h) of $130 for a non-small entity, must be submitted with the missing items identified in this letter.

SUMMARY OF FEES DUE:

Total additional fees required for this application is $**130** for a Large Entity:

- $**130** Surcharge.

ALL OF THE ITEMS SET FORTH ABOVE MUST BE SUBMITTED WITHIN TWO (2) MONTHS FROM THE DATE OF THIS NOTICE OR BY 32 MONTHS FROM THE PRIORITY DATE FOR THE APPLICATION, WHICHEVER IS LATER. FAILURE TO PROPERLY RESPOND WILL RESULT IN ABANDONMENT.

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Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

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TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371		ATTORNEY'S DOCKET NUMBER 2101-3515 U.S. APPLICATION NO. (If known, see 37 CFR 1.5)
INTERNATIONAL APPLICATION NO. PCT/KR2007/000078	INTERNATIONAL FILING DATE 5 January 2007	PRIORITY DATE CLAIMED 5 January 2006
TITLE OF INVENTION METHOD OF TRANSMITTING/RECEIVING A PAGING MESSAGE IN A WIRELESS COMMUNICATION SYSTEM		
APPLICANT(S) FOR DO/EO/US Young Dae LEE, Sung Duck CHUN, Myung Cheul JUNG and Sung Jun PARK		

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☑ This is a **FIRST** submission of items concerning a submission under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a submission under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☑ The US has been elected (Article 31).
5. ☑ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☑ is attached hereto (required only if not communicated by the International Bureau).
   b. ☐ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☑ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☑ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☐ A preliminary amendment.
14. ☐ An Application Data Sheet under 37 CFR 1.76.
15. ☐ A substitute specification.
16. ☐ A power of attorney and/or change of address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.2 and 37 CFR 1.821- 1.825.
18. ☐ A second copy of the published International Application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
	PCT/KR2007/000078	2101-3515

20. Other items or information:

The following fees have been submitted	CALCULATIONS	PTO USE ONLY
21. ☑ Basic national fee (37 CFR 1.492(a)) **$310**	$ 310	
22. ☑ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) .... **$0** All other situations **$210**	$ 210	
23. ☑ Search fee (37 CFR 1.492(b)) If the written opinion of the ISA/US or the International preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) .... **$0** Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority .... **$100** International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB .... **$410** All other situations **$510**	$ 510	
TOTAL OF 21, 22 and 23 =	1,030	

☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)).
The fee is **$260** for each additional 50 sheets of paper or fraction thereof.

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- 100 =	/50 =		x $260	$

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CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total claims	15 - 20 =	0	x **$ 50**	$ 0	
Independent claims	3 - 3 =	0	x **$210**	$ 0	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$370**	$ 370	
TOTAL OF ABOVE CALCULATIONS =				$ 1,400	
☐ Applicant claims small entity status. See 37 CFR 1.27. Fees above are reduced by ½.					
SUBTOTAL =				$ 1,400	
Processing fee of **$130.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i)). +				$	
TOTAL NATIONAL FEE =				$ 1,400	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	
TOTAL FEES ENCLOSED =				$ 1,400	
				Amount to be refunded:	$
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a. ☐ A check in the amount of $ ____________ to cover the above fees is enclosed.

b. ☑ Please charge my Deposit Account No. 502290 in the amount of $ 1,400 to cover the above fees. A duplicate copy of this sheet is enclosed.

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NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

SEND ALL CORRESPONDENCE TO:

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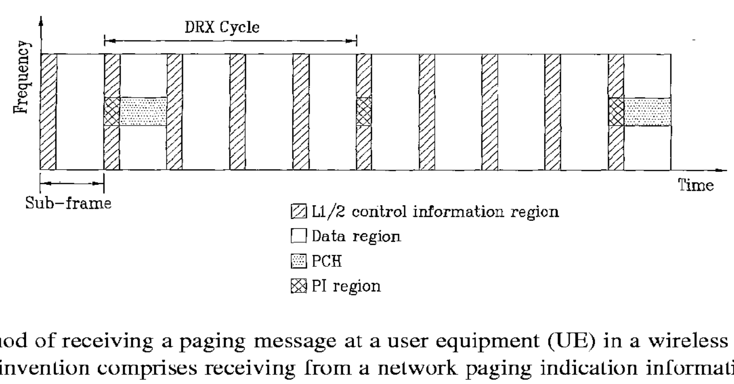
(54) Title: METHOD OF TRANSMITTING/RECEIVING A PAGING MESSAGE IN A WIRELESS COMMUNICATION SYSTEM



(57) Abstract: A method of receiving a paging message at a user equipment (UE) in a wireless communication system in accordance with the present invention comprises receiving from a network paging indication information including a UE identification information and scheduling information for a paging channel (PCH) on which a paging message is transmitted, the scheduling information including allocation information of a time-frequency region through which the paging message is transmitted, obtaining the paging indication information when the UE identification information is identical to an identity of the UE, and receiving from the network the paging message through the time-frequency region indicated by the paging indication information.

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METHOD OF TRANSMITTING/RECEIVING A PAGING MESSAGE IN A WIRELESS COMMUNICATION SYSTEM

[DESCRIPTION]

TECHNICAL FIELD

The present invention relates to a wireless communication system, more particularly, to a method of transmitting/receiving a paging message in a wireless communication system.

BACKGROUND ART

A paging procedure in a mobile communication system is needed when a network calls a user equipment (UE) or a plurality of UEs. Paging Type 1 and Paging Type 2 messages are used in the Universal Mobile Telecommunications System (UMTS).

The Paging Type 1 message is used when a UE is an idle mode, a Cell_PCH or a URA_PCH. A core network (CN) calls a UE in an idle mode for establishing a signaling connection or requesting an establishment of a call or session with the UE. A UE in a Cell_PCH or URA_PCH can be paged to execute a cell update or URA (UTRAN Registration Area) update procedure. In addition, the Paging Type 1 message can be used for the UTRAN to request a UE to read updated system information. All UEs in a cell are paged since the updated system information is important for the all UEs. A UE identity is included in a paging message for identifying a UE, which is high level UE identity such as an IMSI (International Mobile Subscriber Identity), TMSI (Temporary Mobile Subscriber Identity) or P-TMSI (Packet Temporary Mobile Subscriber Identity) for a UE in an idle state and which is a U-RNTI (UTRAN Radio Network Temporary Identifier) for a UE in a connected mode.

The Paging Type 2 message is used when a UE in the Cell_DCH or Cell FACH is additionally paged via a pre-established RRC connection. A dedicated paging for a specific UE is possible because the pre-established RRC connectin is used.

The paging message is paired with paging indication (PI) to be transmitted on a transport channel PCH (paging channel). When a UE is paged, the UTRAN transmits the paging indication to the UE on a paging indication channel (PICH) to inform the UE that a paging message will be transmitted. The UE may receive the paging message on the PCH when a pre-determined period is elapsed after receiving the paging indication.

In the related art, radio resources for transmitting the paging message are fixed. For example, the paging indication is transmitted on a PICH having a spreading factor (SF) of 256 and the PCH including a paging message is transmitted on a S-CCPCH in the UMTS. When the paging message is transmitted through the fixed radio resources, the network cannot have flexibility for scheduling of data transmission so that it becomes hard to be applicable to the change of radio environment. Further, when a UE located in a cell boundary is paged, a paging procedure is not able to be smoothly performed since reception errors increases as a distance between the UE and an eNB is getting larger.

DISCLOSURE OF INVENTION

Accordingly, the present invention is directed to a method of transmitting/receiving a paging message in a wireless communication system that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide to a method of transmitting/receiving a paging message, in which a paging message is dynamically allocated on a radio resource based on paging indication and the same paging message transmitted from multiple cells is combined by a UE so that the scheduler can have more flexibility of scheduling and the paging message can be more correctly received near a cell edge.

Additional features and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, the present invention is embodied in a method of receiving a paging message at a user equipment (UE) in a wireless communication system, the method comprising receiving from a network paging indication information including a UE identification information and scheduling information for a paging channel (PCH) on which a paging message is transmitted, the scheduling information including allocation information of a time-frequency region through which the paging message is transmitted, obtaining the paging indication information when the UE identification information is identical to an identity of the UE, and receiving from the network the paging message through the time-frequency region indicated by the paging indication information.

In accordance with another embodiment of the present invention, a method of transmitting a paging message to a user equipment (UE) in a wireless communication system, the method comprising transmitting to the UE paging indication information including a UE identification information and scheduling information for a paging channel (PCH) on which a paging message is transmitted, the scheduling information including allocation information of a time-frequency region through which the paging message is transmitted, and transmitting the paging message through the time-frequency region indicated by the paging indication information.

In accordance with another embodiment of the present invention, a method of receiving a paging message at a user equipment (UE) in a wireless communication system, the method comprising, receiving from a network paging indication information including a UE identification information and scheduling information for a paging channel (PCH) on which a paging message is transmitted, obtaining the paging indication information when the UE identification information is identical to an identity of the UE, and receiving a paging message using the paging indication information by combining a plurality of paging channels from a plurality of cells.

In accordance with another embodiment of the present invention, a method of receiving at least one paging message on a paging channel, the method comprising receiving paging indication on L1/L2 control signaling, checking whether there is a short identity corresponding to a user equipment (UE) in the paging indication, and receiving a paging message having a long identity on a radio resource indicated by the paging indication in case that there is the sort identity.

BRIEF DESCRIPTION OF DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

In the drawings:

FIG. 1 is a block diagram of a network structure of E-UMTS (evolved universal mobile telecommunications system);

FIG. 2 is a schematic diagram illustrating a protocol architecture of an E-UTRAN.

FIG. 3A and 3B are architectural diagrams of a control plane and a user plane, respectively of a radio interface protocol between UE (user equipment) and UTRAN (UMTS terrestrial radio access network) based on the 3GPP radio access network standard;

FIG. 4 is a diagram illustrating a structure of physical channels in the E-UMTS;

FIG. 5 is a diagram illustrating sub-frames in accordance with a preferred embodiment of the present invention;

FIG. 6A and 6B are diagrams for illustrating another preferred embodiments of the present invention; and

FIG. 7A and FIG. 7B are diagrams illustrating another preferred embodiments of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

FIG. 1 is a block diagram of a network structure of an E-UMTS (Evolved-Universal Mobile Telecommunications System) to which technical features of the present invention are applied. An E-UMTS is a system evolving from the conventional UMTS and its basic standardization is currently handled by the 3GPP (3rd Generation Partnership Project). The E-UMTS can also be called an LTE (Long Term Evolution) system.

Referring to FIG. 1, an E-UMTS network includes a user equipment (hereinafter abbreviated 'UE'), a base station (hereinafter named 'eNode B' or 'eNB') and an access gateway (hereinafter abbreviated 'aGW') connected to an external network by being located at an end of the E-UMTS network. The aGW may be classified into a part for handling user traffic and a part for handling control traffic. A first aGW for processing new user traffic may communicate with a second AG for processing control traffic via a new interface. A eNode-B may include at least one cell. A first interface for transmitting user traffic or a second interface for transmitting control traffic may be located between several eNode-Bs. The CN may include the aGW and a plurality of nodes for registering users of User Equipments (UEs). If required, another interface for discriminating between the E-UTRAN and the CN may also be used for the LTE network. The aGW manages mobility of a UE by unit of a tracking area (TA). A TA comprises a plurality of cells. When a UE moves into a TA from another TA, the UE informs the aGW of the change of the TAs. The eNode B includes at least one cell.

FIG. 2 is a schematic diagram illustrating protocol architecture of an E-UTRAN. In FIG. 2, the hatching part represents functional entities of a control plane and the non-hatching part represents functional entities of a user plane.

Layers of a radio interface protocol between a UE and a network can be classified into a first layer L1, a second layer L2 and a third layer L3 based on three lower layers of OSI (open system interconnection) reference model widely known in communication systems. A physical layer belonging to the first layer L1 provides an information transfer service using a physical channel. A radio resource control (hereinafter abbreviated 'RRC') located at the third layer plays a role in controlling radio resources between the UE and the network. For this, the RRC layer enables RRC messages to be exchanged between the UE and the network. The RRC layer can be distributively located at network nodes including an eNode B, an AG and the like or at either the Node B or the AG.

FIG. 3A and 3B are architectural diagrams of a control plane and a user plane, respectively of a radio interface protocol between UE (user equipment) and UTRAN (UMTS terrestrial radio access network) based on the 3GPP radio access network standard. Referring to FIG. 3A, a radio interface protocol vertically includes a physical layer, a data link layer, and a network layer and horizontally includes a user plane for data information transfer and a control plane for signaling transfer. The protocol layers in FIG. 3A can be classified into L1 (first layer), L2 (second layer), and L3 (third layer) based on three lower layers of the open system interconnection (OSI) standard model widely known in the communications systems.

The respective layers of a radio protocol control plane shown in FIG. 3A and a radio protocol user plane shown in FIG. 3B are explained as follows.

First of all, the physical layer as the first layer provides information transfer service to an upper layer using physical channels. The physical layer (PHY) is connected to a medium access control (hereinafter abbreviated 'MAC') layer above the physical layer via transport channels. Data are transferred between the medium access control layer and the physical layer via the transport channels. Moreover, data is transferred between different physical layers, and more particularly, between one physical layer of a transmitting side and the other physical layer of a receiving side via the physical channels. A downlink physical channel of the E-UMTS is modulated according to an orthogonal frequency division multiplexing (OFDM) scheme and time and frequency are used as radio resources.

The medium access control (hereinafter abbreviated 'MAC') layer of the second layer provides a service to a radio link control (hereinafter abbreviated RLC) layer above the MAC layer via logical channels. The RLC layer of the second layer supports reliable data transfer. In order to effectively transmit IP packets (e.g., IPv4 or IPv6) within a radio-communication period having a narrow bandwidth, a PDCP layer of the second layer (L2) performs header compression to reduce the size of a relatively-large IP packet header containing unnecessary control information.

A radio resource control (hereinafter abbreviated 'RRC') layer located on a lowest part of the third layer is defined in the control plane only and is associated with configuration, reconfiguration and release of radio bearers (hereinafter abbreviated 'RBs') to be in charge of controlling the logical, transport and physical channels. In this case, the RB means a service provided by the second layer for the data transfer between the UE and the UTRAN.

As a downlink transport channel carrying data to UEs from the network, there is a broadcast channel (BCH) carrying system information and a downlink shared channel (SCH) carrying user traffic or control messages. The traffic or control messages of a downlink multicast or broadcast service can be transmitted via the downlink SCH or an additional downlink multicast channel (MCH). Meanwhile, as an uplink transport channel carrying data to the network from UEs, there is a random access channel (RACH) carrying an initial control message and a uplink shared channel (UL-SCH) carrying user traffic or control message.

In the E-UMTS system, an OFDM is used on the downlink and a single carrier frequency division multiple access (SC-FDMA) on the uplink. The OFDM scheme using multiple carriers allocates resources by unit of multiple subcarriers including a group of carriers and utilizes an orthogonal frequency division multiple access (OFDMA) as an access scheme.

A physical layer of an OFDM or OFDMA scheme divides active carriers into a plurality of groups and transmits each group to a different receiving side. Radio resource allocated to each UE which is defined as a time-frequency region on a two-dimensional sphere comprises continuous subcarriers on a frequency axis and symbols on a time axis. A time-frequency region in the OFDM or OFDMA scheme is a rectangular form sectioned by time and frequency coordinates. One or more time-frequency region can be allocated to an uplink for a UE and an eNB can transmit one or more time-frequency region to a UE. In order to define a time-frequency region on the two-dimensional sphere, the number of OFDM symbols and subcarriers starting from a point having an offset from a reference point should be given.

The E-UMTS uses 10 ms radio frame comprising 20 sub-frames. Namely, a sub-frame is 0.5 ms length. A resource block comprises one sub-frame and twelve subcarriers, each of which is 15 kHz. One sub-frame comprises a plurality of OFDM symbols and a part of the plurality of OFDM symbols can be used for L1/2 control information.

FIG. 4 is a diagram illustrating a structure of physical channels in the E-UMTS. In FIG. 4, a sub-frame comprises a L1/2 control information transmission region (the hatching part) and a data transmission region (the non-hatching part).

FIG. 5 is a diagram illustrating sub-frames in accordance with a preferred embodiment of the present invention.

Referring to FIG. 5, a discontinuous reception (DRX) scheme is applied to a UE in an idle mode or an RRC connection state. The UE wakes up at a paging occasion which is pre-defined by system information from an E-UTRAN within a DRX cycle and monitors whether a paging message is transmitted to the UE. In FIG. 5, one DRX cycle comprises five sub-frames and the paging occasion for the UE starts at the first sub-frame. The UE receives a L1/2 control information transmission region and checks whether paging indication information for the UE is transmitted.

The paging indication information includes UE identification information and information associated with radio resource, i.e. a time-frequency region through which a paging message is transmitted. When realizing that the UE identification information in the paging indication information is identical to the UE identity of the UE, the UE receives the paging message on a paging channel (PCH) of the time-frequency region indicated by the paging indication information.

A paging procedure of a UE in an idle mode and a DRX procedure of a UE in an RRC connection mode should be distinguished. Table 1 describes the differences between the paging procedure and the DRX procedure.

[Table 1]

	Paging procedure	DRX procedure
RRC mode	Idle mode	Connected mode
Controlling network node	aGW: paging initiation eNB: paging transmission	eNB
Signalled Area	A TA (Tracking Area)	A cell
UE identity	A long identity (e.g. IMSI, TMSI) allocated by NAS	A short identity (ex. C-RNTI) allocated by AS in eNB

The paging procedure is initiated by an aGW for finding a cell location of a UE within a tracking area (TA) and for managing battery consumption efficiently. The paging procedure is applied to a UE in an idle mode. Since the UE in the idle mode has no short UE identity allocated by a cell, a long UE identity like IMSI or TMSI, etc is included in the paging message.

The DRX procedure is performed by an eNB for a RRC connected UE in order to save a battery of the UE. The DRX procedure can be applied when uplink and downlink traffic is temporarily inactive. Since the RRC connected UE has a short UE identity like C-RNTI(Cell Radio Network Temporary Identifier) allocate by a cell, the eNB enables the RRC connected UE to wake up by including the short UE identity in L1/2 control information.

In case of the DRX procedure, a short UE identity having a length equal to or smaller than 16 bits can be easily included in an L1/2 control channel. On the other hand, a paging message having a long UE identity is not able to be included in the L1/2 control channel. Paging indication information in which the short UE identity is included can be included in the L1/2 control information or a paging indication channel (PICH).

In one preferred embodiment of the present invention, a UE in the idle mode monitors a paging channel (PCH) using a long UE identity. An RRC connected UE monitors L1/2 control information using a short UE identity within a DRX cycle. If the RRC connected UE in the DRX mode is scheduled, an eNB will insert the short UE identity of the UE into L1/2 control information including scheduling information with a pre-defined cycle. If an RRC connected UE in the DRX mode is not scheduled, the eNB will not insert the short UE identity of the UE into the L1/2 control information.

In one preferred embodiment of the present invention, an eNB schedules a paging channel (PCH) as well as a downlink shared channel (DL SCH) at a UE specific paging occasion within every paging DRX cycle. Paging indication information informs the UE of whether a paging message for the UE is scheduled within the paging occasion. The paging indication information includes information associated with time-frequency region allocated for the paging message like SCH scheduling.

The paging indication information may be transmitted by a frequency hopping scheme for frequency diversity. For example, the paging indication information can be transmitted on different sub-carriers in different time interval i.e. different paging occasions. Hopping information i.e. how the paging indication is transmitted on different sub-carriers in different paging occasions is included in system information in a cell to be transmitted.

In one preferred embodiment of the present invention, the paging indication information for a UE in the idle mode and a UE in the RRC connection mode can be included in the L1/2 control channel to be transmitted using a short UE identity. In this case, the UEs monitor the L1/2 channel notwithstanding the state of the UEs.

FIG. 6A and 6B are diagrams for illustrating another preferred embodiments of the present invention. A paging message is transmitted on a paging channel (PCH) in one sub-frame without transmitting paging indication information in the embodiments of FIG. 6A and 6B. In FIG. 6A, the paging message is transmitted through a data transmission region without the paging indication information on which L1/2 control information is not transmitted. A UE obtains information on a time-frequency region through which the paging channel (PCH) is transmitted and then receives the paging message on the paging channel (PCH) using the time-frequency information.

In FIG. 6B, the paging message (PCH) is transmitted the L1/2 control information transmission region without the paging indication information. A UE also obtains information on a time-frequency region through which the paging channel (PCH) is transmitted and then receives the paging message on the paging channel (PCH) using the time-frequency information.

FIG. 7A and FIG. 7B are diagrams illustrating another preferred embodiments of the present invention. A UE located at a cell boundary area can use a combining scheme for optimizing reception of a paging message and/or paging indication information, since an identical paging message and/or paging indication information is transmitted to the UE from a plurality of cells included in one tracking area (TA). The combining scheme can be classified into a soft combining scheme and a selective combining scheme. FIG. 7A and 7B illustrate embodiments according to the soft combining scheme and the selective combining scheme, respectively.

Referring to FIG. 7A, in case of the soft combining scheme, a physical layer (Layer 1) of a UE receives paging messages from a plurality of cells included in one tracking area (TA) and combines the paging messages. The combined data by the physical layer is transferred to an upper layer via a medium access control (MAC) layer. The UE is able to combine paging indication information transmitted from a plurality of cells by the soft combining scheme.

Referring to FIG. 7B, in case of the selective combining scheme, the physical layer

(Layer 1) of the UE receives paging channels (PCHs) from a plurality of cells separately. The Layer 2, e.g. the MAC layer of the UE combines the paging channels transferred from the physical layer and then transfers the combined data to the upper layer.

A cell may be included in a plurality of tracking areas (TAs). In this case, it is necessary that a plurality of paging control channels (PCCHs) and paging channels (PCHs) be configured in the cell. Namely, a paging control channel and a paging channel is configured for each tracking area. Accordingly, the UE needs to select a PCCH and a PCH among the plurality of PCCHs and PCHs based on the tracking area and receive the selected PCCH and PCH.

In particular, in case of the selective combining, L2 sequence numbers for the PCH need to be provided by aGW to support the selective combining in the Layer 2 of the UE. Thus, different sequence numbers are necessary for different tracking area. The sequence number can be added to a data unit carrying a paging message or a paging message itself. When the UE receives a paging channel (PCH), the Layer 2 of the UE arranges the data unit or the paging message received on the PCH based on the sequence number. If the Layer 2 of the UE finds duplicated data units or paging messages having the same sequence number, the Layer 2 of the UE chooses only one of them which are correctly received, sends it to the upper layer and discard the other.

Alternatively, the UE can combine cells included in a eNB to receive a paging channel (PCH). Information associated with cells which can be combined to receive paging messages or paging indication information is signaled from the eNB to the UE using system information. Also, information on whether paging messages or paging indication can be combined or not in a cell can be signaled from the eNB to the UE on the system information.

When a cell provides wider bandwidth than that of a UE, the UE should select which part of bandwidth the UE should receive to find its own paging message. For example, if the cell provides 20 Mhz and the UE 10 Mhz only, then the UE should select which 10 Mhz the UE should receive. In one embodiment of the present invention, the UE selects based on its UE identity. Particularly, the UE select which part of bandwidth the UE should receive based on its long UE identity such as TMSI or IMSI allocated by aGW. Also, the UE selects which paging occasion the UE should monitor within one UE specific DRX cycle based on its long UE identity such as TMSI or IMSI allocated by aGW.

While the present invention has been described and illustrated herein with reference to the preferred embodiments thereof, it will be apparent to those skilled in the art that various modifications and variations can be made therein without departing from the spirit and scope of the invention. Thus, it is intended that the present invention covers the modifications and variations of this invention that come within the scope of the appended claims and their equivalents.

INDUSTRIAL APPLICABILITY

The present invention is applicable to such a wireless communication system as wireless Internet, mobile communication system and the like.

[CLAIMS]

1. A method of receiving a paging message at a user equipment (UE) in a wireless communication system, comprising:

receiving from a network paging indication information including a UE identification information and scheduling information for a paging channel (PCH) on which a paging message is transmitted, the scheduling information including allocation information of a time-frequency region through which the paging message is transmitted;

obtaining the paging indication information when the UE identification information is identical to an identity of the UE; and

receiving from the network the paging message through the time-frequency region indicated by the paging indication information.

2. The method of claim 1, wherein the UE is in an RRC idle mode and the UE identification information is a long UE identity.

3. The method of claim 1, wherein the UE is in an RRC connected mode and the UE identification information is a short UE identity.

4. The method of claim 1, wherein the paging indication information is received on a paging indication channel (PICH).

5. The method of claim 1, wherein the paging indication information is included in L1/2 control information to be transmitted.

6. The method of claim 1, wherein the paging indication information is received on different sub-carriers and in different time interval.

7. The method of claim 1, wherein the paging indication information is received during a paging occasion.

8. A method of transmitting a paging message at a network in a wireless communication system, comprising:

transmitting, to a UE, paging indication information including a UE identification information and scheduling information for a paging channel (PCH) on which a paging message is transmitted, the scheduling information including allocation information of a time-frequency region through which the paging message is transmitted; and

transmitting the paging message through the time-frequency region indicated by the paging indication information.

9. The method of claim 8, wherein the UE is in an RRC idle mode and the UE identification information is a long UE identity.

10. The method of claim 8, wherein the UE is in an RRC connected mode and the UE identification information is a short UE identity.

11. A method of receiving a paging message at a user equipment (UE) in a wireless communication system, comprising:

receiving from a network paging indication information including a UE identification information and scheduling information for a paging channel (PCH) on which a paging message is transmitted;

obtaining the paging indication information when the UE identification information is identical to an identity of the UE; and receiving a paging message using the paging indication information by combining a plurality of paging channels from a plurality of cells.

12. The method of claim 11, wherein the scheduling information includes allocation information of a time-frequency region through which the paging message is transmitted.

13. The method of claim 11, wherein the paging indication information is received from a plurality of cells and further comprises combining the paging indication information from the plurality of cells.

14. The method of claim 11 or 13, wherein the plurality of cells are included in one tracking area (TA).

FIG. 1

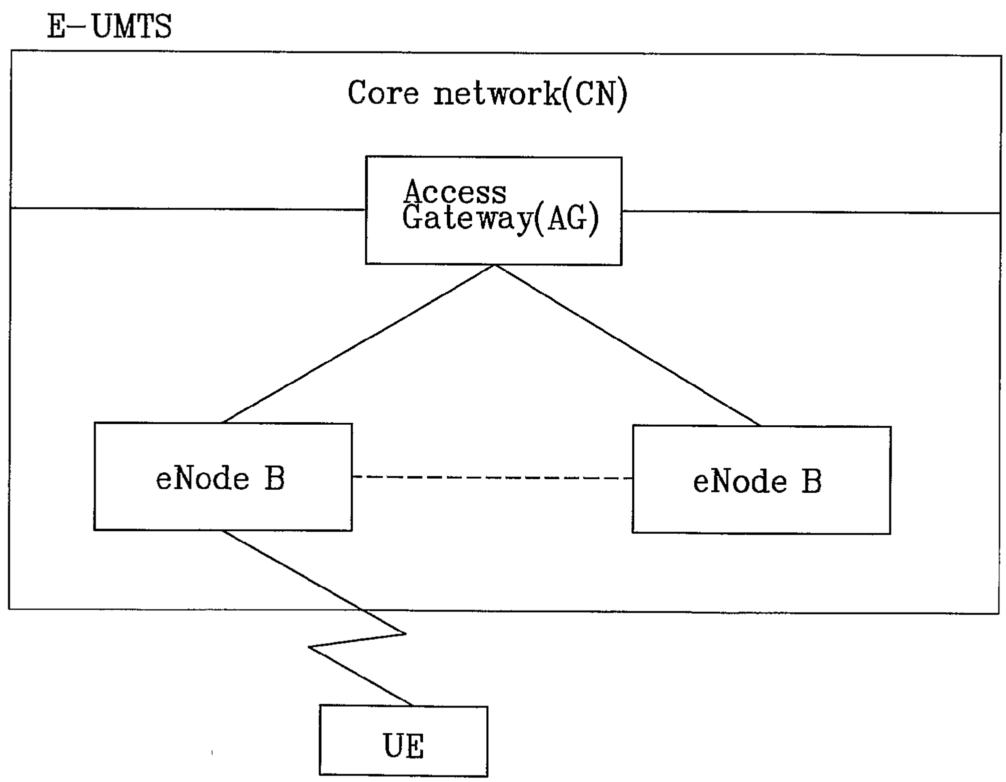


FIG. 2

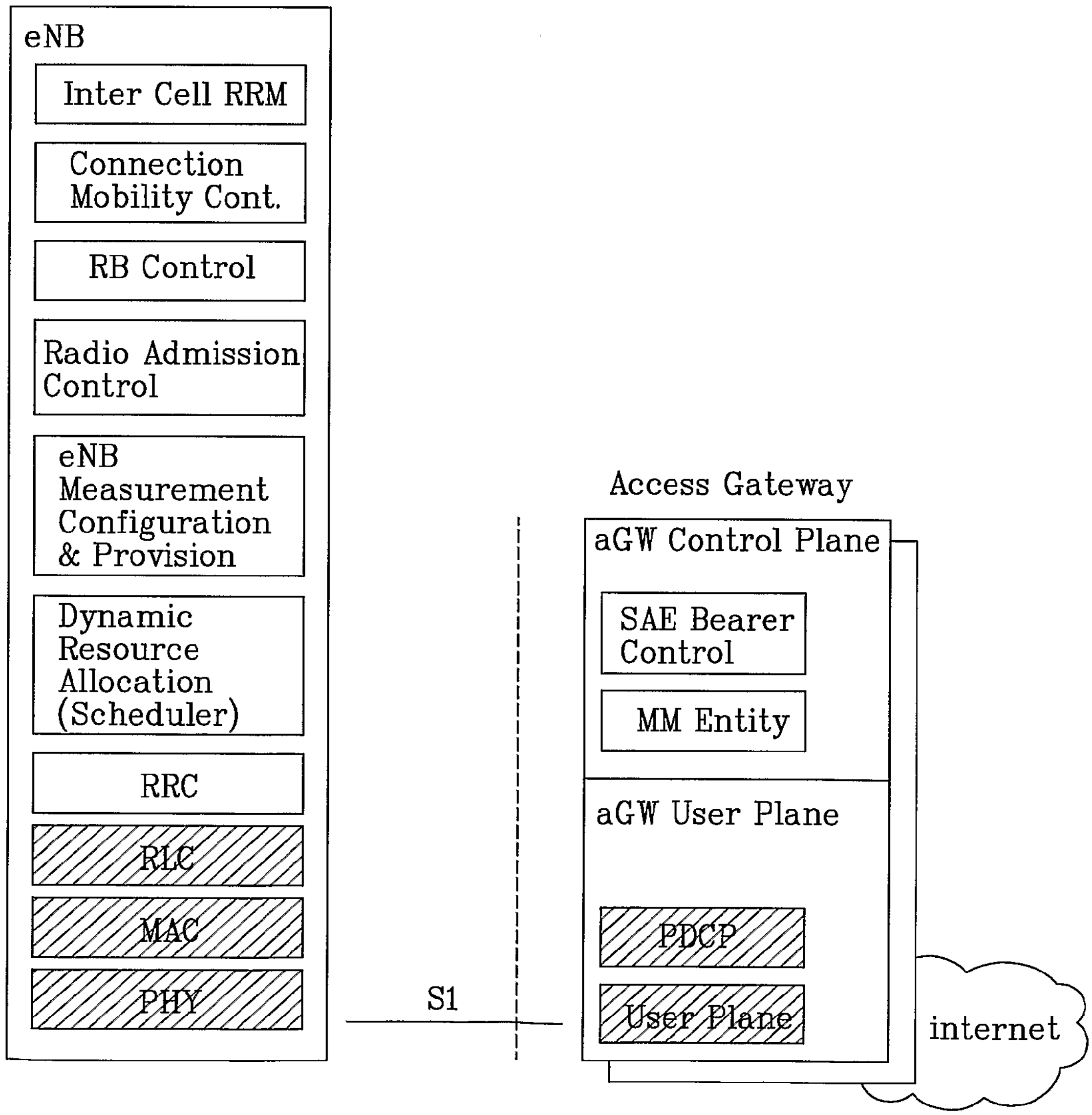

eNB
Inter Cell RRM
Connection Mobility Cont.
RB Control
Radio Admission Control
eNB Measurement Configuration & Provision
Dynamic Resource Allocation (Scheduler)
RRC
RLC
MAC
PHY
S1
Access Gateway
aGW Control Plane
SAE Bearer Control
MM Entity
aGW User Plane
PDCP
User Plane
internet

FIG. 3A

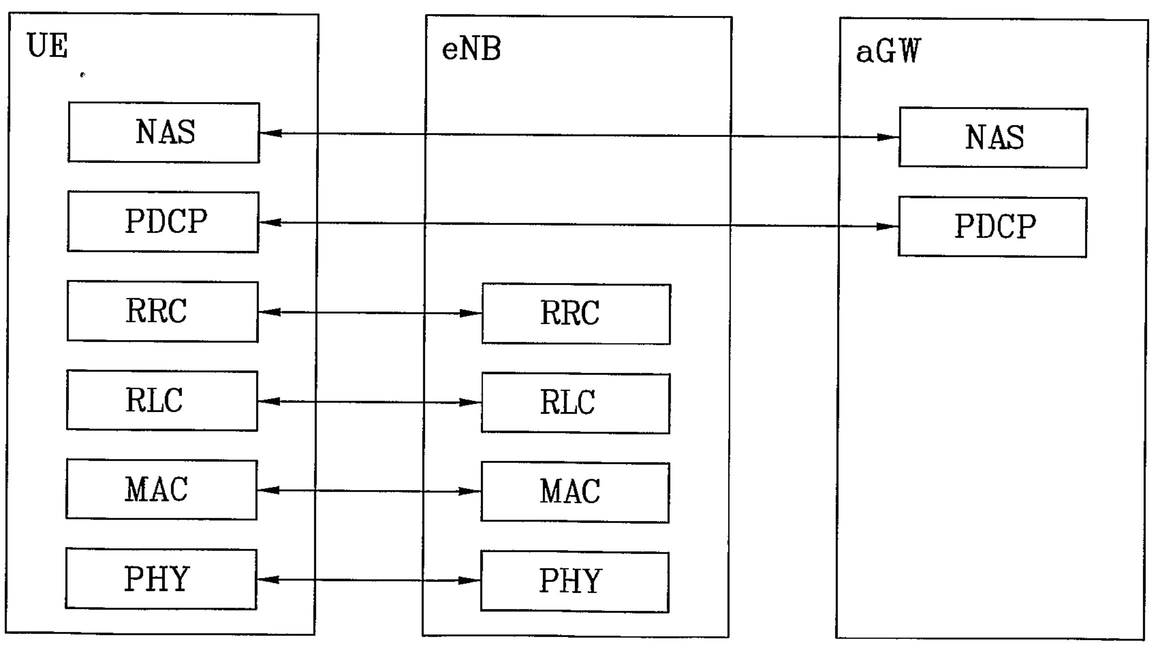


FIG. 3B

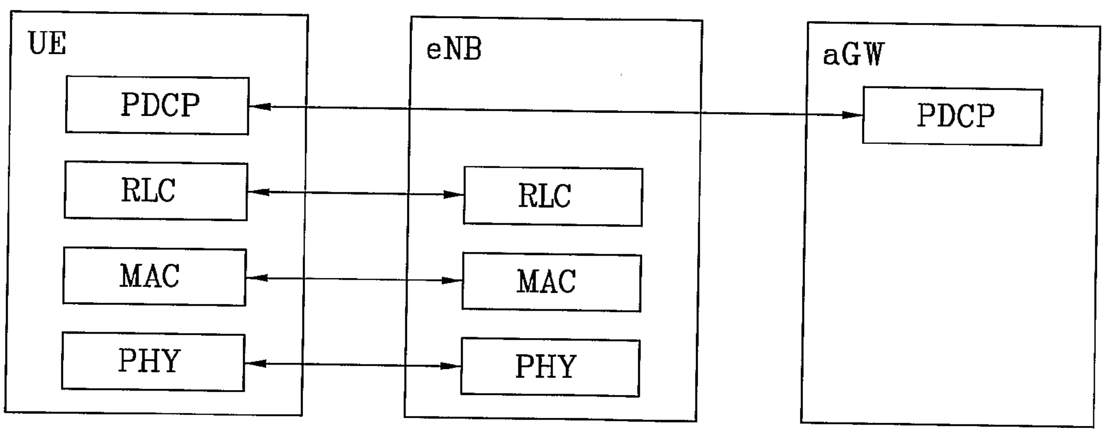


FIG. 4

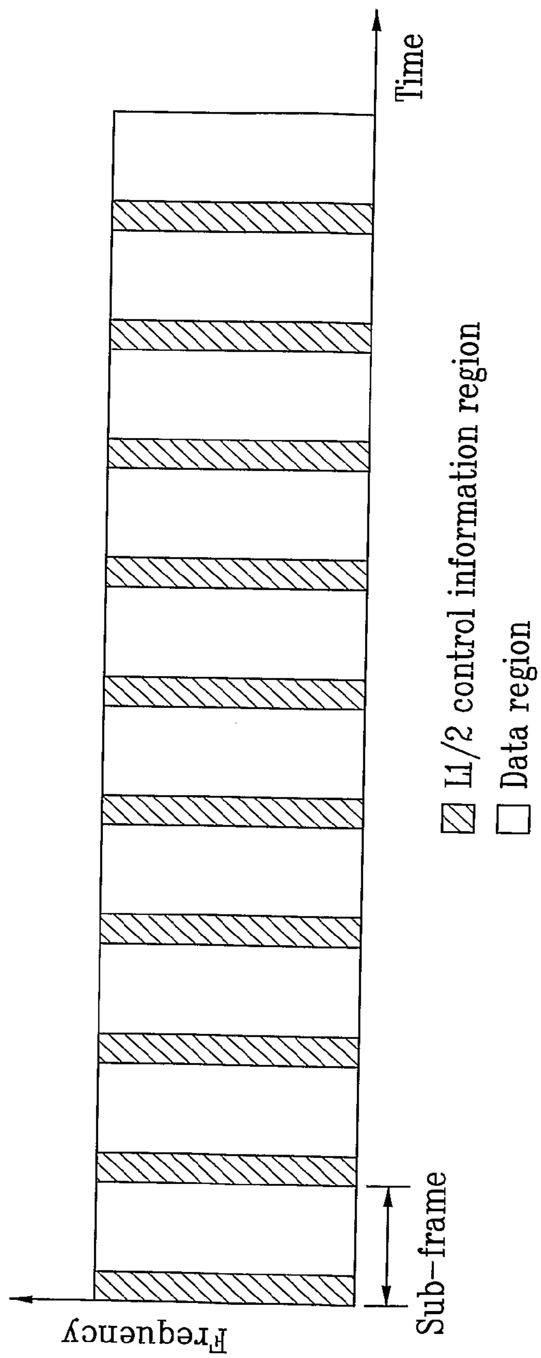

Time
L1/2 control information region
Data region
Sub-frame
Frequency

FIG. 5

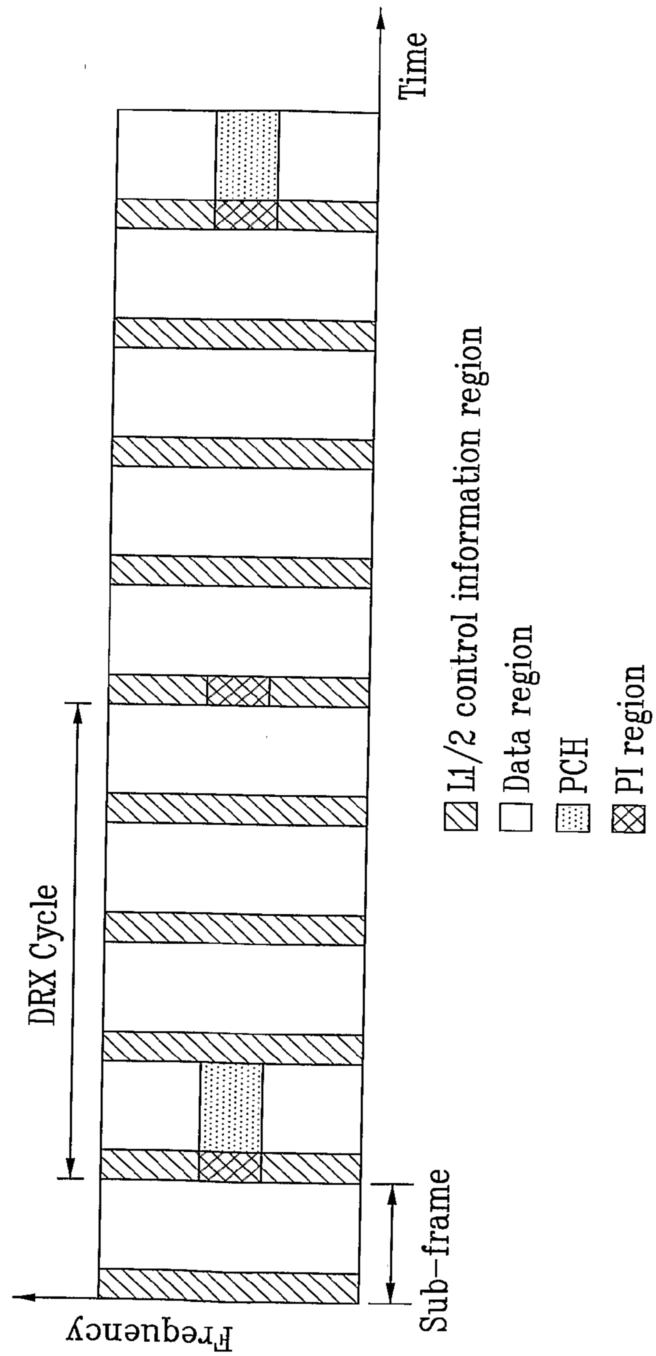

Time
Frequency
Sub-frame
DRX Cycle
L1/2 control information region
Data region
PCH
PI region

FIG. 6A

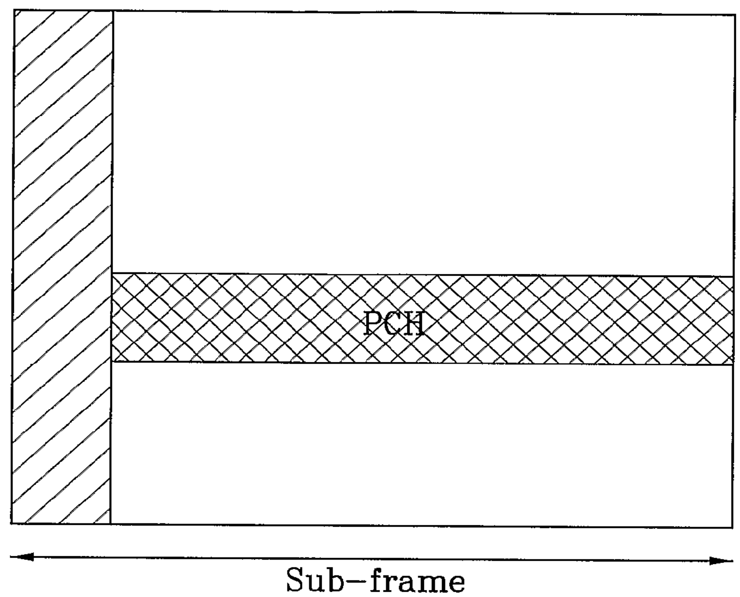


FIG. 6B

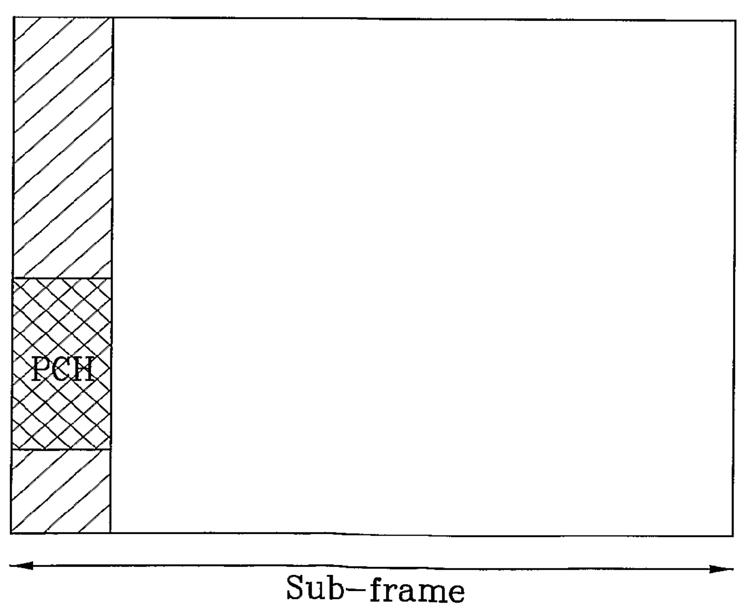


FIG. 7A

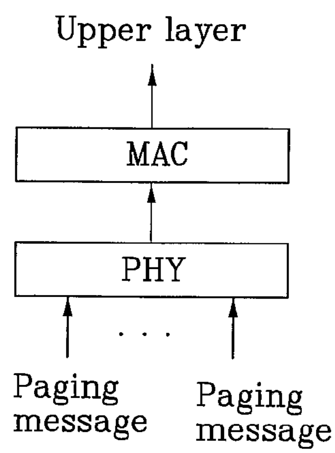
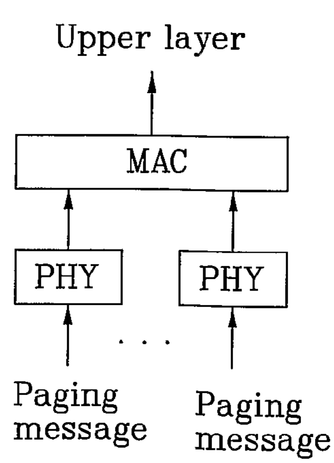

Upper layer
MAC
PHY
. . .
Paging message
Paging message

FIG. 7B


Upper layer
MAC
PHY
PHY
. . .
Paging message
Paging message

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	METHOD OF TRANSMITTING/RECEIVING A PAGING MESSAGE IN A WIRELESS COMMUNICATION SYSTEM
First Named Inventor/Applicant Name:	Young Dae Lee
Filer:	Harry Sung Lee/Maggie Wen
Attorney Docket Number:	2101-3515
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U.S. National Stage under 35 USC 371 Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
National Stage Fee	1631	1	310	310
National Stage Search - all other cases	1632	1	510	510
National Stage Exam - all other cases	1633	1	210	210
Pages:				
Claims:				
Multiple dependent claims	1616	1	370	370
Miscellaneous-Filing:				
Petition:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
	Total in USD ($)			**1400**

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First Named Inventor/Applicant Name:	Young Dae Lee
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal of New Application	2101-3515_XM.pdf	236864 e5d016fd7498c4dcc24d319e763195e71a9fcb0b	no	3
Warnings:					
Information:					
2		TZ-2006-0179-PUB-WO2007078172_TOT.pdf	926171 239775e3cea7bc0c129f9afc3921946e2c8776fa	yes	25

Multipart Description/PDF files in .zip description

Document Description	Start	End
Abstract	1	1
Specification	2	14
Claims	15	17
Drawings-only black and white line drawings	18	25

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Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
3	Fee Worksheet (PTO-06)	fee-info.pdf	8551 234e7b600c8f3d86d0530b65537ae326e1de7d7a	no	2
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Application Number

출 원 일 자 : 2007년 01월 04일
Date of Application JAN 04, 2007

출 원 인 : 엘지전자 주식회사
Applicant(s) LG Electronics Inc.

2007 년 02 월 01 일

특 허 청 장
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【수신처】	특허청장
【참조번호】	0006
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【국제특허분류】	H04B
【발명의 국문명칭】	무선 통신 시스템에서의 페이징 메시지 전송 및 수신 방법
【발명의 영문명칭】	Method of transmitting and receiving paging message in wireless communication system
【출원인】	
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【출원인코드】	1-2002-012840-3
【대리인】	
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【대리인코드】	9-1998-000022-1
【포괄위임등록번호】	2006-037573-8
【대리인】	
【성명】	심창섭
【대리인코드】	9-1998-000279-9
【포괄위임등록번호】	2006-037574-5
【발명자】	
【성명】	이영대
【성명의 영문표기】	LEE,Young Dae
【주민등록번호】	731215-1105411
【우편번호】	465-711
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【우편번호】 156-032

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【성명의 영문표기】 PARK,Sung Jun

【주민등록번호】 780316-1822418

【우편번호】 425-021

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【국적】 KR

【우선권 주장】

【출원국명】 US

【출원종류】 특허

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【증명서류】 미첨부

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【출원종류】 특허

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【출원종류】 특허

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【증명서류】 미첨부

【취지】 특허법 제42조의 규정에 의하여 위와 같이 출원합니다.

대리인 김용인 (인)

대리인 심창섭 (인)

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【요약서】

【요약】

본 발명은 무선 통신 시스템에서의 페이징 메시지 전송 및 수신 방법에 관한 것이다. 본 발명에 따른 페이징 메시지 수신 방법은, 무선 통신 시스템의 단말에서의 페이징 메시지 수신 방법에 있어서, 단말 식별정보 및 페이징 메시지가 전달되는 페이징 채널(PCH)이 전송되는 시간-주파수 영역의 할당 정보를 포함하는 스케줄링 정보를 포함하는 페이징 인디케이션 정보를 네트워크로부터 수신하는 단계와, 상기 단말 식별정보가 상기 단말의 식별자(identity)와 동일한 경우 상기 페이징 인디케이션 정보를 획득하는 단계와, 상기 페이징 인디케이션 정보에 의해 지시되는 상기 시간-주파수 영역을 통해 상기 네트워크로부터 페이징 메시지를 수신하는 단계를 포함하여 구성됨을 특징으로 한다.

【대표도】

도 4

【색인어】

E-UMTS, LTE, 페이징, PCH, PICH, PI

【명세서】

【발명의 명칭】

무선 통신 시스템에서의 페이징 메시지 전송 및 수신 방법{Method of transmitting and receiving paging message in wireless communication system}

【도면의 간단한 설명】

<1> 도 1은 E-UMTS의 망 구조를 도시한 도면이다.

<2> 도 2는 E-UTRAN(Evolved Universal Terrestrial Radio Access Network)의 개략적인 구성도이다.

<3> 도 3A 및 도 3B는 단말(UE)과 E-UTRAN 사이의 무선 인터페이스 프로토콜(Radio Interface Protocol)의 구조를 도시한 것으로서, 도 3A가 제어 평면 프로토콜 구성도이고, 도 3B가 사용자 평면 프로토콜 구성도이다.

<4> 도 4는 E-UMTS 시스템에서 사용하는 물리채널 구조의 일 예를 도시한 것이다.

<5> 도 5는 본 발명의 바람직한 일 실시예를 설명하기 위한 도면이다.

<6> 도 6A 및 도 6B는 본 발명에 따른 다른 실시예들을 설명하기 위한 도면이다.

<7> 도 7A 및 도 7B는 본 발명의 바람직한 다른 실시예를 설명하기 위한 도면이다.

【발명의 상세한 설명】

【발명의 목적】

【발명이 속하는 기술분야 및 그 분야의 종래기술】

<8> 본 발명은 무선 통신 시스템에 관한 것으로서, 보다 상세하게는, 무선 통신 시스템에서의 페이징 메시지 전송 및 수신 방법에 관한 것이다.

<9> 이동통신 시스템에서 페이징 절차는 특정 단말 또는 다수의 단말들을 호출할 때 사용된다. UMTS(Universal Mobile Telecommunications System)에서 Paging Type 1과 Paging Type 2의 두 가지 종류의 페이징 메시지가 사용된다.

<10> Paging Type 1 메시지는 단말이 유휴 모드(Idle Mode), Cell_PCH 상태, URA_PCH 상태인 경우에 사용된다. 유휴 모드에 있는 단말에 대하여, 핵심망은 단말과의 시그널링 접속을 설정하거나, 호 또는 세션의 설정을 요구하기 위해 단말을 호출할 수 있고, Cell_PCH 또는 URA_PCH 상태에 있는 단말에 대해서는 셀 업데이트(cell update) 절차 또는 URA(UTRAN Registration Area) Update 절차를 수행하도록 단말을 호출할 수 있다. 이와 함께, UTRAN은 단말이 갱신된 시스템 정보를 읽도록 지시하기 위해서도 Paging Type 1 메시지를 사용한다. 갱신된 시스템 정보는 셀 내의 모든 단말에게 중요한 정보이므로 호출 대상은 셀 내의 모든 단말이 된다. 호출되는 단말을 구분하기 위하여 페이징 메시지에는 단말의 식별 정보가 포함되어 있으며, 단말이 유휴 모드인 경우에 IMSI(International Mobile Subscriber Identity), TMSI(Temporary Mobile Subscriber Identity), P-TMSI(Packet Temporary Mobile Subscriber Identity)와 같은 상위 수준의 단말 식별 정보가 포함되고, 연결 모드(Connected Mode)인 경우에는 U-RNTI(UTRAN Radio Network Temporary Identity)가 사용된다.

<11> Paging Type 2 메시지는 단말이 Cell_DCH 상태 또는 Cell_FACH 상태에 있는 경우에 사용되며, 기존에 설정되어 있는 RRC 접속을 통해 추가적으로 단말을 호출할 때 사용된다. Paging Type 2 메시지는 기존에 설정된 RRC 접속을 이용하므로 특정 단말에 대한 전용 호출이 가능하다.

<12> UMTS 시스템에서 페이징 메시지는 전송채널 PCH(Paging Channel)를 통해 전송되며 페이징 인디케이션 정보(PI: Paging Indication)와 짝을 이뤄 사용된다. 즉, 단말 호출 시에 UTRAN은 PICH(Paging Indication Channel)를 통해 PI를 전송하여 일정 시간 후에 페이징 메시지가 전송될 것임을 지시한다. PI를 수신한 단말은 일정 시간 후에 페이징 메시지를 수신한다.

<13> 종래기술에 있어서는 페이징 메시지 전송을 위한 무선자원은 고정되어 있었다. 즉, PI를 확산계수(SF: Spreading Factor)가 256인 PICH를 통해 전송되었고, 페이징 메시지를 포함하는 PCH는 S-CCPCH를 통해 전송되었다. 종래기술과 같이, 고정된 무선자원을 통해 페이징 메시지를 전송하는 경우 네트워크에서의 데이터 전송 스케줄링에 유연성(flexibility)이 없기 때문에 변화되는 환경에 빠르게 적응할 수 없는 문제점이 있다. 한편, 셀 경계에 있는 단말을 호출하는 경우에 기지국으로부터 거리가 멀어짐에 따라 수신 에러가 증가하여 원활한 페이징이 이루어지지 않는 문제점이 있다.

【발명이 이루고자 하는 기술적 과제】

<14> 본 발명은 상기한 바와 같은 종래기술의 문제점을 해결하기 위하여 안출된 것으로서, 본 발명의 목적은 유한한 무선 자원을 효율적으로 사용할 수 있는 무선

통신 시스템에서의 페이징 메시지 전송 및 수신 방법을 제공하는 것이다.

【발명의 구성】

<15> 본 발명의 일 양상으로서, 본 발명에 따른 페이징 메시지 수신 방법은, 무선 통신 시스템의 단말에서의 페이징 메시지 수신 방법에 있어서, 단말 식별정보 및 페이징 메시지가 전달되는 페이징 채널(PCH)이 전송되는 시간-주파수 영역의 할당 정보를 포함하는 스케줄링 정보를 포함하는 페이징 인디케이션 정보를 네트워크로부터 수신하는 단계와, 상기 단말 식별정보가 상기 단말의 식별자(identity)와 동일한 경우 상기 페이징 인디케이션 정보를 획득하는 단계와, 상기 페이징 인디케이션 정보에 의해 지시되는 상기 시간-주파수 영역을 통해 상기 네트워크로부터 페이징 메시지를 수신하는 단계를 포함하여 구성됨을 특징으로 한다.

<16> 본 발명의 다른 양상으로서, 본 발명에 따른 페이징 메시지 전송 방법은, 무선 통신 시스템의 네트워크에서의 페이징 메시지 전송 방법에 있어서, 단말 식별정보 및 페이징 메시지가 전달되는 페이징 채널(PCH)이 전송되는 시간-주파수 영역의 할당 정보를 포함하는 스케줄링 정보를 포함하는 페이징 인디케이션 정보를 단말로 전송하는 단계와, 상기 페이징 인디케이션 정보에 의해 지시된 시간-주파수 영역을 통해 페이징 메시지를 전송하는 단계를 포함하여 구성됨을 특징으로 한다.

<17> 본 발명의 또 다른 양상으로서, 본 발명에 따른 페이징 메시지 수신 방법은, 무선 통신 시스템의 단말에서의 페이징 메시지 수신 방법에 있어서, 단말 식별정보 및 페이징 메시지가 전송될 페이징 채널(PCH)에 대한 스케줄링 정보를 포함하는 페이징 인디케이션 정보를 수신하는 단계와, 상기 단말 식별정보가 상기 단말의 식별

자와 동일한 경우 상기 페이징 인디케이션 정보를 획득하는 단계와, 상기 페이징 인디케이션 정보를 이용하여 다수의 셀들로부터 전송되는 다수의 페이징 채널을 결합함으로써 페이징 메시지를 수신하는 단계를 포함하여 구성됨을 특징으로 한다.

<18> 이하에서 첨부된 도면을 참조하여 설명된 본 발명의 실시예들에 의해 본 발명의 구성, 작용 및 다른 특징들이 용이하게 이해될 수 있을 것이다. 이하에서 설명되는 실시예들은 본 발명의 기술적 특징들이 E-UMTS(Evolved Universal Mobile Telecommunications System)에 적용된 예들이다.

<19> 도 1은 E-UMTS의 망 구조를 도시한 도면이다. E-UMTS 시스템은 기존 UMTS 시스템에서 진화한 시스템으로 현재 3GPP(3rd Generation Partnership Project)에서 기초적인 표준화 작업을 진행하고 있다. E-UMTS는 LTE(Long Term Evolution) 시스템이라 불리기도 한다.

<20> 도 1을 참조하면, E-UMTS는 크게 단말(User Equipment; UE라 약칭함)과 기지국(이하 eNode B 또는 eNB), 네트워크(E-UTRAN)의 종단에 위치하여 외부망과 연결되는 접속 게이트웨이(Access Gateway; 이하 aGW로 약칭함)로 구성된다. aGW는 사용자 트래픽 처리를 담당하는 부분과 제어용 트래픽을 처리하는 부분으로 나누어질 수도 있다. 이때, 새로운 사용자 트래픽 처리를 위한 aGW와 제어용 트래픽을 처리하는 aGW 사이에 새로운 인터페이스를 사용하여 서로 통신할 수 있다. 하나의 Node B에는 하나 이상의 셀(cell)이 존재한다. eNode B 간에는 사용자 트래픽 또는 제어 트래픽 전송을 위한 인터페이스가 사용될 수 있다. CN(Core Network)은 aGW와 UE의 사용자 등록 등을 위한 네트워크 노드 등으로 구성될 수 있다. E-UTRAN과 CN을 구

분하기 위한 인터페이스가 사용될 수 있다. aGW는 TA(Tracking Area) 단위로 단말의 이동성을 관리한다. TA는 복수의 셀들로 구성되며, 단말은 특정 TA에서 다른 TA로 이동할 경우, aGW에게 자신이 위치한 TA가 변경되었음을 알려준다.

<21> 단말과 네트워크 사이의 무선 인터페이스 프로토콜(Radio Interface Protocol)의 계층들은 통신 시스템에서 널리 알려진 개방형 시스템간 상호 접속(Open System Interconnection; OSI)기준모델의 하위 3개 계층을 바탕으로 L1(제1계층), L2(제2계층), L3(제3계층)로 구분될 수 있는데, 이 중에서 제1계층에 속하는 물리계층은 물리채널(Physical Channel)을 이용한 정보 전송 서비스(Information Transfer Service)를 제공하며, 제3계층에 위치하는 무선자원제어(Radio Resource Control; 이하 RRC라 약칭함) 계층은 단말과 네트워크 간에 무선자원을 제어하는 역할을 수행한다. 이를 위해 RRC 계층은 단말과 네트워크 간에 RRC 메시지를 서로 교환한다. RRC 계층은 Node B와 aGW 등 네트워크 노드들에 분산되어 위치할 수도 있고, Node B 또는 aGW에 독립적으로 위치할 수도 있다.

<22> 도 2는 E-UTRAN(Evolved Universal Terrestrial Radio Access Network)의 개략적인 구성도이다. 도 2에서, 해칭(hatching)한 부분은 사용자 평면(user plane)의 기능적 엔티티들을 도시한 것이고, 해칭하지 않은 부분은 제어 평면(control plane)의 기능적 엔티티들을 도시한 것이다.

<23> 도 3A 및 도 3B는 단말(UE)과 E-UTRAN 사이의 무선 인터페이스 프로토콜(Radio Interface Protocol)의 구조를 도시한 것으로서, 도 3A가 제어 평면 프로토콜 구성도이고, 도 3B가 사용자 평면 프로토콜 구성도이다. 도 3A 및 도 3B의 무선

인터페이스 프로토콜은 수평적으로 물리계층(Physical Layer), 데이터링크 계층(Data Link Layer) 및 네트워크 계층(Network Layer)으로 이루어지며, 수직적으로는 데이터 정보 전송을 위한 사용자 평면(User Plane)과 제어신호(Signaling)전달을 위한 제어 평면(Control Plane)으로 구분된다. 도 3A 및 도 3B의 프로토콜 계층들은 통신 시스템에서 널리 알려진 개방형 시스템간 상호 접속(Open System Interconnection; OSI) 기준모델의 하위 3개 계층을 바탕으로 L1(제1계층), L2(제2계층), L3(제3계층)로 구분될 수 있다.

<24> 제1계층인 물리계층은 물리채널(Physical Channel)을 이용하여 상위 계층에게 정보 전송 서비스(Information Transfer Service)를 제공한다. 물리계층은 상위에 있는 매체접속제어(Medium Access Control) 계층과는 전송채널(Transport Channel)을 통해 연결되어 있으며, 이 전송채널을 통해 매체접속제어 계층과 물리계층 사이의 데이터가 이동한다. 그리고, 서로 다른 물리계층 사이, 즉 송신측과 수신측의 물리계층 사이는 물리채널을 통해 데이터가 이동한다. E-UMTS에서 상기 물리채널은 OFDM(Orthogonal Frequency Division Multiplexing) 방식으로 변조되며, 이에 따라 시간(time)과 주파수(frequency)를 무선자원으로 활용한다.

<25> 제2계층의 매체접속제어(Medium Access Control; 이하 MAC이라 약칭함) 계층은 논리채널(Logical Channel)을 통해 상위계층인 무선링크제어(Radio Link Control) 계층에 서비스를 제공한다. 제2계층의 무선링크제어(Radio Link Control; 이하 RLC라 약칭함) 계층은 신뢰성 있는 데이터의 전송을 지원한다. 제2계층의 PDCP 계층은 IPv4나 IPv6와 같은 IP 패킷을 이용하여 전송되는 데이터가 상대적으

로 대역폭이 작은 무선 구간에서 효율적으로 전송하기 위해 불필요한 제어정보를 줄여주는 헤더 압축(Header Compression) 기능을 수행한다.

<26> 제3계층의 가장 하부에 위치한 무선자원제어(Radio Resource Control; 이하 RRC라 약칭함) 계층은 제어평면에서만 정의되며, 무선베어러(Radio Bearer; RB라 약칭함)들의 설정(Configuration), 재설정(Re-configuration) 및 해제(Release)와 관련되어 논리채널, 전송채널 및 물리채널들의 제어를 담당한다. 이때, RB는 단말과 UTRAN 간의 데이터 전달을 위해 제2계층에 의해 제공되는 서비스를 의미한다.

<27> 네트워크에서 단말로 데이터를 전송하는 하향 전송채널로는 시스템 정보를 전송하는 BCH(Broadcast Channel), 페이징 메시지를 전송하는 PCH(Paging Channel), 그 이외에 사용자 트래픽이나 제어메시지를 전송하는 하향 SCH(Shared Channel)이 있다. 하향 멀티캐스트 또는 방송 서비스의 트래픽 또는 제어메시지의 경우 하향 SCH를 통해 전송될 수도 있고, 또는 별도의 하향 MCH(Multicast Channel)을 통해 전송될 수도 있다. 한편, 단말에서 망으로 데이터를 전송하는 상향 전송채널로는 초기 제어메시지를 전송하는 RACH(Random Access Channel)와 그 이외에 사용자 트래픽이나 제어메시지를 전송하는 상향 SCH(Shared Channel)가 있다.

<28> 전송채널 상위에 있으며, 전송채널에 매핑되는 논리채널(Logical Channel)로는 BCCH(Broadcast Channel), PCCH(Paging Control Channel), CCCH(Common Control Channel), MCCH(Multicast Control Channel), MTCH(Multicast Traffic Channel) 등이 있다.

<29> E-UMTS 시스템에서는 하향링크에서 OFDM 방식을 사용하고 상향링크에서는 SC-FDMA(Single Carrier-Frequency Division Multiple Access) 방식을 사용한다. 다중 반송파 방식인 OFDM 시스템은 반송파의 일부를 그룹화한 다수의 부반송파(subcarriers) 단위로 자원을 할당하는 시스템으로서, 접속 방식으로 OFDMA(Orthogonal Frequency Division Multiple Access)를 사용한다.

<30> OFDM 또는 OFDMA 시스템의 물리계층에서는 활성 반송파를 그룹으로 분리해서, 그룹별로 각기 다른 수신측으로 송신된다. 각 UE에게 할당되는 무선자원은 2차원 공간의 시간-주파수 영역(time-frequency region)에 의해서 정의되며 연속적인 부반송파의 집합이다. OFDM 또는 OFDMA 시스템에서 하나의 시간-주파수 영역은 시간 좌표와 부반송파 좌표에 의해 결정되는 직사각형으로 구분된다. 즉, 하나의 시간-주파수 영역은 적어도 하나 이상의 시간 축 상에서의 심볼과 다수의 주파수 축 상에서의 부반송파에 의해 구획되는 직사각형으로 구분될 수 있다. 이러한 시간-주파수 영역은 특정 UE의 상향링크에 할당되거나 또는 하향링크에서는 특정한 사용자에게 기지국이 시간-주파수 영역을 전송할 수 있다. 2차원 공간에서 이와 같은 시간-주파수 영역을 정의하기 위해서는 시간 영역에서 OFDM 심볼의 수와 주파수 영역에서 기준점에서부터의 오프셋(offset)만큼 떨어진 위치에서 시작되는 연속적인 부반송파의 수가 주어져야 한다.

<31> 현재 논의가 진행 중인 E-UMTS 시스템에서는 10 ms의 무선 프레임(radio frame)을 사용하고 하나의 무선 프레임은 20 개의 서브 프레임(subframe)으로 구성된다. 즉, 하나의 서브 프레임은 0.5ms이다. 하나의 리소스 블록(resource block)

은 하나의 서브 프레임과 각각 15 kHz 대역인 부반송파 12 개로 구성된다. 또한, 하나의 서브 프레임은 다수의 OFDM 심볼들로 구성되며, 다수의 OFDM 심볼들 중 일부 심볼(예를 들어, 첫 번째 심볼)은 L1/2 제어정보를 전송하기 위해 사용될 수 있다. 도 4는 E-UMTS 시스템에서 사용하는 물리채널 구조의 일 예를 도시한 것으로서, 하나의 서브 프레임은 L1/2 제어정보 전송 영역(해칭한 부분)과 데이터 전송 영역으로 구성된다.

<32> 도 5는 본 발명의 바람직한 일 실시예를 설명하기 위한 도면이다.

<33> 도 5를 참조하면, 유휴 모드(idle mode)에 있거나, RRC 연결 상태에 있으나 DRX(Discontinuous Reception) 수신을 하는 단말은 DRX 주기 내에서 시스템 정보에 따라 미리 설정된 페이징 지점(paging occasion)마다 깨어나 자신에게 전달되는 페이징 메시지가 있는지 모니터링한다. 도 5에서, 하나의 DRX 주기는 네 개의 서브프레임을 포함하고, 특정 단말에 대한 페이징 지점은 첫 번째 서브프레임에 시작된다. 상기 단말은 상기 DRX 주기의 첫 번째 서브 프레임의 L1/2 제어정보 전송 영역을 수신하여 자신에게 전송되는 페이징 인디케이션 정보(PI)가 있는지를 체크한다.

<34> 상기 페이징 인디케이션 정보는 단말 식별 정보 및 페이징 메시지가 전송되는 무선자원, 즉 시간-주파수 영역에 관한 정보를 포함한다. 상기 단말이 수신된 상기 페이징 인디케이션 정보에 포함된 단말 식별 정보가 자신의 것임을 확인한 경우 상기 페이징 인디케이션 정보에 의해 지시되는 시간-주파수 영역의 페이징 채널(PCH)을 통해 페이징 메시지를 수신한다.

<35> 유휴 모드에 있는 단말의 페이징 절차와 RRC 연결 모드에 있는 단말의 DRX 절차는 구분되어야 한다. 표 1은 양자의 특징을 비교한 것이다.

【표 1】

<36>

	페이징 절차	DRX 절차
RRC 모드	유휴 모드	연결 모드
제어 네트워크 노드	aGW: 페이징 초기화 eNB: 페이징 메시지 전송	eNB
시그널링 영역	TA(Tracking Area)	셀
UE 식별 정보	NAS에 의해 할당된 long identity(ex. IMSI, TMSI)	eNB에서 AS에 의해 할당된 short identity(ex. C-RNTI)

<37> 페이징 절차는 단말이 TA의 어느 셀에 위치하는지를 파악하고 단말의 배터리 소모를 효율적으로 하기 위해 aGW에 의해 수행된다. 페이징 절차는 유휴 모드에 있는 단말에 적용된다. 유휴 모드에 있는 단말은 셀에서 할당 받은 C-RNTI(Cell Radio Network Temporary Identity)와 같은 'short UE ID'를 갖고 있지 않기 때문에 페이징 메시지에는 IMSI, TMSI 등과 같은 'long UE ID'가 포함된다.

<38> DRX 절차는 RRC 연결 모드에 있는 단말에 대해 상기 단말의 배터리를 절약하기 위해 eNB가 수행한다. 하향/상향 트래픽이 일시적으로 비활성화되는 경우에 DRX 절차가 적용될 수 있다. RRC 연결 모드에 있는 단말은 셀에 의해 할당된 C-RNTI와 같은 'short UE ID'를 가지고 있기 때문에 eNB는 L1/2 제어정보에 상기 'short UE ID'를 포함시킴으로써 단말을 깨어나게 할 수 있다.

<39> DRX 절차의 경우, 16 비트 이하의 길이를 갖는 'short UE ID'가 서브프레임의 첫 번째 심볼의 L1/2 제어 채널에 용이하게 포함될 수 있다. 반면에, 'long UE ID'를 포함하는 페이징 메시지는 L1/2 제어 채널에 포함될 수 없다. 그러나,

'short UE ID'를 포함하는 페이징 인디케이션 정보(PI)는 L1/2 제어채널 또는 PICH에 포함될 수 있다.

<40> 본 발명의 일 실시예에 있어서, 유휴 모드에 있는 단말은 'long UE ID'를 이용하여 PCH를 모니터링한다. RRC 연결 모드에 있는 단말은 DRX 주기 내에서 'short UE ID'를 이용하여 L1/2 제어정보를 모니터링한다. RRC 연결 모드에 있는 특정 단말이 스케줄링되는 경우 설정된 주기에 따라 스케줄링 정보를 포함하는 L1/2 제어정보에 'short UE ID'를 포함시킨다. RRC 연결 모드에 있는 특정 단말이 스케줄링되지 않는 경우 L1/2 제어 정보에 'short UE ID'를 포함시키지 않는다.

<41> 본 발명의 일 실시예에서, eNB는 모든 DRX 주기의 단말 별 페이징 지점(paging occasion) 내에서 하향링크(DL) SCH 뿐만 아니라 PCH를 스케줄링한다. 페이징 지점 내의 페이징 인디케이션 정보는 단말에게 해당 페이징 지점 내에 상기 단말을 위한 페이징 메시지가 스케줄링되는지 아닌지에 대한 정보를 제공한다. 상기 페이징 인디케이션 정보는 상기 페이징 메시지가 전송되는 시간-주파수 영역과 관련된 정보를 포함할 수 있다. 상기 페이징 인디케이션 정보는 PICH(Paging Indicator Channel)를 통해 전송되거나, L1/2 제어정보에 포함되어 전송될 수 있다.

<42> 상기 페이징 인디케이션 정보는 주파수 다이버시티(frequency diversity)를 위해 주파수 호핑(frequency hopping) 방식에 의해 전송될 수 있다. 예를 들어, 상기 주파수 인디케이션 정보는 서로 다른 시간 간격(페이징 지점) 내에서 서로 다른 부반송파를 통해 전송될 수 있다. 서로 다른 페이징 지점 내에서 서로 다른 부반송

파를 이용하여 어떻게 페이징 인디케이션 정보를 전송할지에 대한 정보는 셀 내에서 시스템 정보에 의해 시그널링된다.

<43> 본 발명의 일 실시예에 있어서, 유휴 모드에 있는 단말 및 RRC 연결 모드에 있는 단말에 대한 페이징 인디케이션 정보는 'short UE ID'를 이용하여 동일한 L1/2 제어 채널을 통해 전송될 수 있다. 이 경우, 단말은 RRC 상태에 상관 없이 L1/2 제어 채널을 모니터링한다.

<44> 도 6A 및 도 6B는 본 발명에 따른 다른 실시예들을 설명하기 위한 도면으로서, 도 6A 및 도 6B의 실시예들은 페이징 인디케이션 정보 없이 하나의 서브프레임에서 페이징 채널을 전송하는 예들이다. 도 6A에서, 페이징 채널은 페이징 인디케이션 정보 없이 데이터 전송 영역, 즉 L1/2 제어정보가 전송되지 않는 영역을 통해 전송된다. 이때, 단말은 시스템 정보를 수신하여 페이징 메시지를 포함하는 페이징 채널이 전송되는 시간-주파수 영역에 대한 정보를 획득하고, 이에 따라 상기 페이징 채널을 수신한다.

<45> 도 6B에서, 페이징 메시지를 포함하는 페이징 채널은 페이징 인디케이션 정보 없이 L1/2 제어정보 전송 영역을 통해 전송된다. 이 경우도, 단말은 시스템 정보를 수신하여 페이징 메시지를 포함하는 페이징 채널이 전송되는 시간-주파수 영역에 대한 정보를 획득하고, 이에 따라 상기 페이징 채널을 수신한다.

<46> 도 7A 및 도 7B는 본 발명의 바람직한 다른 실시예를 설명하기 위한 도면이다. 셀 경계 지역에 있는 단말에 대해서 하나의 TA(Tracking Area)에 속하는 다수의 셀들로부터 동일한 페이징 메시지 및/또는 페이징 인디케이션 정보가 전송되기

때문에 컴바이닝(combininb)에 의해 페이징 메시지 또는 페이징 인디케이션 정보의 수신이 최적화될 수 있다. 컴바이닝 방식으로서 소프트 컴바이닝(soft combining)과 선택적 컴바이닝(selective combining)을 고려할 수 있다. 도 7A는 소프트 컴바이닝 기법과 관련된 실시예를 설명하기 위한 도면이고, 도 7B는 선택적 컴바이닝 기법과 관련된 실시예를 설명하기 위한 도면이다.

<47> 도 7A를 참조하면, 소프트 컴바이닝의 경우, 단말의 물리계층(Layer 1)은 동일한 TA에 속하는 다수의 셀들로부터 전송되는 페이징 메시지들을 수신하여 결합한다. 물리계층에서 결합된 데이터는 MAC 계층을 통해 상위계층으로 전달된다. 셀 경계에 있는 단말이 다수의 셀들로부터 페이징 인디케이션 정보를 수신하는 경우 소프트 컴바이닝 방식에 의해 결합 수신할 수 있다.

<48> 도 7B를 참조하면, 선택적 컴바이닝의 경우, 상기 단말의 물리계층은 상기 다수의 셀들로부터의 페이징 채널들을 독립적으로 수신한다. 동일한 TA에 속하는 다수의 셀들로부터 전송된 전송채널 PCH는 단말의 제2계층에 속하는 MAC 계층에 의해 결합되고, 결합된 페이징 메시지는 상위계층으로 전달된다.

<49> 하나의 셀이 하나 이상의 TA에 위치할 수 있기 때문에, 서로 다른 셀들이 서로 다른 TA의 조합을 가질 수 있다. 이 경우에, 다수의 PCCH 및 PCH 채널들이 하나의 셀에 설정될 필요가 있다. 각 TA에는 하나의 PCCH 및 PCH 채널이 설정된다. 따라서, 단말은 TA에 기초하여 PCH 및 PCCH 채널을 선택하고, 선택된 PCH 및 PCCH 채널을 수신해야 한다.

<50> 선택적 컴바이닝의 경우, 제2계층에서의 선택적 컴바이닝을 지원하기 위하여

aGW는 PCH의 L2 일련 번호(sequence number)를 제공하여야 한다. 서로 다른 TA들에 대해서는 서로 다른 일련 번호가 제공될 필요가 있다. 상기 일련 번호는 페이징 메시지를 포함하는 데이터 유닛 또는 페이징 메시지 그 자체에 부가될 수 있다. 단말이 페이징 메시지를 수신했을 때, 상기 단말의 제2계층은 PCH 및 PCCH를 통해 수신된 데이터 유닛 또는 페이징 메시지를 일련 번호에 따라 배열한다. 상기 단말의 제2계층이 동일한 일련 번호를 갖는 데이터 유닛들과 페이징 메시지들을 인식한 경우 상기 단말의 제2계층은 오류 없이 수신된 것을 선택하여 상위계층으로 전달하고, 선택되지 않은 것은 디스카드(discard)한다.

<51> 단말은 동일한 eNB에 속하는 다수의 셀들만을 결합하여 PCH 채널을 수신할 수 있다. 페이징 메시지 또는 페이징 인디케이션 정보를 수신하기 위하여 어떠한 셀들이 결합되어야 하는지에 대한 정보는 eNB로부터 상기 단말로 시스템 정보를 통해 전달된다. 페이징 메시지 또는 페이징 인디케이션 정보가 결합될 수 있는지의 여부 또한 eNB에 의해 시스템 정보를 통해 시그널링될 수 있다.

<52> 셀이 단말보다 더 넓은 대역폭을 제공하는 경우, 상기 단말은 페이징 메시지를 획득하기 위해 어떠한 범위의 대역폭을 수신해야 하는지를 선택해야 한다. 예를 들어, 셀이 20 Mhz 대역을 제공하고, 단말이 10 Mhz 대역을 제공하는 경우, 상기 단말은 수신해야 하는 10 Mhz를 선택해야 한다. 본 발명의 일 실시예에 있어서, 상기 단말은 단말 식별정보를 기초로 대역폭을 선택한다. 즉, 상기 단말은 aGW에 의해 할당받은 TMSI 또는 IMSI 등과 같은 'long UE ID'를 기초로 상기 단말이 수신할 대역폭 부분을 선택한다. 또한, 상기 단말은 aGW에 의해 할당받은 TMSI 또는 IMSI

등과 같은 'long UE ID'를 기초로 상기 단말이 모니터링할 페이징 지점(paging occasion)을 선택한다.

<53> 본 발명은 본 발명의 정신 및 필수적 특징을 벗어나지 않는 범위에서 다른 특정한 형태로 구체화될 수 있음은 당업자에게 자명하다. 따라서, 상기의 상세한 설명은 모든 면에서 제한적으로 해석되어서는 아니되고 예시적인 것으로 고려되어야 한다. 본 발명의 범위는 첨부된 청구항의 합리적 해석에 의해 결정되어야 하고, 본 발명의 등가적 범위 내에서의 모든 변경은 본 발명의 범위에 포함된다.

【발명의 효과】

<54> 본 발명에 따르면, 페이징 메시지를 전송하기 위한 무선자원을 동적으로 할당함으로써 무선자원의 낭비를 막고 효율적으로 무선자원을 사용할 수 있는 효과가 있다.

【특허청구범위】

【청구항 1】

무선 통신 시스템의 단말에서의 페이징 메시지 수신 방법에 있어서,

단말 식별정보 및 페이징 메시지가 전달되는 페이징 채널(PCH)이 전송되는 시간-주파수 영역의 할당 정보를 포함하는 스케줄링 정보를 포함하는 페이징 인디케이션 정보를 네트워크로부터 수신하는 단계;

상기 단말 식별정보가 상기 단말의 식별자(identity)와 동일한 경우 상기 페이징 인디케이션 정보를 획득하는 단계; 및

상기 페이징 인디케이션 정보에 의해 지시되는 상기 시간-주파수 영역을 통해 상기 네트워크로부터 페이징 메시지를 수신하는 단계를 포함하는, 페이징 메시지 수신 방법.

【청구항 2】

제1항에 있어서,

상기 단말은 유휴모드 상태에 있고, 상기 단말 식별정보는 'long UE idnetity'인 것을 특징으로 하는, 페이징 메시지 수신 방법.

【청구항 3】

제1항에 있어서,

상기 단말은 RRC 연결 모드에 있고, 상기 단말 식별정보는 'short UE identity'인 것을 특징으로 하는, 페이징 메시지 수신 방법.

【청구항 4】

제1항에 있어서,

상기 페이징 인디케이션 정보는 페이징 인디케이션 채널(PICH)을 통해 수신되는 것을 특징으로 하는, 페이징 메시지 수신 방법.

【청구항 5】

제1항에 있어서,

상기 페이징 인디케이션 정보는 L1/2 제어정보에 포함되어 전송되는 것을 특징으로 하는, 페이징 메시지 수신 방법.

【청구항 6】

제1항에 있어서,

상기 페이징 인디케이션 정보는 서로 다른 부반송파(sub-carriers) 및 시간 구간 동안 수신되는 것을 특징으로 하는, 페이징 메시지 수신 방법.

【청구항 7】

제1항에 있어서,

상기 페이징 인디케이션 정보는 페이징 지점(paging occasion) 동안 수신되는 것을 특징으로 하는, 페이징 메시지 수신 방법.

【청구항 8】

무선 통신 시스템의 네트워크에서의 페이징 메시지 전송 방법에 있어서,

단말 식별정보 및 페이징 메시지가 전달되는 페이징 채널(PCH)이 전송되는

시간-주파수 영역의 할당 정보를 포함하는 스케줄링 정보를 포함하는 페이징 인디케이션 정보를 단말로 전송하는 단계; 및

상기 페이징 인디케이션 정보에 의해 지시된 시간-주파수 영역을 통해 페이징 메시지를 전송하는 단계를 포함하는, 페이징 메시지 전송 방법.

【청구항 9】

제8항에 있어서,

상기 단말은 유휴모드 상태에 있고, 상기 단말 식별정보는 'long UE idnetity'인 것을 특징으로 하는, 페이징 메시지 전송 방법.

【청구항 10】

제8항에 있어서,

상기 단말은 RRC 연결 모드에 있고, 상기 단말 식별정보는 'short UE identity'인 것을 특징으로 하는, 페이징 메시지 전송 방법.

【청구항 11】

무선 통신 시스템의 단말에서의 페이징 메시지 수신 방법에 있어서,

단말 식별정보 및 페이징 메시지가 전송될 페이징 채널(PCH)에 대한 스케줄링 정보를 포함하는 페이징 인디케이션 정보를 수신하는 단계;

상기 단말 식별정보가 상기 단말의 식별자와 동일한 경우 상기 페이징 인디케이션 정보를 획득하는 단계; 및

상기 페이징 인디케이션 정보를 이용하여 다수의 셀들로부터 전송되는 다수

의 페이징 채널을 결합함으로써 페이징 메시지를 수신하는 단계를 포함하는, 페이징 메시지 수신 방법.

【청구항 12】

제11항에 있어서,

상기 스케줄링 정보는 상기 페이징 메시지가 전송되는 시간-주파수 영역의 할당정보를 포함하는 것을 특징으로 하는, 페이징 메시지 수신 방법.

【청구항 13】

제11항에 있어서,

상기 페이징 인디케이션 정보는 다수의 셀들로부터 수신되고, 상기 다수의 셀들로부터 수신되는 페이징 인디케이션 정보를 결합하는 단계를 더 포함하는, 페이징 메시지 수신 방법.

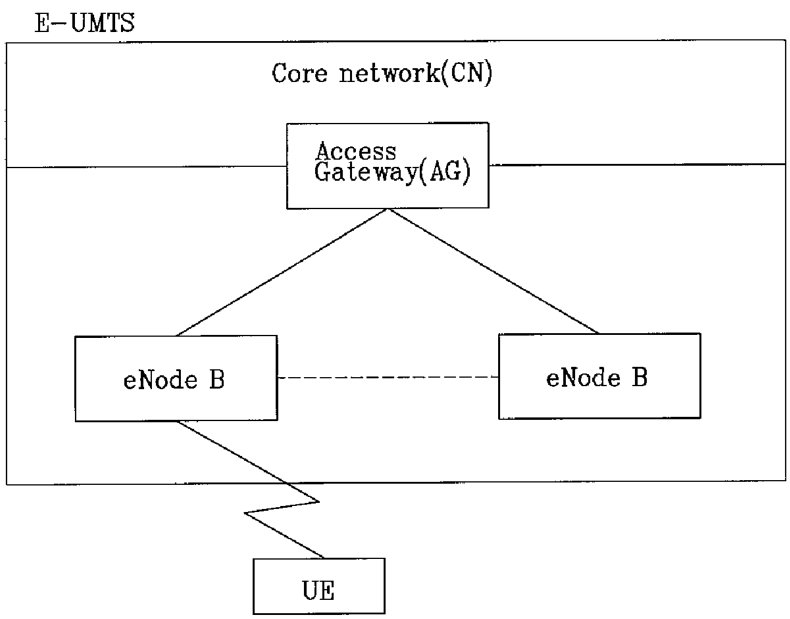
【청구항 14】

제11항 또는 제13항에 있어서,

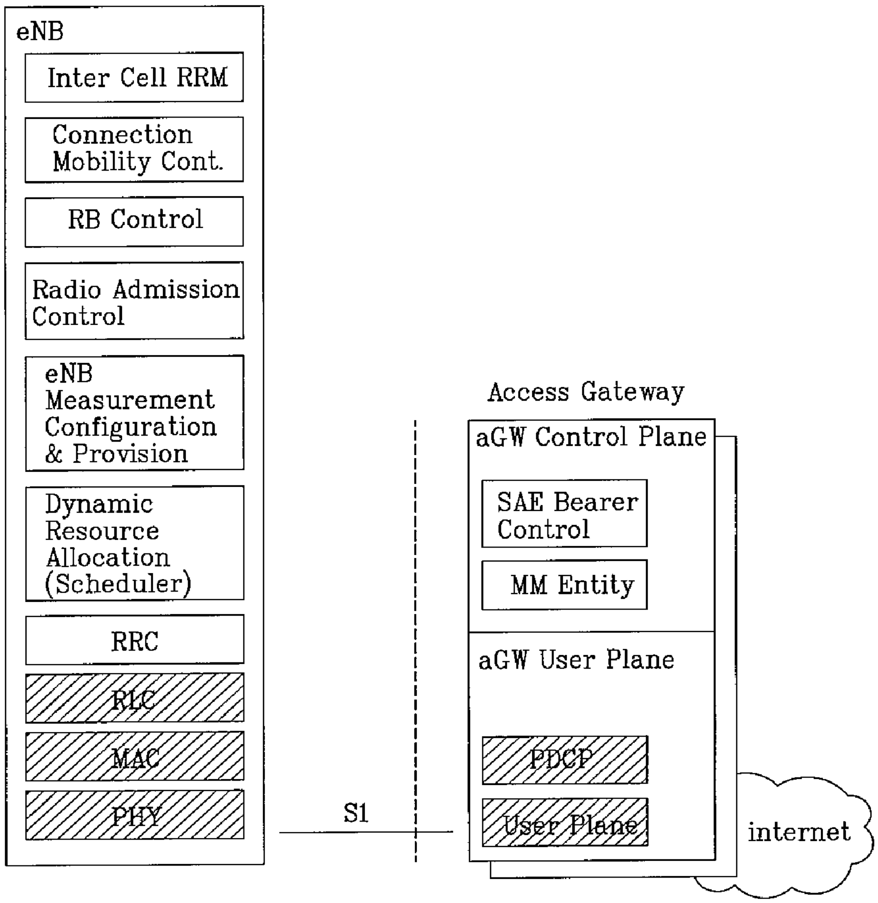
상기 다수의 셀들은 하나의 TA(Tracking Area)에 속하는 것을 특징으로 하는, 페이징 메시지 수신 방법.

【도면】

【도 1】



【도 2】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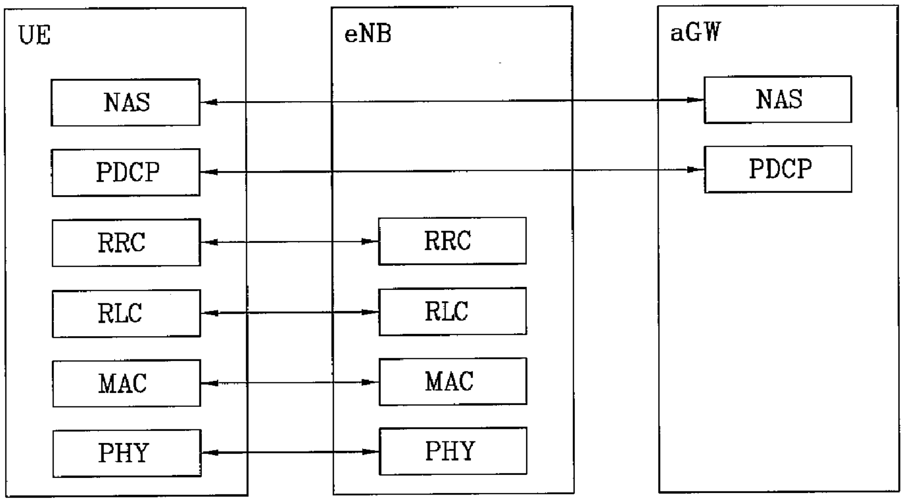
Inter Cell RRM
Connection Mobility Cont.
RB Control
Radio Admission Control
eNB Measurement Configuration & Provision
Dynamic Resource Allocation (Scheduler)
RRC
RLC
MAC
PHY
S1
Access Gateway
aGW Control Plane
SAE Bearer Control
MM Entity
aGW User Plane
PDCP
User Plane
internet

【도 3a】


UE
NAS
PDCP
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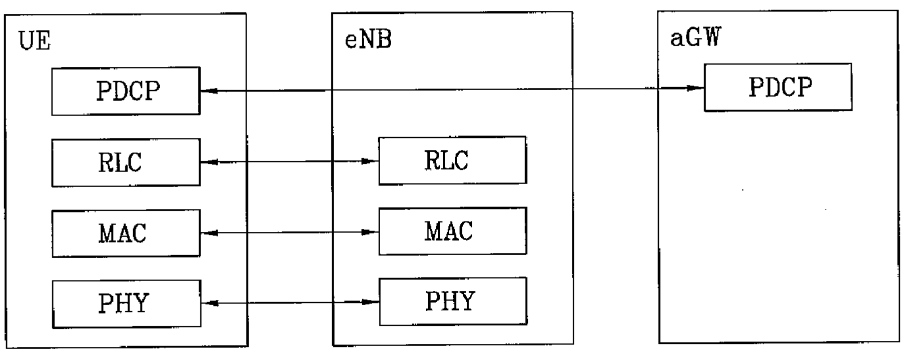
RLC
MAC
PHY
eNB
RRC
RLC
MAC
PHY
aGW
NAS
PDCP

【도 3b】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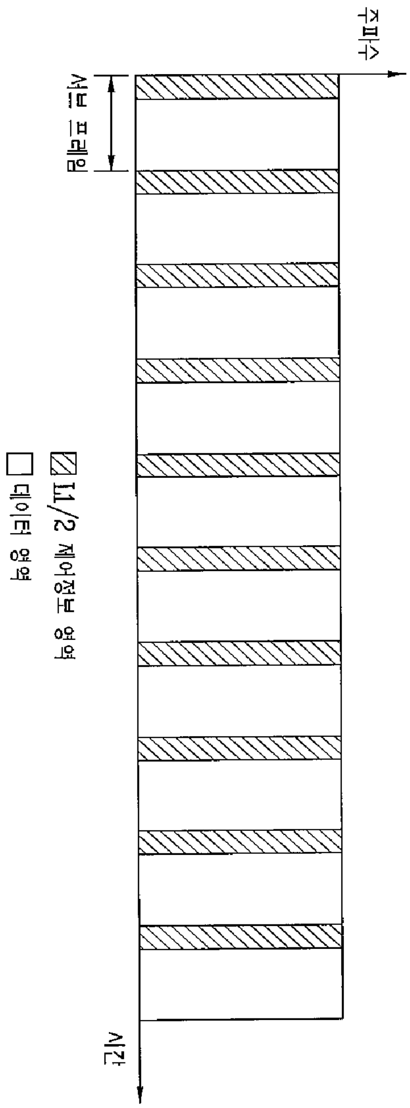
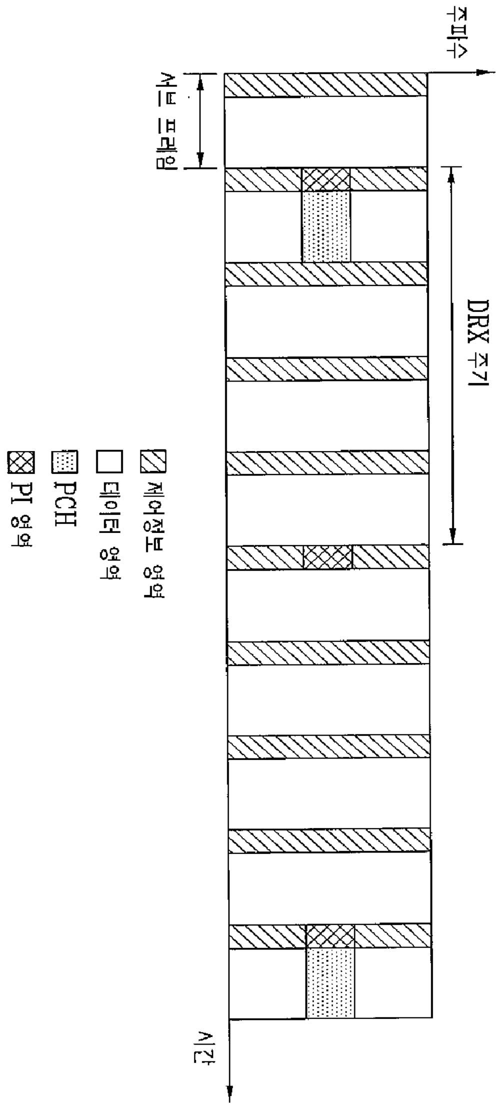
PDCP

【도 4】



【도 5】



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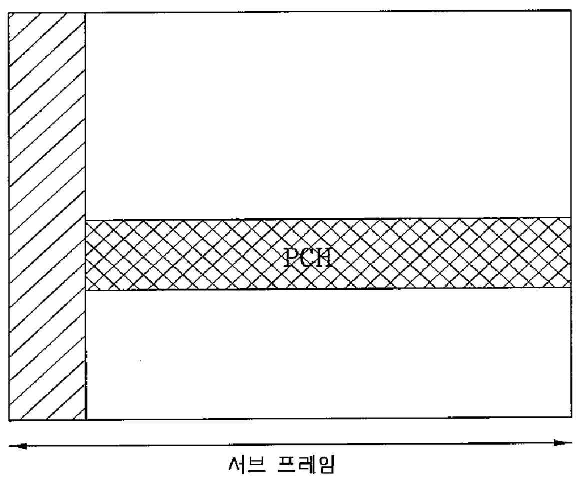

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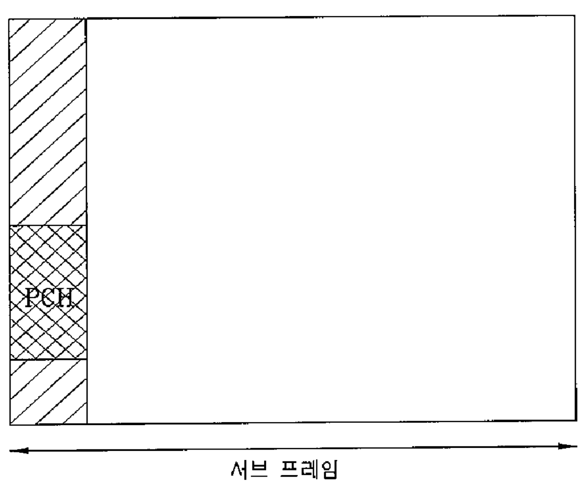

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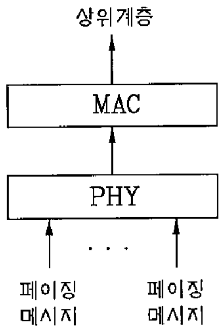

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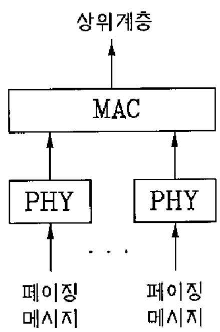

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World Intellectual Property Organization (WIPO) - Geneva, Switzerland
Organisation Mondiale de la Propriété Intellectuelle (OMPI) - Genève, Suisse

PA 7046547

THE UNITED STATES OF AMERICA

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United States Patent and Trademark Office

January 08, 2007

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APPLICATION NUMBER: *60/757,063*
FILING DATE: *January 05, 2006*

THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS *US60/757,063*

By Authority of the
Under Secretary of Commerce for Intellectual Property
and Director of the United States Patent and Trademark Office

M. Tarver

M. TARVER
Certifying Officer

PTO/SB/16 (10-05)
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET – Page 1 of 2

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. EV 656512996 US

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
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SungDuck	Chun	Seoul, Korea
SungJun	Park	Gunpo, Korea
Patrick	Fischer	Bourg la Reine, France

Additional inventors are being named on the ____________ *separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max):

RADIO PROTOCOLS AND PROCEDURES FOR FUTURE MOBILE SYSTEM

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

☑ The address corresponding to Customer Number: 035884

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☐ Application Data Sheet. See 37 CFR 1.76

☐ CD(s), Number of CDs ____________

☑ Specification *Number of Pages* 72

☐ Other (specify) ____________

☐ Drawing(s) *Number of Sheets* ____________

Fees Due: Filing Fee of $200 ($100 for small entity). If the specification and drawings exceed 100 sheets of paper, an application size fee is also due, which is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

METHOD OF PAYMENT OF THE FILING FEE AND APPLICATION SIZE FEE FOR THIS PROVISIONAL APPLICATION FOR PATENT

☐ Applicant claims small entity status. See 37 CFR 1.27.

☑ A check or money order is enclosed to cover the filing fee and application size fee (if applicable).

☐ Payment by credit card. Form PTO-2038 is attached

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TOTAL FEE AMOUNT ($) 200.00

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PROVISIONAL APPLICATION COVER SHEET
Page 2 of 2

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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☑ No.

☐ Yes, the name of the U.S. Government agency and the Government contract number are: ____________________

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SIGNATURE Lew Macapagal   Date January 5, 2006

TYPED or PRINTED NAME Lew Edward V. Macapagal   REGISTRATION NO. 55,416
(if appropriate)

TELEPHONE 213-623-2221   Docket Number: 2101-9150

Customer No: 035884 Attorney Docket No: 2101-9150

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: YoungDae LEE, MyungCheul JUNG, SungDuck CHUN, SungJun PARK and Patrick FISCHER	Art Unit:
	Examiner:
Serial No:	
Filed: Herewith	
For: RADIO PROTOCOLS AND PROCEDURES FOR FUTURE MOBILE SYSTEM	

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Date of Deposit: January 5, 2006

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- ☒ check in amount of $ 200 as filing fee
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PROVISIONAL APPLICATION FOR UNITED STATES PATENT IN THE NAMES OF

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for

RADIO PROTOCOLS AND PROCEDURES FOR FUTURE MOBILE SYSTEM

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1.MAC functionality

Following is assumed to be functionalities of MAC.

- Control of MAC sub-state

The MAC sub-state of UE is controlled by either Node-b or UE. When UE expects no downlink or uplink data for a pre-defined period, it can request the Node-b to transit the UE into MAC-DORMANT sub-state. In this case, if the Node-b agrees to the UE request, then it sends accept message to the UE. The accept message can use either Physical or MAC signalling. Further detailed mechanism should be investigated. The dormant period that will be used in MAC-DORMANT sub-state can be negotiated between UE and Node-b based on the characteristics of the ongoing services.

- Multiplexing of logical channels and transport channels

For optimized radio resource usage, multiplexing of multiple logical channels into one transport channel is desirable. In this case, RBs with similar requirement are combined. At the receiving side, de-multiplexing operation occurs. RBs which are configured to be combined constitute one receiving buffer at the receiver side..

- Priority control

Within a UE, this is related to which RBs should be served before other RBs are served. And within multiple UE, this is related to which UEs should be served before other UEs are served. QoS or each UE and RB can be considered. (How many queues should be supported should be studied? Queue may have relation with Mac-d flows? UDP/TCP/Signalling separation is enough? How many RBs ?)

- QoS Control

Each RB has different delay and bitrate requirement. According to the QoS requirement of each RB, error ratio or delay will be considered. Because UDP type RB has loose error-ratio requirement, this RB may not need upper ARQ mechanism and HARQ operation is enough. On the other hand TCP type RB needs strict error ratio requirement, it needs ARQ in addition to HARQ.

- Scheduling signalling

This function is used for UE to request uplink resource. And this is used to notify scheduled resources to UE. It is FFS whether separate TVM is needed or not. And this information is delivered through scheduling information (MAP) in physical layer..

- HARQ

HARQ is the first entity to control retransmission. After decoding of received data, receiver transmits ACK/NACK to the transmitting side to report the decoding status of the transmitted data. And this information is used for the transmitting to perform another re-transmission or not. It is also FFS whether to use CQI or not, and when to send ACK/NACK. ACK/NACK resource allocation is FFS.

- Status reporting/Error control

ARQ information is used for error-free transmission. Receiver transmits status report to inform transmitter of unsuccessfully received data block. ARQ mechanism further reduce error ratio after HARQ processing.

2. MAC Sub-state

MAC-ACTIVE and MAC-DORMANT are candidates for the sub-states of MAC.

MAC-DORMANT:

While the UE is in MAC-DORMANT, the Node-b does not schedule the UE and the UE can go into DRX. In this state, the UE has to monitor only the first scheduling MAP of each Dormant Period to check for the Downlink data.

It is necessary to support PS continuous connectivity. i.e, the mechanism for the longer stay in RRC-Connected mode should be supported. In this case, there is trade-off between longer Dormant Period and user's perception of QoS. What is general assumption on the period of inactivity period?

We should think about the difference of transition from idle mode to Active mode and transition from Dormant to Active, and vice versa. The trigger for the state transition from MAC-ACTIVE to MAC-DORMANT is also FFS. What should be the criterion? The transition from ACTIVE to dormant is initiated only by Node-b? Or, UE can request transition from ACTIVE to Dormant? So there is a need for a new signalling?

Also it's FFS whether there is a need for a new synchronization mechanism for the uplink for the UE in MAC-DORMANT state.

We believe that there should be a mechanism for a UE to transmit or request resource in uplink direction in the middle of Dormant Period. It's FFS whether this is different mechanism from the RACH mechanism used when going from idle mode to active mode.

The Dormant Period should be flexible or negotiable between UE and Node-b.

MAC-ACTIVE

In this state, UE is actively communicating with Node-B. In this state, the UE has to monitor scheduling MAP at every scheduling period.

To support longer battery time, the scheduling period should be long. So when the UE is not scheduled in this scheduling period, then the UE can go sleep mode until next Scheduling MAP message. Whether this is feasible or not should be consulted.

3. MAC Architecture

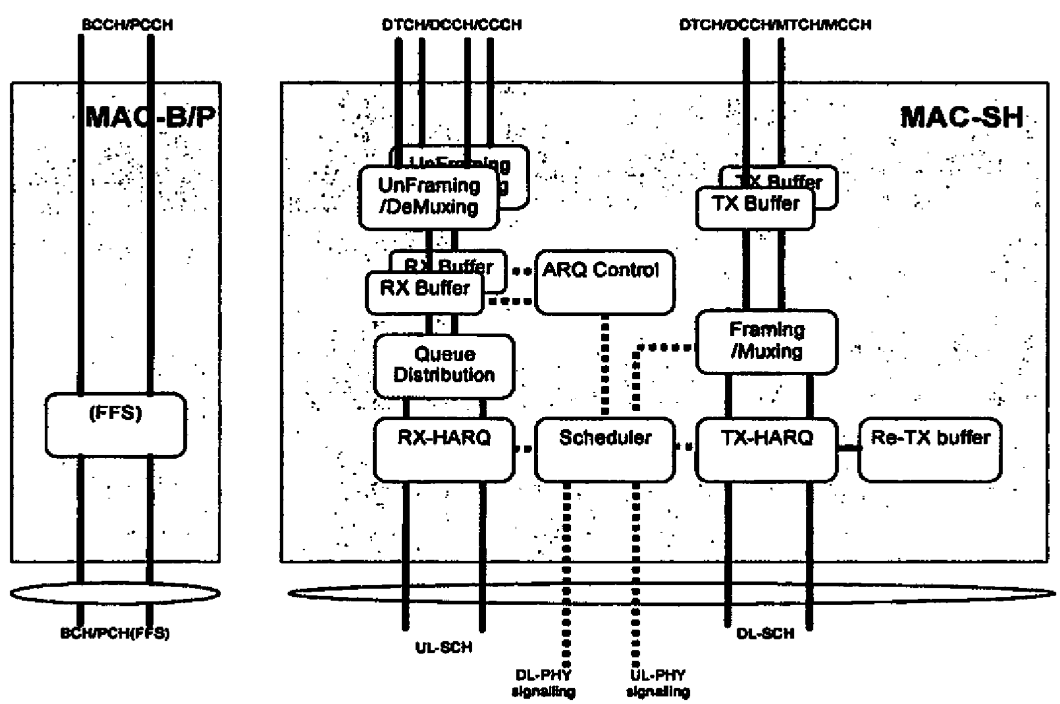


그림 1 Node-B MAC Architecture

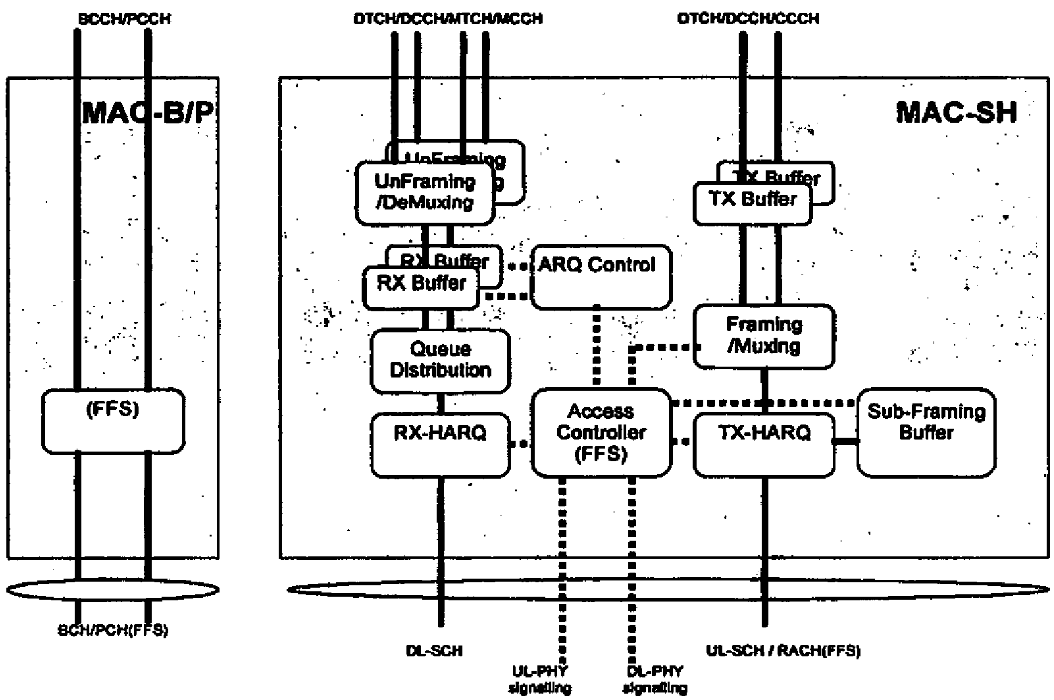


그림 2 UE MAC Architecture

In fact, current figure for the UE and UTRAN look almost same. Further investigation is need. It's because the current figure only consider dedicated traffic. Common traffic or common control signalling and broadcast data should be considered in another figure.

Current figure includes following entities:

- **TX- Buffer**: This is storage for IP SDU which is delivered from Upper layer. After all the PDUs related to the SDU are correctly received by the peer entity, the SDU is removed from storage. In this case, it is FFS whether the delivery of lower numbered SDU should be considered before deletion. Timer can be used to prevent the SDU from staying in the buffer too long. More stall avoidance can be considered. It is assumed that IP SDU has sequence number. With this sequence number of IP SDU level, the UE and Node-b will be operated in synchronization after handover.

- **Framing/Multiplexing**: This is entity which generates MAC PDU according to size and priority indicated by scheduler. In one MAC PDU, data from RBs which are allowed to be multiplexed together are included. And TSN setting is done in this entity. RBs with same QoS requirement are combined into single MAC-d flow or Queue. This restriction can be configured by Node-b.

- **TX-HARQ**: This entity performs HARQ Re-transmission as indicated by scheduler. When ordered to perform HARQ retransmission, the TX HARQ entity performs HARQ retransmission. When ordered to perform new HARQ transmission, it starts new HARQ operation using the new MAC PDU from Framing/multiplexing entity. Old MAC PDU is forwarded to re-TX buffer. In downlink, though MAC PDU retransmission is caused by ARQ not HARQ, the MAC PDU is not subdivided. In this case, the resource allocation is adjusted to support original MAC PDU. The support of this in uplink direction is more complex, further study is needed. Parallel HARQ processes may be needed for optimal performance. The number of process is related to RTT.(We needs an assumption on the number RTT) When scheduler request the retransmission of MAC PDU in re-tx-buffer, then the TX HARQ entity retrieve the MAC PDU from re-tx-buffer and start new HARQ transmission.

- **Re-TX buffer**: This buffer stores MAC PDU transmitted over the air. Until ARQ entity receives confirmation for the successful reception for the MAC PDU, MAC PDU is stored. After ARQ acknowledgement from peer entity, the MAC PDU is removed from storage. This is only in Node-b.

- **Sub-Framing buffer**: This buffer has similar functionality of Re-TX buffer of Node-b. But this buffer additional functionality of re-framing of original MAC PDU. When the allocated resource is less than what is needed for the transmission of original MAC PDU, the original MAC PDU has to be divided into MAC SubPDU. Thus Re-framing buffer performs subframing of original MAC PDU. This is only in UE.

- **Rx-HARQ**: This entity performs HARQ for the reception. Depending on the result of decoding, it generates ACK or NACK. The ACK/NACK is transmitted in physical layer. How the resource for ACK/NACK is allocated is FFS. If a MAC PDU is decoded successfully, it forwards the MAC PDU to Queue Distribution entity. It is assumed that even though retransmission occurs asynchronously, ACK/NACK timing is synchronous to the data transmission. But resource allocation for the HARQ retransmission can be merged with ACK/NACK for optimal scheduling.

- **Queue Distribution**: This entity distributes the MAC PDU to appropriate RX buffer (queue). MAC PDU includes appropriate information such as TSN and queue identity.

- **RX Buffer**: This is buffer for the received MAC PDU. Until all the appropriate MAC PDUs are received, the MAC PDU stays in this buffer. In-order sequence delivery is also supported in this entity. Missing MAC PDUs are detected in this entity and this information is delivered to ARQ Control entity. When ARQ status report is discovered, this information is delivered to scheduler.

- **UnFraming/De-multiplexing** : Using header information, MAC SDUs is recovered form MAC PDUs. And the MAC SDUs are delivered to upper layers via appropriate RBs.

- **ARQ Control**: When there is missing MAC PDU in RX buffer, ARQ control entity generate status report. And this information is delivered to Framing/multiplexing entity, and this information is transferred to the transmitting side included in the MAC PDU. When ARQ information is received from peer entity, the MAC PDUs that should be retransmitted is informed to scheduler.

- **Scheduler:** This is entity that control when to perform transmission of which data. Scheduler informs Framing/Multiplexing entity the available size of MAC PDU and the priority of RBs that should be included in the new MAC PDU. The Scheduler informs TX-HARQ whether to perform new MaC PDU transmission or HaRQ retransmission or ARQ retransmission. Also Scheduler informs TX HARQ when to perform transmission. Node-b scheduler decides the allocation of uplink/downlink resource allocation among the UEs and RBs. And this information is delivered to physical layer. UE scheduler is notified its allocated resource through physical layer which decode UL/DL MAP. This is located in Node-b.

- **Access Controller:** This is entity that control when to perform transmission of which data. Based on the allocated resource by DL/UL MAP, it control the transmission of ACK/NACK or ARQ information, Retransmission, framing, etc. It is FFS whether this entity control RACH access procedure. This entity is in UE.

Note; Above architecture works well for downlink transmission because the scheduler has enough information and enough power.

But Uplink has power limitation and UE scheduler has limited knowledge of Node-b scheduler's intention for the resource allocation. Also the Node-b does not know the size and the priority of missing MAC PDU.

So simpler (even there is inefficiency) or different mechanism is needed. In above architecture, sub-framing is used in UL direction.

For RACH/FACH (it is FFS whether this channels is needed or not. But in case there are needed, RX-TX HARQ's usage is FFS)

We needs to decides terminology. At least "DL/UL MAP" should be changed to nicer name?

---

4. MAC scheduling

Still, I don't have complete picture regarding scheduling. But because there is no activity in LG Ran2, I list the result of my thinking.

Following is my thinking about scheduling.

Asynchronous vs synchronous: When receiver fails in decoding HARQ transmission, HARQ retransmission should occur. Each retransmission occurs after configured time has passed? Or, each retransmission occurs when scheduler has explicitly scheduled the re-transmission? Uplink/Downlink should be considered differently.

Scheduling input parameter:

The scheduler in Node-b should have following information?:

- The priority of each RB
- The priority of each UE
- The support of NST(like in HSUPA)
- The amount of buffered data for each RB
- Negotiated QoS parameter in upper layer
- Support for common/dedicated scheduling?:
- The number of occurred re-transmission (Or, average number?)
- Etc.

Uplink/Downlink timing/interaction:

Only after decoding UL/DL Map, the UE can transmit. So, my assumption is that uplink transmission timing is later than the downlink transmission timing. Then the difference in time is fixed? The difference may not be not UE specific. Node-b has the possibility to combing HARQ ACK/NACK/CQI resource with resource for dedicated traffic for both uplink/downlink. But dedicated physical ACK/NACK channel is also possible. But timing and optimized resource usage should be considered.

Paging

Paging block may precedes scheduling information block. Rather than using PI,(using PICh and PCH), just transmitting UE identity can be considered. This will reduce false alarm. But this may increase wake up time.

Scheduling period concept:

Per TTI scheduling seems to cause much overhead. My assumption is that the scheduling information for the UE is not transmitted in every TTI. At least 4 or 8 TTI is combined to form scheduling period. In this case, Node-b notifies the TTI in which the scheduling information is delivered. For example, if the scheduling period is 4, then some UE has to find scheduling information in first TTI, and some UEs have to find scheduling information in the second TTI.

Bit map scheduling:

The basic idea is that bitmap indicates whether a specific UE will have allocated resource at specific TTI or not. For UE in Active mode, one bit in bitmap indicates whether the UE scheduled or not. If one bit is set for a UE, the UE reads whole scheduling information afterward.

Or if we took a concept hyper frame, which consist of several TTI(0.5ms), the first TTI includes the list of UE which is scheduled in the hyper frame. And the order in which each UE appear indicate the bit location in bitmap(or this can be used short identity). The other tTIs in hyperframe use short identity to reduce overhead.

But for RACH access, every TTI has possibility to transmit scheduling.

Multiple Processes concept:

My assumption is that for each UE at most One PdU is transmitted in one TTI. Thus considering round trip time, there should be at least one process. For higher speed, more than one processes are needed. For downlink, the PDU size of each process can be different.

RE-access:

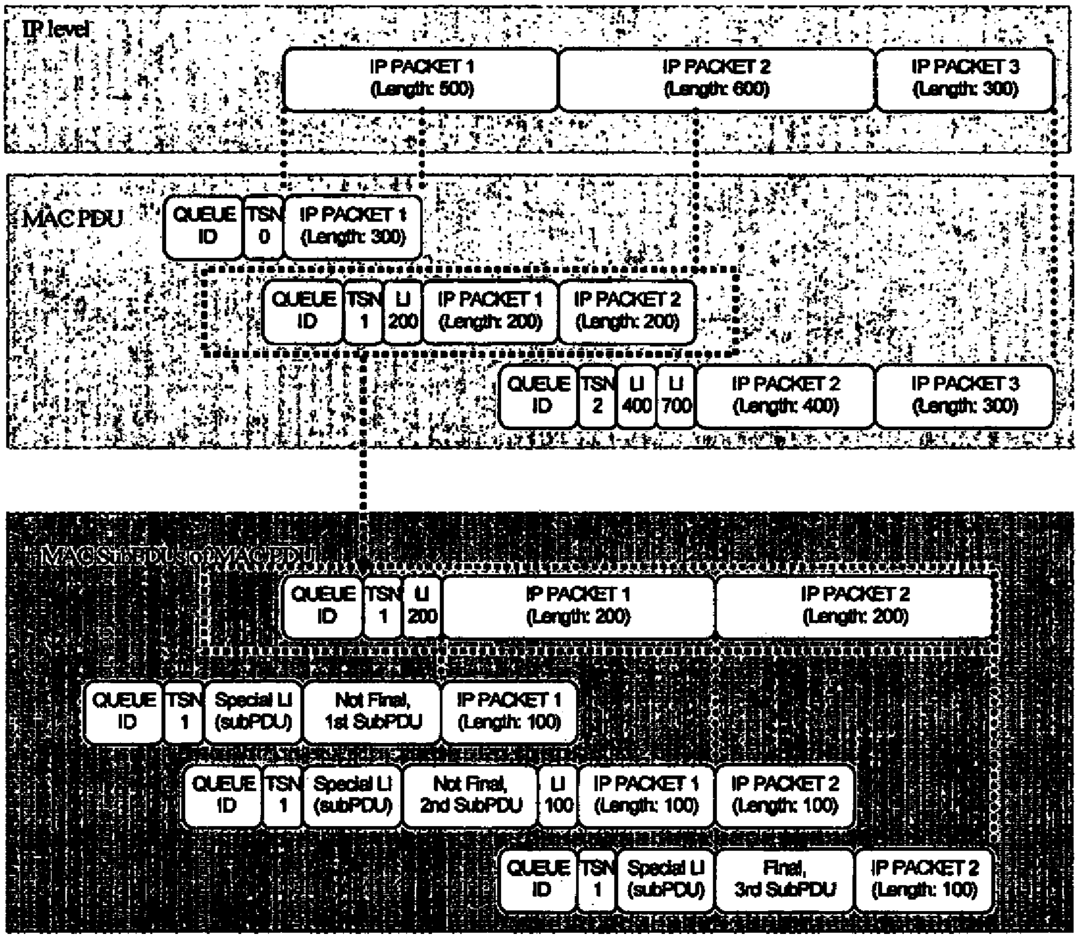
When a Active Mode is not scheduled for uplink resource in hyper frame(or scheduling period), then the UE have to start from contention based channel. To prevent this, the Node-b just include the UE id in scheduling information block without allocation resource. This UE may be allocated dedicated resource in next scheduling period(or hyper frame.)

5. HARQ

5.1 HARQ overview

HARQ is operated per MAC PDU. ARQ is operated based on MAC PDU not MAC SDU. Accordingly, TSN is used for ARQ regardless of whether MAC SDU has its own sequence number or not.

5.2Framing/SubFraming



In UL, the allocated resource does not allow the original size of MAC PDU, the subframing is performed. The original MAC PDU is subdivided into MAC sub-PDUs.

In MAC PDU, following IE is defined:

Queue ID: This defines the relevant queue to which this MAC PDU belongs. Several Queues are defined according to their QoS. RBs of same QoS are grouped into same Queue.

TSN (Transmission sequence number): This is used for re-ordering and ARQ. Whenever new MAC PDU is transmitted, the TSN is incremented.

LI: (Length Indicator). This is used to indicate the boundary of each SDU within a MAC PDU.

Special LI: Some LIs are reserved for special indication. In above example, special LI is used to indicate that the concerned MAC PDU is MAC SubPDU. In above example, next IE of special LI carries about reassembly information. "Final""Non-final" means whether this is final MAC subPDU of MAC PDU. And '1st SubPDU" means this is the first segment of MAC PDU. Thus in above example, the 3rd SUB PDU carries "Final""3rd SubPDU". Thus the receiver knows how many pieces the MAC PDU is divided into.

In fact there is "N" field in HSxPA. But in LTE, PDUs are not of same size and SDUs are tailored best fit to allowed MAC PDU size. Thus N is assumed as 1 in all case.

In this figure logical channel identity information like C/T field is not shown. But it can be easily inserted.

6. RLC status enhancement

RLC status reporting, i.e ARQ, is done using TSN of MAC PDU. When receiving side reports TSNs of missing PDUs, transmitting side re-transmit the PDU.

Because HARQ is employed and the error ratio of HARQ is quite small, it is assumed that we can simply ARQ status report. If we assume HARQ error ratio is 10^{-2}, then there is one missing MAC PDU in every 100 MAC PDU. For 100 MAC PdU, the bit map SUFI needs 13 bytes. But the length of sequence number itself may be less than 2 bytes. Thus it is proposed that only ACK SUFI and List SUFI are used for RLC STATUS report.

MRW is very complex. And this is somewhat related to lossless relocation functionality. And this is related to the fact that PDCP PDU does not have explicit Sequence number. So one possibility is to use sequence number in MAC SDU (this is naturally the case when security is done in AGW).Or MAC PdU use special LI or sufi. But "send MRW" option should be reconsidered.

Reset is very rare event in R6. And this is caused by out-of-sync security context or bad channel condition. In fact RRC and MAC is in the same node. Thus RRC signalling using cell update does not take long time. Thus Reset is handled in RRC.

NACK should be transmitted as soon as possible. Incorporation into MAC PDU header is one possibility. Then special LI can be used.

6. MAC-PHY interface/Primitive/Service

This is the result of previous section.

Agenda item: 8.2

Source: LG Electronics Inc.

Title: HARQ and ARQ Operation 1

Document for: Discussion, Decision

1. Introduction

Through several previous meetings, basic assumption in RAN2 is that ARQ operation is needed in addition to HARQ operation. Though HARQ operation itself can achieve very low error rate required by TCP, the gain is not so big to justify the cost required in physical layer.

With this assumption that both HARQ and ARQ are needed, this document discuss what is expected for each ARQ and HARQ and how they should interact with each other.

2. Discussion

2.1 HARQ and ARQ Operation

HARQ operation works with MAC PDU that is delivered from upper entity. Some entity above HARQ composes MAC PDUs from MAC SDUs. And ARQ operation is located above HARQ.

Depending on what is signalled over ARQ mechanism, following two mechanisms can be considered:

ARQ over MAC PDU:

In this mechanism, the ARQ status information from receiving side tells about which MAC PDUs are received and which MAC PDUs are not received.

ARQ over MAC SDU:

In this mechanism, the ARQ status information from receiving side tells about which MAC SDUs are received and which MAC SDUs are not received.

Following is brief comparison for the two mechanisms.

	ARQ over MAC PDU	ARQ over MAC SDU
Pros	When HARQ transmission fails, only MAC PDU are retransmitted. Because MAC PDU is one level below than MAC SDU, ARQ status reporting is faster. MAC SDU needs not include SN within itself. SN of MAC PDU is enough. But MAC SDU may have SN between ENode-b and ACGW.[FFS]	Amount of bits required for ARQ status information is fewer. When MAC SDU is ARQ-level retransmitted, whole new MAC PDU is constructed. This will ease the scheduling burden.
Cons	Amount of bits required for ARQ status information is larger than the case of ARQ	When HARQ transmission fails, all MAC PDUs for the MAC SDU are retransmitted. In the case when one MAC PDU includes more

	over MAC SDU. When MAC PDU is ARQ-level retransmitted, the allocated resource should be adjusted. This will limit scheduling flexibility.	than one MAC SDU, which can be as long as 1500 bytes, whole MAC SDUs have to be retransmitted. Because MAC PDU is one level below than MAC SDU, ARQ status reporting is slower. MAC SDU has to include its own SN within itself. This is different the use of SN attached to MAC SDU between ENode-b and ACGW. Until ARQ ACK reception, ENode-B has to buffer MAC SDUs though they are segmented into MAC PDUs.

But if HARQ is so robust that HARQ error rate is 10-2 ~10-3, then roughly one MAC PDU out of 100 MAC PDUs is not received in the receiving side. And if only missing PDUs are reported in the ARQ status report, the difference in the required bits for ARQ status reporting may be small.

At first look, when a MAC PDU is needed to be retransmitted due to ARQ status report and when allocated resource is not enough for the transmission of MAC PDU, it seems that ARQ over MAC SDU is preferable. But if we can further segment MAC PDU into smaller pieces, then resource limitation can be easily overcome. In section 2.2, we show how sub segmentation can be done.

Thus, considering above points, we think that ARQ over MAC PDU is preferable in terms of efficiency and throughput.

Conclusion:

The unit of ARQ operation is MAC PDU.

2.2 Framing/SubFraming

In this section, we show one of many methods to perform SubFraming. SubFraming is used to transmit only data included in the MAC PDUs that are reported missing by the receiving side. Without SubFraming, though one MAC PDU is missing in the receiver, whole data of the related MAC SDUs of the MAC PDU is transmitted.

It is FFS whether SubFraming is used only for Uplink direction. Because cell resource scheduler is located in the ENode-b, the frequency and time resource for the MAC PDU in Downlink can be adjusted according channel characteristic. Then, original size of MAC PDU can be supported. But for Uplink direction, due to power limitation and UE capability, more frequency and time resource allocation may not be useful for transmission of original MAC PDU. Thus in this case, SubFraming is useful.

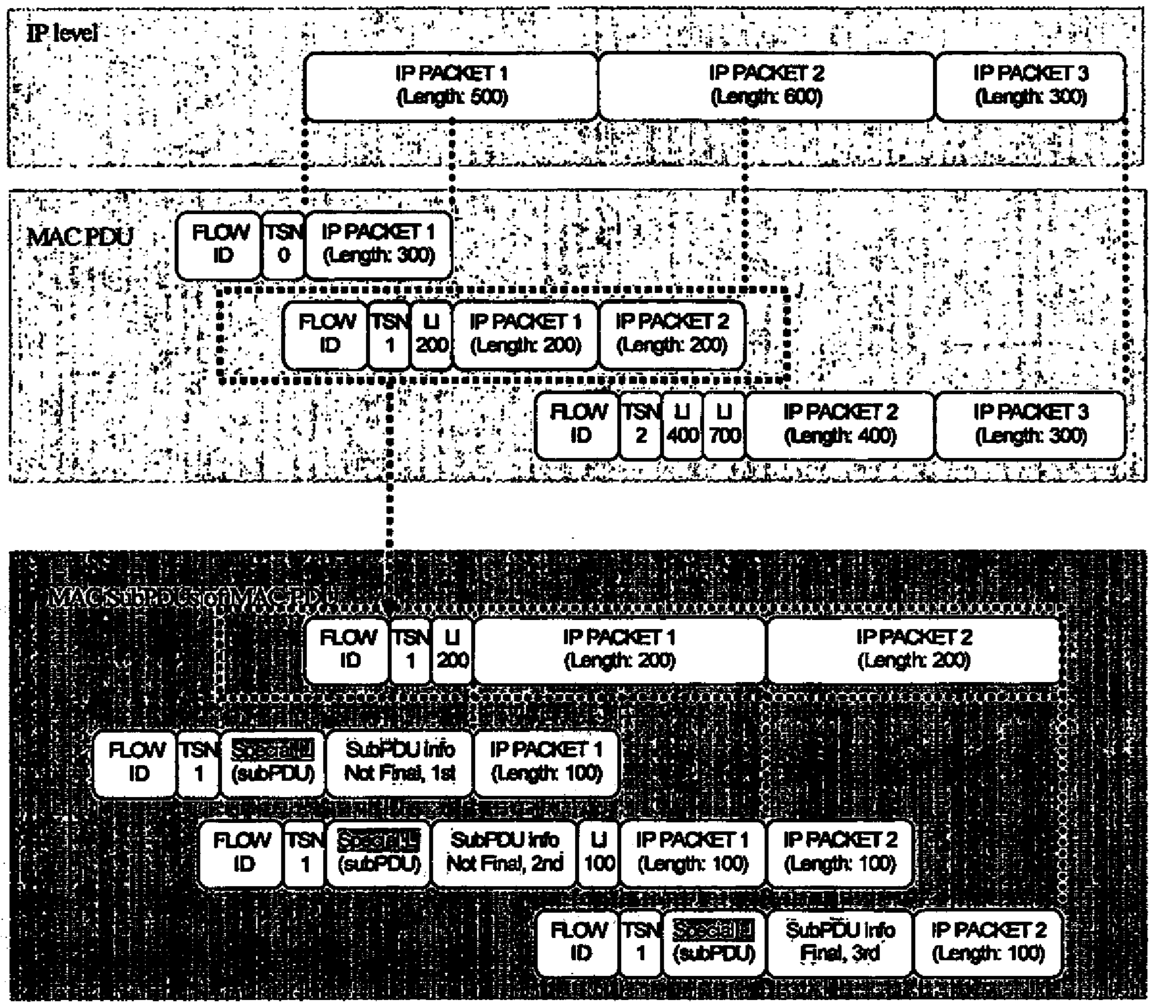


Figure 1 Example of Framing/SubFraming

Above figure 1 shows example on how subframing can be done. For simplicity reason, some fields such as 'F' and 'C/T' are omitted. Following is description for the above figure.

Blue box:

In blue box, three IP packets is shown. From MAC entity point of view, this IP packet is actually MAC SDU. In this example, the length of each IP Packet is 500,600,300 bit.

Yellow box:

In yellow box, how MAC PDUs are composed from original IP packets (MAC SDUs) is shown. The size of each MAC PDU is decided by scheduler. In this example, allowed sizes of MAC PDUs are 300,400 and 700 bit.

MAC PDU includes several header fields.

- Flow ID: This field indicates which flow the MAC PDU belongs to. Several flows may be defined according to their QoS. RBs of similar QoS requirement may be grouped together into same flow.
- TSN (Transmission sequence number): This is used for re-ordering and ARQ purpose. Whenever new MAC PDU is generated, the TSN is incremented. TSN uniquely identifies the order of MAC PDUs.

- LI: (Length Indicator): This is used to indicate the boundary of SDUs within a MAC PDU. Without LI, the receiving side does not know how to reassemble MAC PDUs into MAC SDUs.

Green Box:

In green box, how MAC SubPDUs are composed from original MAC PDU is shown. When upper ARQ indicates that a MAC PDU is missing in the receiving side, the MAC PDU needs to be retransmitted. But at the moment of retransmission, the allocated resource may not be big enough for the size of original MAC PDU. In this case, MAC PDU should be sub-divided into MAC SubPDUs.

In above figure, the second MAC PDU in Yellow box is divided into MAC SubPDUs. The available size of MAC SubPDU is assumed to be 100, 200 and 100 bit.

To discriminate MAC SubPDUs from MAC PDUs, LI with special value is used. When receiving side find a special LI in MAC PDU, it treats this MAC PDU as MAC SubPDU. To identify the original MAC PDU, the TSN field of MAC SubPDU is set to the TSN of original MAC PDU. Here, special LI means LI that has specific value. Normally, the value in the field LI indicates the boundary of MAC SDU. But when this value is set to specific value, then the this is used to signal specific information.

But Special LI can be implemented in other way. Ie when a MaC PDU is marked to have control information, then a type field can be included into the MAC PDU. It's possible for one MAC PDU include several different type of information group, and this information group has different type identifier to assist the receiving side. After type field, the essential information that will be used by the receiver follows.

To identify the order of several MAC SubPDUs for one MAC PDU, "SubPDU info" field is inserted immediately after the special LI. This field tells two things: Whether this MAC SubPDU is the last segment of MAC PDU, the position of this MAC SubPDU within all the MAC SubPDUs. So in above figure, the "SubPDU info" of third MAC SubPDU is set to 'Final' and '3rd'. This indicates that the MAC SubPDU is the final segment of a MAC PDU and the SubPDU is third in position. Accordingly, the receiving side knows that there is 3 MAC SubPDUs.

From HARQ entity's viewpoint, MAC SubPDU is transmitted just like MAC PDU.

Conclusion:

Consider using SubFraming mechanism to support ARQ over MAC PDU.

Another way of construction of MAC PDU is also possible. Rather than using method of LI based MAC PDU construction, each MAC PDU include bitmap which indicates what kind of header field or control information or data is included.

For example, MAC PDU header field can include bit field to indicate the existence of missing MAC PDU information, LI information, discarded MAC PDU information, padding information, etc. So when each of this bit is set, then it means that related information is included in the MAC PDU. This will save many bits. Or this bit can indicate whether this MaC PDU is MAC SubPDU or not.

For simplicity, it is also one of method to some header information into the DL/UL scheduling information. For example, TSN or MAC flow ID information can be included into the DL/UL scheduling information. This will help receiving side whether it has to wait for ARQ level retransmission or whether it has to send ARQ status report or not. Also, this information will help UE to request ARQ level retransmission as soon as HARQ transmission fails. This is beneficial especially when NACK/ACK error has occurred.

2.3 ARQ Status Reporting

Unlike AM RLC of R6, which does not have so much information about HARQ status in MAC layer, ARQ layer can work in optimized way when ARQ and HARQ are included in the same MAC entity and share information. First of all, following events can be considered.

Failure of Maximum Number of HARQ Retransmission:

This event is used at transmitting side. When transmitter receives HARQ NACK for the last trial of HARQ retransmission for a MAC PDU, this event can be used to trigger ARQ level retransmission. Accordingly, ARQ level

MAC PDU retransmission occurs faster than the case when the ARQ level retransmission is triggered by Status Report from peer entity.

But this should be considered carefully. It's because automatic ARQ level retransmission can cause unnecessary transmission if the received final HARQ NACK is caused by misinterpretation of HARQ ACK. And if control information is included in that MAC PDU, automatic ARQ retransmission is not desirable.

Thus maximum number of HARQ retransmission failure event should not be used as the criterion for trigger of ARQ level retransmission.

New MAC PDU Transmission in Case of NACK Transmission

This event is used at receiving side. When the HARQ process did not reach maximum number of retransmission and the receiving side transmitted HARQ NACK, if receiving side detects new MAC PDU transmission for the same HARQ process, this situation can be used to trigger ARQ status reporting. Because the receiving side know that there is a missing MAC PDU, the receiver can transmit Status Report immediately.

But the problem is that the receiving side does not know what kind of data is included in the missed MAC PDU. For example, if the MAC PDU was used to transport data for the VoIP service, then ARQ will not be used. Accordingly, the NACK/ACK misinterpretation event should not be as the only criterion for the receiver to send Status Report.

In short, implicit generation of ARQ status information using HARQ status has both merit and drawback. But assuming short TTI of 0.5ms and very low rate of HARQ error, the additional burden cause by implicit ARQ status reporting seems not convincing.

Accordingly, explicit indication of missing MAC PDUs from receiving side to transmitting side as in R6 AM RLC should be used for ARQ level retransmission.

Conclusion:

Explicit ARQ status reporting is used for LTE.

Because the Status reporting mechanism in R6 AM RLC is too complex, Status Reporting in LTE should be more simple. Following can be considered.

SUFI in Control PDU

In R6, there are many different kinds of SUFIs for RLC AM. Considering that HARQ is robust as to allow 10-2 error rate and the number of MAC PDUs for a MAC SDU will be small due to optimized framing, it seems that so much different kind of SUFI of R6 is not justified. It seems to be rare case that one Status Report indicates more than one missing MAC PDU.

Reset and MRW Procedure

In R6, reasons for the occurrences for RESET or MRW procedure are out-of-sync security context or bad channel condition. With robust HARQ, it seems that the condition for RESET or MRW is rarely met. And when a MAC PDU fails a certain number of ARQ level retransmission, reconfiguration at RRC level can be one solution. Accordingly, it is proposed not to adopt Reset and MRW procedure or to process this event at RRC level.

Timer_Poll_Prohibit, Timer_Poll_Periodic, Timer_Status_Prohibit, Timer_Status_Periodic

Because ARQ and HARQ reside in the same entity, it can share much information. Because of HARQ transmission status is available, the usefulness of these complex mechanisms are questionable. It is proposed not to adopt these mechanisms or limit there applicable scenario to minimum in LTE.

Considering above three points, one simple method for ARQ status reporting is that receiving side transmits ARQ status report as soon as receiver detects missing MAC PDU. It is FFS how the ARQ status reporting is delivered. Inclusion of ARQ Status report into MAC PDU header or using stand alone control MAC PDU is one of many possibility.

Following is possible method for ARQ Status Reporting

Status Reporting in MAC PDU Header

In this method, the information about missing MAC PDU is included in the MAC PDU header. When receiving side has detected missing MAC PDU, then the receiver include the SN of missing MAC PDU into the MAC header of MAC

PDU that will be transmitted. To indicate the existence of Status Report, special LI can be used. After special LI that indicates the existence of Status Report, the sequence number of missing MAC PDU can be listed.

Status Reporting in DL/UL scheduling

In this method, the information about missing MAC PDU is included in the DL/UL scheduling information. At least for downlink, the scheduler in Enode-b indicates the UE what MAC PDU it should retransmit. HARQ level ACK/NACk is different thing. And in UL/DL scheduling information, the transmitter include the information about MAC PDU which will not be re-transmitted even in ARQ level. Or after final trial of HARQ retransmission, scheduling information can include information of MaC PDU which it has aborted transmission. With this information, the receiving side can decide whether it will wait for this MaC PDU or whether it will request further the retransmission of this MaC PDU.

Status Reporting requirement in UL/UL scheduling

When Enode-b schedule new transmission, it include the ARQ requirement into DL/UL scheduling information. In other words, when the E-nodeb indicate new MAC PDU transmission over DL/UL scheduling information, it also indicates whether the ARQ level acknowledge of thie MAC PDU is required or not. When it is indicated that the ARQ level acknowledge is required for this MAC PDU, the UE should indicated the reception status of this MAC PDU in ARQ level in addition to the HARQ level ACK/NACk.

MRW over MAC PDU header

When the transmitter decides that it will not transmit an MAC PDU over ARQ level, then it should indicates this fact to the receiving. Unless, the receiving side will wait this MaC PDU or it will request the retransmission of the MAC PDU. Thus, the transmitting side should inform the MAC PDU that it will not ARQ level re-transmit or it does not want to receive ARQ level acknowledgement for this MAC PDU. To do this, the transmitting side indicates the TSN of the MAC PDU into MAC PDU header. For this, MAC header can use special LI.

HARQ NACK with scheduling. Or process ID

For one MAC PDU, the ACK/NACk for the HARQ transmission is transmitted via separate channel. But for the ACK/NACk for the last trial of HARQ transmission, this can be sent over DL/UL scheduling information. This will help the receiving side to immediate schedule ARQ level retransmission of the MAC PDU. Or for each period, the UL/DL scheduling information can include not only ACk/nack for HARQ operation but also the ARQ status report.

Field Omission For same Process

One of possibility to reduce MAC PDU overhead is to map RB or MAC I flow to process. In other words, if one process handles only one MAC I flow and other process does not carry data for that flow, then some field like TSN or flow ID can be omitted. It seems possible to remove other header field.

3. Conclusion

It is proposed to discuss and agree to:

- Use ARQ over MAC PDU.
- Include mechanism in section 2.2 as one possibility of SubFraming mechanism in the LTE TR.
- Use ARQ Status reporting to request ARQ level retransmission.

4. Reference

[1] R2-060xxx, Rxx, LG Electronics

3GPP TSG-RAN WG2 #50 **R2-060106**

Agenda item: 8.2

Source: LG Electronics Inc.

Title: HARQ and ARQ Operation 2

Document for: Discussion, Decision

1. Introduction

Through several previous meetings, basic assumption in RAN2 is that ARQ operation is needed in addition to HARQ operation. Though HARQ operation itself can achieve very low error rate required by TCP, the gain of removing ARQ is not so big to justify the cost required in physical layer.

With this assumption that both HARQ and ARQ are needed, this document discuss what is expected for each ARQ and HARQ and how they should interact with each other.

2. Discussion

2.1 Location of ARQ

There are in principle two alternatives for the location of the ARQ entity, i.e. the E-NodeB or the RNC. Different scenarios could be envisaged which impact the design of the ARQ / HARQ entity:

Ciphering or Integrity Protection could be done either in the AGW or in the ENodeB depending on further discussions. However even in the case it will be decided that ciphering and integrity protection should be done in the AGW we believe that the ARQ should be located in the E-NodeB because this allows the quickest feedback and reduces the overhead due to retransmissions in the normal stationary case.

Proposal: Locate the ARQ entity in the E-NodeB.

2.2 HARQ and ARQ Operation

In our model the ARQ functionality would be located in the MAC layer. The main function would be the lossless delivery if necessary, and segmentation and re-assembly in order to adapt the MAC-SDUs to the size required by the scheduler. Detection of Duplication and In-sequence delivery should also be included as functionality.

In R6 the RLC PDU size in case of AM-RLC was fixed. This was due to the fact that fast channel type switching was required whilst maintaining the RLC context. At this moment we don't see the need for fast channel type switching and propose therefore that the ARQ PDUs would be of variable size depending on the size requested by the scheduler.

HARQ operation works on MAC PDUs that are delivered from the ARQ entity. The ARQ entity above the HARQ entity composes MAC PDUs from MAC SDUs. The main functions for the HARQ entity would be the transmission of the MAC PDUs and the error detection. It should be considered whether in-sequence delivery should be a required, or whether the ARQ protocol can be designed to support out-of-sequence delivery.

There are two choices on which the retransmission protocol could act:

ARQ retransmits MAC PDUs:

In this mechanism, the ARQ status information from receiving side tells about which MAC PDUs are received and which MAC PDUs are not received.

ARQ retransmits MAC SDU:

In this mechanism, the ARQ status information from receiving side tells about which MAC SDUs are received and which MAC SDUs are not received.

Following is a brief comparison for the two mechanisms.

	ARQ over MAC PDU	ARQ over MAC SDU
Pros	When HARQ transmission fails, only MAC PDUs are retransmitted. Because MAC PDUs are one level lower than MAC SDUs, ARQ status reporting is faster. MAC SDU does not need to include a SN within itself. SN of MAC PDU is enough. But MAC SDU may have SN between ENode-b and ACGW.[FFS]	Amount of bits required for ARQ status information is smaller. When MAC SDU is ARQ-level retransmitted, whole new MAC PDU is constructed. This will ease the scheduling burden and allows to adapt to changed radio / traffic scenario.
Cons	Amount of bits required for ARQ status information is larger than the case of ARQ over MAC SDU. When MAC PDU is ARQ-level retransmitted, the allocated resource should be adjusted. This will limit scheduling flexibility.	When HARQ transmission fails, all MAC PDUs for the MAC SDU are retransmitted. In the case when one MAC PDU includes more than one MAC SDU, which can be as long as 1500 bytes, whole MAC SDUs have to be retransmitted. Because MAC PDU is one level below than MAC SDU, ARQ status reporting is slower. MAC SDU has to include its own SN within itself. This is different the use of SN attached to MAC SDU between ENode-b and ACGW. Until ARQ ACK reception, ENode-B has to buffer MAC SDUs though they are segmented into MAC PDUs.

If HARQ is so robust that HARQ error rate is 10-2 ~10-3, then roughly one MAC PDU out of 100 MAC PDUs is not received in the receiving side. And if only missing PDUs are reported in the ARQ status report, the difference in the required bits for ARQ status reporting may be small.The framing for ARQ is shown in Figure 1, where the segmentation / concatenation is shown in the orange box.

Conclusion:

The unit of ARQ operation is MAC PDU.

2.3 Framing/SubFraming

When a MAC PDU is needed to be retransmitted due to ARQ status report it could be possible that the channel quality and / or the traffic situation have degraded. Therefore the size of the MAC-PDU needs to adapted.

In this section, we show one of many methods to perform SubFraming. SubFraming is used to transmit only MAC PDUs that are reported missing by the receiving side. Without SubFraming, when one MAC PDU is missing in the receiver and the MAC-PDU size would exceed the available resources of the scheduler, this would result in a blocked situation.

It is FFS whether SubFraming is used only for Uplink direction. Because cell resource scheduler is located in the ENode-b, the frequency and time resource for the MAC PDU in Downlink might be adjusted according channel characteristic. Therefore the cases where the, original size of MAC PDU can not be supported should be rare. But for Uplink direction, due to power limitation and UE capability, more frequency and time resource allocation may not be useful for transmission of original MAC PDU. Thus in this case, SubFraming is useful.

PFI: In the drawing the special indicator needs to come before the TSN such that control and data PDUs can be distinguished

SD: In the drawing, special LI indicates this is MAC SubPDU. Additionally, I included one more word below. ("D/C")

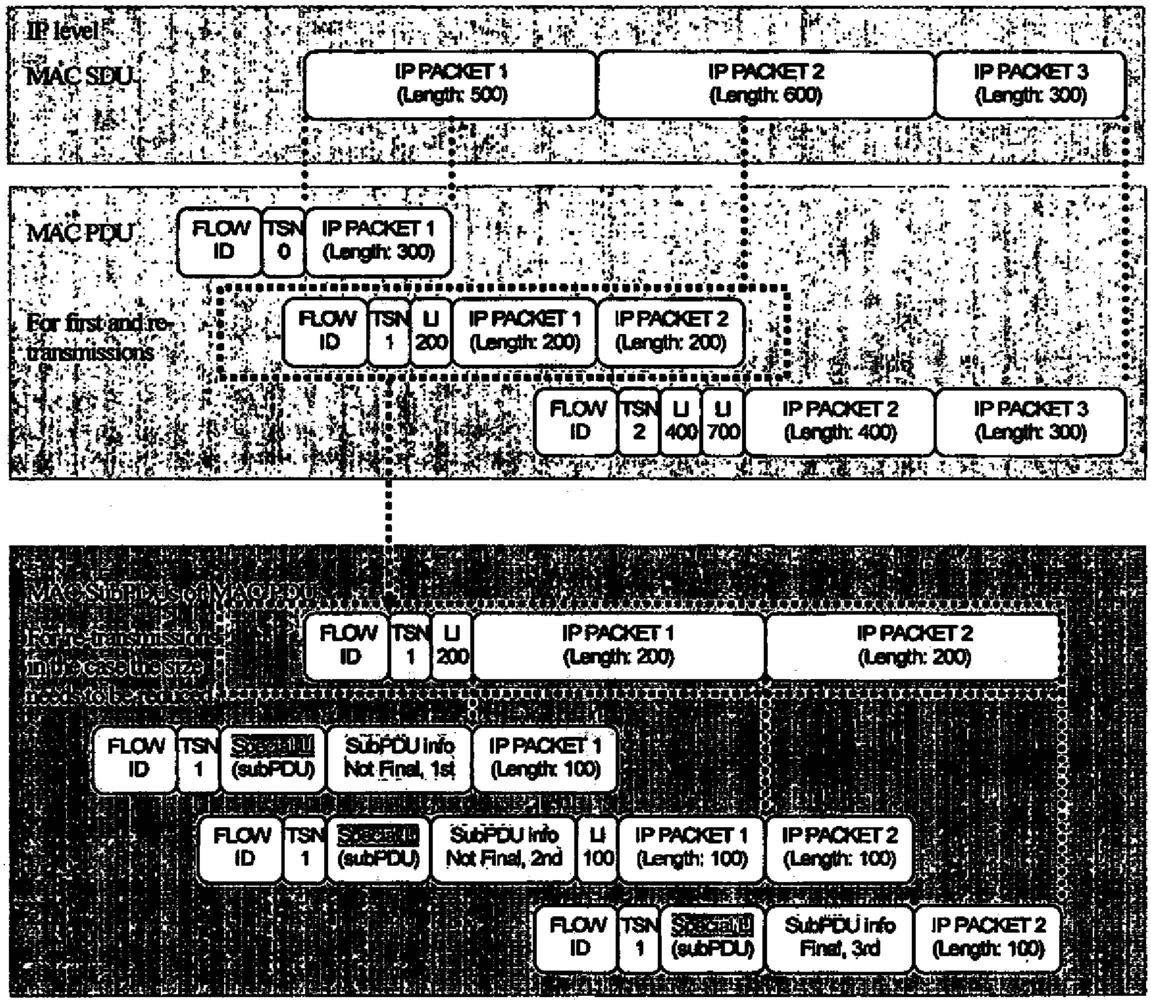


Figure 1 Example of Framing/SubFraming

Above figure 1 shows an example on how subframing can be done. For simplicity reason, some fields such as 'F' and 'C/T' or "D/C" are omitted. Following is description for the above figure.

Blue box:

In the blue box, three IP packets are shown. From MAC entity point of view, this IP packet is actually MAC SDU. In this example, the length of each IP Packet is 500,600,300 bit.

Yellow box:

In the yellow box, how MAC PDUs are composed from original IP packets (MAC SDUs) is shown. The size of each MAC PDU is decided by the scheduler. In this example, the allowed sizes of MAC PDUs are 300,400 and 700 bit.

MAC PDU include several header fields.

- Flow ID: This field indicates which flow the MAC PDU belongs to. Several flows may be defined according to their QoS. RBs of similar QoS requirement may be grouped together into the same flow although this is FFS.
- TSN (Transmission sequence number): This is used for re-ordering and ARQ purpose. Whenever new MAC PDU is generated, the TSN is incremented. TSN uniquely identifies the order of MAC PDUs.
- LI: (Length Indicator): This is used to indicate the boundary of SDUs within a MAC PDU. Without LI, the receiving side does not know how to reassemble MAC PDUs into MAC SDUs.

Green Box:

In the green box it is shown how MAC SubPDUs are composed from original MAC PDU. When upper ARQ indicates that a MAC PDU is missing in the receiving side, the MAC PDU needs to be retransmitted. In the case that at the moment of retransmission the allocated resource are not big enough for the size of the original MAC PDU the MAC PDU should be sub-divided into MAC SubPDUs.

In above figure, the second MAC PDU in the yellow box is divided into MAC SubPDUs. The available size of MAC SubPDU is assumed to be 100, 200 and 100 bit.

To discriminate MAC SubPDUs from MAC PDUs, a LI with a special value would be used. When the receiving side finds a special LI in MAC PDU, it treats this MAC PDU as MAC SubPDU. To identify the original MAC PDU, the TSN field of MAC SubPDU is set to the TSN of the original MAC PDU.

To identify the order of several MAC SubPDUs for one MAC PDU, "SubPDU info" field is inserted immediately after the special LI. This field tells two things: Whether this MAC SubPDU is the last segment of MAC PDU, the position of this MAC SubPDU within all the MAC SubPDUs. So in above figure, the "SubPDU info" of third MAC SubPDU is set to 'Final' and '3rd'. This indicates that the MAC SubPDU is the final segment of a MAC PDU and the SubPDU is third in position. Accordingly, the receiving side knows that there is 3 MAC SubPDUs.

In the case that a transmission of MAC SubPDU would fail the handling is FFS, i.e. whether the MAC SubPDU would be segmented further or not. One possibility is to set lower target error ratio for MAC SubPDU. But one can argue that the probability of transmission of both MAC PDU and its MAC SubPDU is very small.

From HARQ entity's viewpoint, MAC SubPDU is transmitted just like MAC PDU.

Conclusion:

Consider using SubFraming mechanism to support ARQ over MAC PDU.

2.4 ARQ Status Reporting

Unlike AM RLC of R6, which does not have so much information about HARQ status in MAC layer, ARQ layer can work in an optimized way when ARQ and HARQ are included in the same MAC entity and share information. Details for the interoperation would be FFS. Because the BLER of the HARQ should be very small we believe that it should be reasonable that a quite limited ARQ mechanism would be implemented.

3. Conclusion

It is proposed to discuss and agree to:

- Use ARQ over MAC PDU.
- Include mechanism in section 2.2 as one possibility of SubFraming mechanism in the LTE TR.

4. Reference

[1] R2-060105, MAC Architecture of LTE, LG Electronics

3GPP TSG RAN WG2 Meeting #50 ***R2-06xxxx***

Source: **LG Electronics**

Title: **LTE MAC scheduling and signaling parameters**

Agenda Item: **8.3**

Document for: **Discussion & Decision**

1. Introduction

This document discusses MAC scheduling and scheduling related signalling parameters for LTE system.

2. Discussion

Scheduling Period for Shared Channel

E-NB periodically transfers 'Scheduling Information' every scheduling period for Shared Channels. The Scheduling Information may be transmitted using fixed position of radio resource at each TTI (0.5 ms). Thus, E-NB could schedule transmissions every TTI for several users.

However, per TTI scheduling for one UE seems to cause much overhead. For this reason, the scheduling information for one UE is not transmitted in every TTI. As one scheduling grant is used for all the active processes in HSUPA, several TTI may be combined to form one scheduling period. E-NB may allocate the start of scheduling period of different UEs to different TTI in order to distribute signalling overhead over several TTIs.

E-NB may be able to configure length and offset of scheduling period for each UE based on UE/NB capabilities. Also, E-NB could take into account UE DRX operation to determine length and offset of scheduling period for the UE.

It should be studied whether or not scheduling period of DL transmission is always related to scheduling period of UL transmission for one UE. If scheduling period for DL/UL transmissions are same for one UE, signalling overhead for DL/UL scheduling information could be reduced.

In details, transmission of scheduling information for UL transmission is collocated with transmission of scheduling information for DL transmission. Thus, UE can receive scheduling information for UL transmission whenever UE receives scheduling information for DL transmission. E-NB will indicate only scheduling period for DL transmission to the UE.

Feedback for Shared Channel Transmissions

To control AMC, frequent channel quality reporting like CQI should be supported in uplink. Also, ACK/NACK signalling is needed for HARQ in both directions.

To transmit CQI and ACK/NACK for DL traffic, an uplink control channel for DL traffic is needed. Also, to transmit ACK/NACK for UL traffic, a downlink ACK/NACK channel for UL traffic may need to be introduced. It is assumed that time difference between a packet and its ACK/NACK is fixed at least in terms of TTI for both uplink and downlink.

The downlink ACK/NACK channel for UL traffic can be different from DL control channel transmitting scheduling information of DL or UL transmissions. But, if not, for UL transmissions, a group of ACK/NACKs of several HARQ processes for each scheduling period could be included in each scheduling information transmitted on DL for the scheduling period. In this case, time difference between a packet and its ACK/NACK is not fixed. When a scheduling information is transmitted on DL, UE can receive a group of ACK/NACKs of several HARQ processes for UL transmissions every scheduling period.

In uplink, CQI could be reported every TTI (0.5 ms) in case radio channel is fast varying. If CQI reporting is very frequent from several users, radio resource used for CQI transmissions would suppress the amount of traffic transmitted in uplink. Thus, optimized way of CQI transmission needs to be studied.

When E-NB schedules data transmissions, E-NB could control CQI reporting. Also, E-NB could re-assign radio resources for CQI reporting and ACK/NACK transmissions of scheduled data.

Scheduling of Paging & System Information

If PCH channel always uses fixed radio resource i.e. frequency and time, E-NB has less flexibility of SCH scheduling. Thus, we could consider that E-NB schedules PCH channel as well as SCH channel within a UE specific paging occasion of every paging DRX cycle. A paging indication within the paging occasion could inform the UE of whether or not a paging message for the UE is scheduled within the paging occasion. Also, the paging indication could signal scheduled time/frequency of the paging message like the SCH scheduling.

In case of system information, MIB should use a fixed resource because LTE UE cannot presumably acquire any control information before receiving MIB in a cell. However, E-NB could schedule SIBs like SCH within a specific TTI indicated by MIB. If a certain SIB is scheduled within a certain TTI, control information of the TTI could indicate existence of SIB in the TTI and scheduled time/frequency of SIB. By this way, E-NB could have more flexible size of SIB within a range of minimum UE capability. Also, E-NB can have more flexibility of SCH scheduling.

In details, at first UE receives MIB at the fixed DL resource (e.g. time/code/frequency). If MIB includes a long-term scheduling information of SIB transmissions and UE has a specific SIB that the UE should receive, UE receives the DL control channel for one or more TTIs indicated by the long-term scheduling information of the SIB in order to acquire a short-term scheduling of the SIB. And then if UE find that the short-term scheduling information at the TTI on a DL control channel indicates the existence of the SIB in this TTI and the UE successfully receives the short-term scheduling information of the SIB, UE receives the SIB at the DL resource on a DL broadcast channel (e.g. time and frequency of the DL broadcast channel) indicated by the short-term scheduling of the SIB. Afterwards, UE operates based on the received SIB.

Scheduling of Multicast & Broadcast

It is suggested that MBMS is transmitted on DL SCH channel. In this case, scheduling information of MBMS transmissions are provided on scheduling information of DL SCH channel. Thus, there may be no need for R6 MSCH like channel. Further study on this is needed.

In details, the scheduling information of DL SCH channel at one or more TTIs on DL shared control channel indicates short-term scheduling information of an MBMS service transmission within the one or more TTIs. Thus, If UE receives the short-term scheduling information at one or more TTIs on DL shared control channel for an MBMS service transmission the UE wishes to receive, the UE receives MBMS traffic or control information for the MBMS service transmission at the one or more TTIs by using DL resource (e.g. time/frequency/code) indicated by the received short-term scheduling information. In the meantime, UE can receive a long-term scheduling information relating to the MBMS service transmission by receiving a DL channel. The long-term scheduling information indicates when the MBMS service transmission is available. UE will try to receive the DL shared control channel for a period indicated by the received long-term scheduling information, in order to acquire the short-term scheduling information of the MBMS service transmission.

DL SCH for MBMS would be different from DL SCH for dedicated services. For example, it is difficult to use ACK/NACK and CQI reporting for MBMS transmissions. Thus, multiplexing of MBMS and dedicated services on the same SCH should not be allowed for simplicity. But, scheduling of MBMS and dedicated services at the same TTI does not need to be prevented in order to give more freedom to E-NB scheduler.

3. Scheduling related Signalling Parameters

The following signalling parameters are proposed for MAC or L1 signalling. Details of parameters are FFS. Additional information can be included in this list.

Information transmitted on DL for DL SCH transmission

1. List of Scheduled UE/Service
   - UE identity (cell level identity or TA level identity [FFS])
   - Service identity (for MBMS)
2. HARQ/ARQ information for each UE identity [Details are FFS]
3. DL TFRI information for each UE/Service identity
   - Modulation and coding info

- Transport block size (= Transport block set size)
- Time and frequency for scheduled DL transmission

4. Feedback information for each UE identity
   - Time and frequency for UL feedback of scheduled DL transmission (i.e. UL resource allocation of ACK/NACK/CQI transmissions for scheduling period):

     In details, E-NB allocates a certain UL resource (e.g. time and frequency) to UL ACK/NACK of the transport block included in this information and to CQI reporting for a scheduling period in which this resource allocation is valid. If UE receive this feedback information for a UE identity corresponding to the UE and this feedback information corresponds to transmission of the transport block that UE will receive, after reception of the transport block, the UE should transmit ACK/NACK with this allocated time and frequency i.e. this allocated UL resource allocation for the scheduling period. And If UE receive this feedback information for a UE identity corresponding to the UE, the UE should transmit CQI with this allocated time and frequency i.e. this allocated UL resource allocation for the identified scheduling period. Additionally, this feedback information can comprise a period of CQI reporting, number of repetition of CQI/ACK/NACK information and how CQI reporting is triggered. If UE receives the additional feedback information, UE has to transmit CQI/ACK/NACK information according to the received additional feedback information.

Information transmitted on UL for DL SCH transmission

1. CQI reporting

Information transmitted on DL for UL SCH transmission

1. List of scheduled UE
   - UE identity (cell level identity or TA level identity [FFS])
   - UE Group identity [FFS] (like R6 secondary E-RNTI)
2. Scheduling grant for each identity [Contents of scheduling grant are FFS]

Information transmitted on UL for UL SCH transmission

1. Scheduling Information
   - Logical channel Identity [Details are FFS]
   - UE buffer occupancy [Details are FFS]
   - Further information is FFS
2. UL TFCI information
   - Modulation and coding info
   - Transport block size (= Transport block set size)
3. HARQ/ARQ information [Details are FFS]
4. Happy bit [FFS]

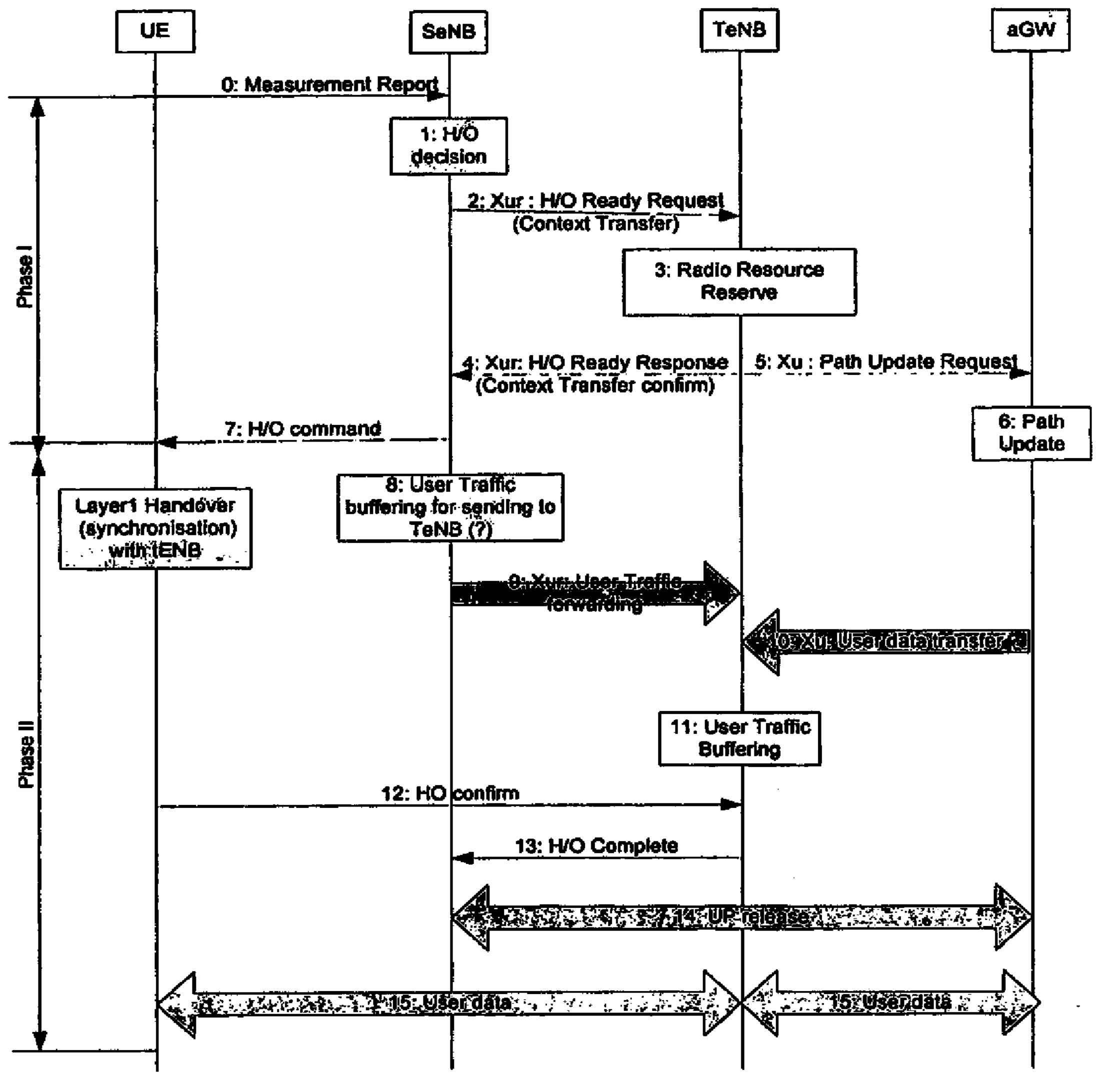
4. Conclusion

It is proposed to capture MAC scheduling aspects and parameters above in TR 25.813.

Basic Assumption of LGE proposal for handover

- Handover Decision is taken by eNodeB based on the measurement report from UE

- User Traffic transfer from SeNodeB to TeNodeB



Alternative 1: routing path switch

0: Measurement report: UE □ SeNB

1: Handover Decision: in the SeNB

2: Handover Ready Request: SeNB to TeNB

- UE Context transfer: detailed context information is FFS

3: Resource Reservation: in TeNB

4: Handover Ready Request: TeNB to SeNB

5, 6: Path Update Request: TeNB to aGW

- After receiving this message, aGW switch routing path for user traffic

- The exact timing to send this message is FFS.

7: Handover command: SeNB to UE

8,9: User Traffic buffering and forwarding: SeNB to TeNB

10: User data transfer: aGW to TeNB

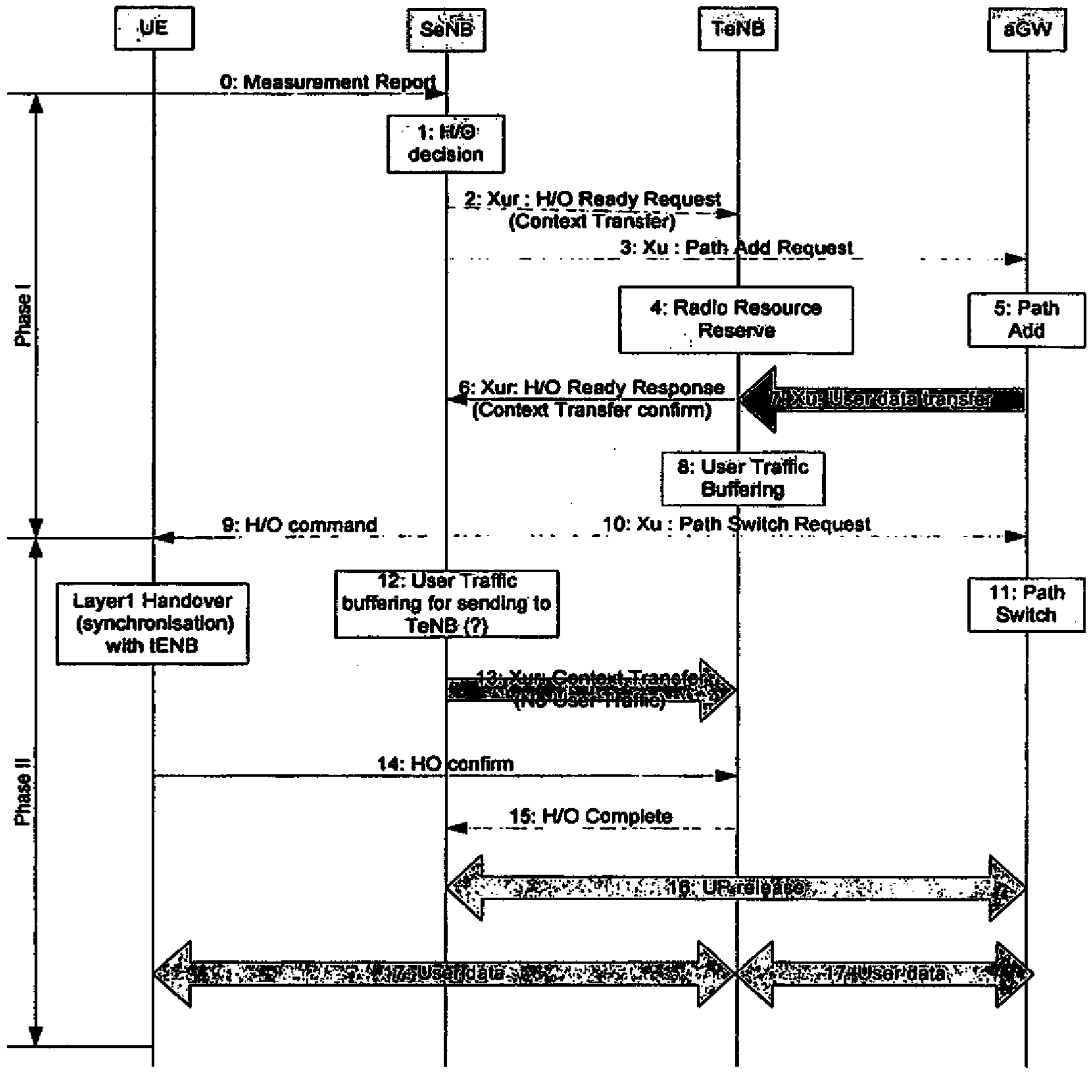
11: User Traffic buffering:

12: Handover confirm: UE to TeNB

13: Handover complete: TeNB to SeNB

14: UP release

15: User data transfer



Alternative 2: Path add and switch

0: Measurement report: UE □ SeNB

1: Handover Decision: in the SeNB

2: Handover Ready Request: SeNB to TeNB

- UE Context transfer: detailed context information is FFS

3,5: Path Add Request: SeNB to aGW

- User Traffic path from aGW to TeNB is added

4: Resource Reservation: in TeNB

6: Handover Ready Response: TeNB to SeNB

7: User data transfer: aGW to TeNB

8: User Traffic buffering: in TeNB

9: Handover command: SeNB to UE

10: Path Switch request: SeNB to aGW

11: Path Switch: in aGW

- remove routing path from aGW to SeNB

12,13: User Traffic buffering and forwarding: SeNB to TeNB

14: Handover confirm: UE to TeNB

15: Handover complete: TeNB to SeNB

16: UP release

17: User data transfer

Check the pros and cons between two alternatives to take one for next meeting.

	Pros	Cons
Alternative 1	- No redundant user data transfer from aGW to SNB - Possibility to minimize user traffic transfer from SNB to TNB	- User data transfer from SNB to TBN
Alternative 2	- No user data transfer from SNB to TNB	- Redundant user data transfer from aGW to SNB - Difficult to manage buffer(signaling from SNB to TNB)

Source: LG Electronics

Title: Impacts of MBMS services on Scheduling

Agenda Item: 14

Document for: Discussion & Decision

Introduction

MBMS and dedicated services

In RAN2#48 bis the advantages to use the same shared downlink channel for both dedicated services and MBMS services have been discussed. Also in 25.913 it has been clarified that the MBMS service in E-UMTS shall allow to be executed simultaneously along with dedicated services.

Measurements and scheduling

Also in the RAN2#48 bis meeting it has been discussed that it would be advantageous to avoid a systematic compressed mode for downlink / uplink scheduling for measurements, and leave it up to the Scheduler to create the required gaps to allow for measurements. One good argument for this choice is also to allow for technology evolution to reduce the time necessary for measurements, and thus allow to reduce the necessary gaps.

Discussion

General requirements on the DL Scheduler

In Rel5 HSDPA stop and wait HARQ protocols have been implemented in the UMTS standard. In this case the scheduler in the NodeB is aware of the UE capabilities, e.g. number of available processes, minimum inter-TTI interval, Maximum number of HS-DSCH codes, Maximum number of bits of an HS-DSCH transport block received within an HS-DSCH TTI etc. It can be supposed that the E-UMTS will use similar techniques which require the scheduler to adapt the scheduling to the UE capabilities, where potentially the scheduler might take into account also different criteria, e.g. supported bandwidth, supported bands etc. depending on the outcome of the discussions on these issues.

Specific issues for MBMS

In MBMS in RAN2 the general principle has been adopted that e.g. for broadcast services the network should not be aware of the fact which UEs try to receive this service. More specifically it has been agreed that for MBMS the network is not responsible for handling the UE capabilities that are occupied by the reception of MBMS on a PtM bearer, only the UE capabilities that are used by services transmitted via PtP bearers are handled by the network.

UE capability issue

In general it is reasonable to assume that a UE that can receive the complete data rate that is available e.g. on a 20 MHz band will not be the most commercial interesting UE, thus most reasonably a UE will be able to process only a subset of the possible maximum data rate. When receiving broadcast services the reception of those services will use some of the available processing resources in the UE. Therefore less resources would be available for the reception of dedicated services. It is necessary that the UE capabilities can be shared between the dedicated and the broadcast services.

Proposal

In order to allow the optimal use of the available UE resources different mechanisms are possible:

Dynamic update of the UE capabilities for MBMS

It has already been discussed earlier that e.g. the capability to receive HS-DSCH could be updated by the UE based on whether the UE would receive a parallel MBMS service or not. However this had been abandoned since the overhead due to the L3 signalling and the fact that this would require a (slow) reconfiguration. However since in LTE MBMS and dedicated services are supposed to be sent via the same channel only the NodeB scheduler would need to be updated with the information on e.g. how many processes are available for the reception of dedicated services. This could be updated dynamically by the UE e.g. via L1 or L2 signalling. Simultaneously, in order to allow the UE to estimate the resources that are necessary for the reception of a broadcast channel and thus to calculate the resources that are available for the dedicated channel it would be necessary that the UE is informed about the resources that the broadcast channel would occupy, such that the UE can calculate the available processing and reception resources. The resources to be exchanged between the UE and the Scheduler could thus contain the frequencies, number of processes etc. This also allows to work in macro-diversity scenarios.

Indication of received services on MBMS

In order to allow an even better usage of the UE resources it would also be possible that the UE in active mode indicates to the scheduler which other (MBMS) flows are received by the UE, such that the scheduler can adapt the resources used by the dedicated flow to the resources instantaneously used by the MBMS channel. Since the reception of a MBMS flow can be interrupted signalling would be necessary such that the Scheduler can be made aware of which services the UE receives at a given time.

Interruptions for measurements

As explained above the required measurement periods depend heavily on the UE implementation and performance. In order to allow a flexible implementation in the UE and to allow to benefit in technology advances it should be possible that the UE indicates to the network when measurements are necessary. This would allow e.g. in active mode that the UE triggers inter-frequency measurements based on the measurements made on the current frequency, and the UE would only indicate to the NodeB Scheduler for which period the scheduler should not schedule any data for the UE. Depending on the implementation of the UE the UE could also e.g. request that the bandwidth used by the scheduler would be reduced, or the number of processes would be reduced etc.

Conclusion

In this paper we propose that for efficient UE capability handling the network indicates to the UE the necessary resources for the reception of a MBMS service transmitted on a PtM bearer (e.g. for a given time), such that the UE in active mode (i.e. receiving dedicated services on PtP bearers) can allocate the resources, and can calculate based on the interest in the different services which resources are available for receiving services on PtP bearers.

Alternatively the UE in active mode (i.e. receiving a service on a PtP bearer) could also indicate to the network in which services it is interested, and allow thus the scheduler to take into account the scheduling of the PtM services in the scheduling of the PtP services for the given UE.

Furthermore the indication of available resources should allow the UE to signal that temporarily only a restricted number of resources or no resources are available, e.g. when receiving a MBMS PtM bearer in parallel, or when the UE has decided to perform measurements on another frequency / rat, e.g. based on the quality of the current frequency / cell.

References:

[1] 25.321, Medium Access Control (MAC) protocol specification, V6.5.0

[2] 25.331, Radio Resource Control (RRC), V6.7.0

Agenda item: 8.1

Source: LG Electronics Inc.

Title: MAC Architecture of LTE

Document for: Discussion, Decision

1. Introduction

In this document, we propose MAC architecture for E-UTRA. MAC entity in E-UTRAN performs similar functionality of MAC-hs and MAC-e/es of UTRAN. But in this document, MAC entity also includes some functionality of RLC of UTRAN. In fact, MAC entity and RLC entities combined into one entity for better performance.

2. Discussion

2.1 ENode-b Side Architecture

Following is proposed architecture for MAC entities of ENode-b.

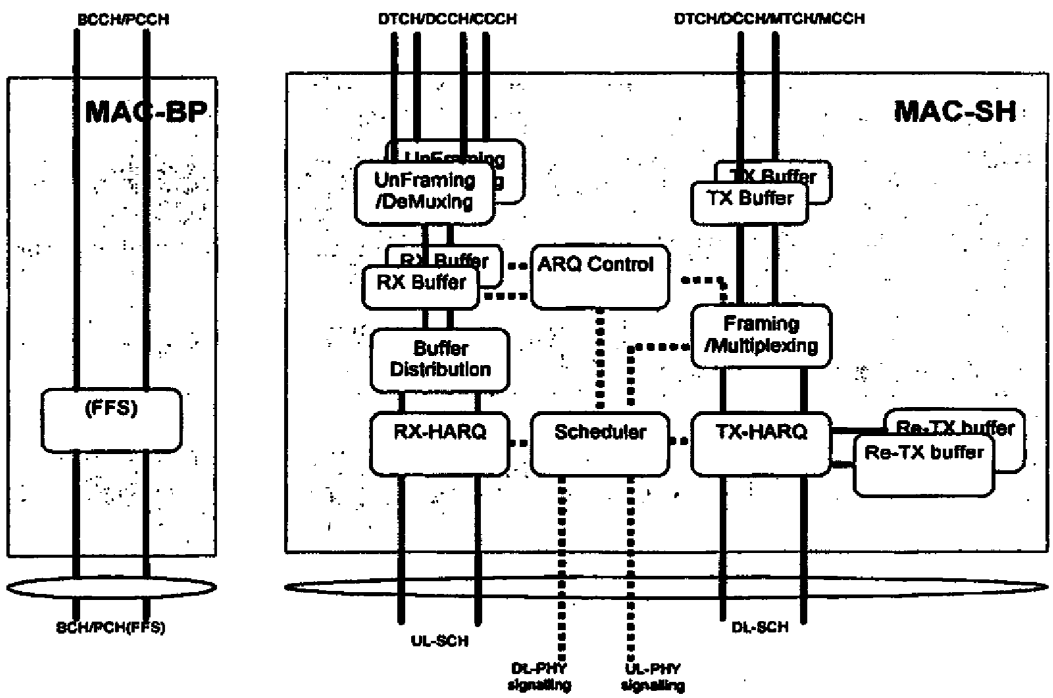


Figure 1. MAC architecture of ENode-b

In the following sections, the role and function of each entity in Figure 1 is shown. One MAC-SH and one MAC-BP are established per cell.

2.1.1 Entities In MAC-SH

- **TX Buffer**: This is storage for MAC SDUs delivered from upper layer in CN. When one MAC SDU is delivered to Framing/Multiplexing entity, it is removed from TX Buffer. Timer can be used to prevent MAC SDUs from waiting too long in the TX Buffer due to higher priority data of other RBs [FFS]. When ENode-b relocation occurs, serving ENode-b transfer the remaining MAC SDUs to target ENode-b. This TX Buffer is established per UE and per RB.

- **Framing/Multiplexing**: This entity composes MAC PDUs from MAC SDUs according to size and priority information from scheduler. One MAC PDU includes data from RBs indicated by scheduler and includes data from one UE. And TSN setting is also done in this entity. RBs with same QoS or same priority are multiplexed into single MAC-I (MAC internal) flow. This flow is matched with one RX buffer in the UE. The RBs which can be multiplexed together is configured by RRC. In one TTI, at most one MAC PDU is generated for one UE and several MAC PDUs are generated for several UEs. This Framing/Multiplexing entity is established per cell.

- **TX-HARQ**: This entity performs HARQ transmission as indicated by scheduler. When it is ordered to perform HARQ retransmission, the TX HARQ entity performs HARQ retransmission. When it is ordered to perform new HARQ transmission, it starts new HARQ operation using the new MAC PDU received from Framing/multiplexing entity. When one HARQ process start transmission for new MAC PDU, previous MAC PDU of that process is moved into re-TX Buffer. When scheduler request for TX-HARQ entity to perform transmission of MAC PDU in re-TX Buffer, TX-HARQ entity retrieve the MAC PDU from re-TX buffer and start transmission. In this case, by adjusting the allocated radio resource to support original MAC PDU size, the original MAC PDU is transmitted without sub-framing,[FFS] For one UE, several processes can be allocated to support high data rate.

- **Re-TX Buffer**: This buffer stores MAC PDUs which TX HARQ entity has performed HARQ transmission but ARQ acknowledge is not received for those MAC PDUs. Until ARQ Control entity receives indication of successful reception for a MAC PDU, the MAC PDU is stored in Re-TX Buffer. After ARQ acknowledgement from peer entity, the MAC PDUs are removed from this entity. When ENode-b relocation occurs, MAC PDU in TX HARQ entity and MAC PDU in this entity is forwarded to target ENode-b.[FFS] This entity is established per UE and per MAC-I flow.

- **Rx-HARQ**: This entity performs HARQ operation for the reception of uplink. Depending on the result of decoding, it generates ACK or NACK. How ACK/NACK is transmitted over physical channel is FFS. If a MAC PDU is decoded successfully, Rx-HARQ entity forwards the MAC PDU to Queue Distribution entity. Ack/Nack information is also delivered to scheduler entity.

- **Buffer Distribution**: This entity distributes the successfully decoded MAC PDUs to appropriate RX buffer. MAC PDU includes appropriate information such as TSN and MAC-I flow identity to assist distribution function. There is one to one match between RX buffer and MAC-I flow..

- **RX Buffer**: This is buffer for the received MAC PDUs. Until all the appropriate MAC PDUs for one MAC SDU are received, the MAC PDU stays in this buffer. When all the appropriate MAC PDUs are received for one MAC SDU and lower number MAC PDUs are processed, this MAC PDUs are delivered to UnFraming/DeMultiplexing entity. Because In-order sequence delivery is supported in this entity, this entity performs virtually re-ordering functionality. If this entity detects a missing MAC PDU, this information is delivered to ARQ Control entity. When ARQ status report is included in the MAC PDU, this information is delivered to ARQ Control entity. RX Buffer entity is established per UE and per MAC-I flow.

- **UnFraming/DeMultiplexing** : Using header information, MAC SDUs is reassembled from MAC PDUs. And the MAC SDUs are delivered to upper layers via appropriate RBs to CN. When several RBs are multiplexed in a MAC-I flow, the reassembled MAC SDU are forwarded to appropriate RB using field like C/T as in R99. This entity is established per UE and per MAC-I flow.

- **ARQ Control**: When there are detected missing MAC PDUs in RX buffer, ARQ control entity generates ARQ status report. And this information is delivered to Framing/multiplexing entity and included into MAC PDU. When ARQ status report is received from peer entity, ARQ Control entity notifies scheduler of MAC PDUs that should be retransmitted.

- **Scheduler**: This entity decides when to transmit what. Scheduler entity informs Framing/Multiplexing entity the size of new MAC PDU and the priority of RBs that should be included in the MAC PDU. The Scheduler informs TX-HARQ entity whether to perform new MAC PDU transmission or HARQ retransmission or ARQ retransmission as well as timing. Node-b scheduler decides the uplink/downlink resource allocation among the UEs and RBs. And this information is delivered to physical layer. UE Access Controller is notified its allocated uplink/downlink resource through scheduling information block through physical layer. This Scheduler entity is located in ENode-b.-

2.1.2 Entities in MAC-BP

MAC-BP entity is used to deliver paging information and system information. It is FFS whether multiplexing and additional mechanisms are needed.

2.2 UE Side

Following is proposed architecture for MAC entities of UE.

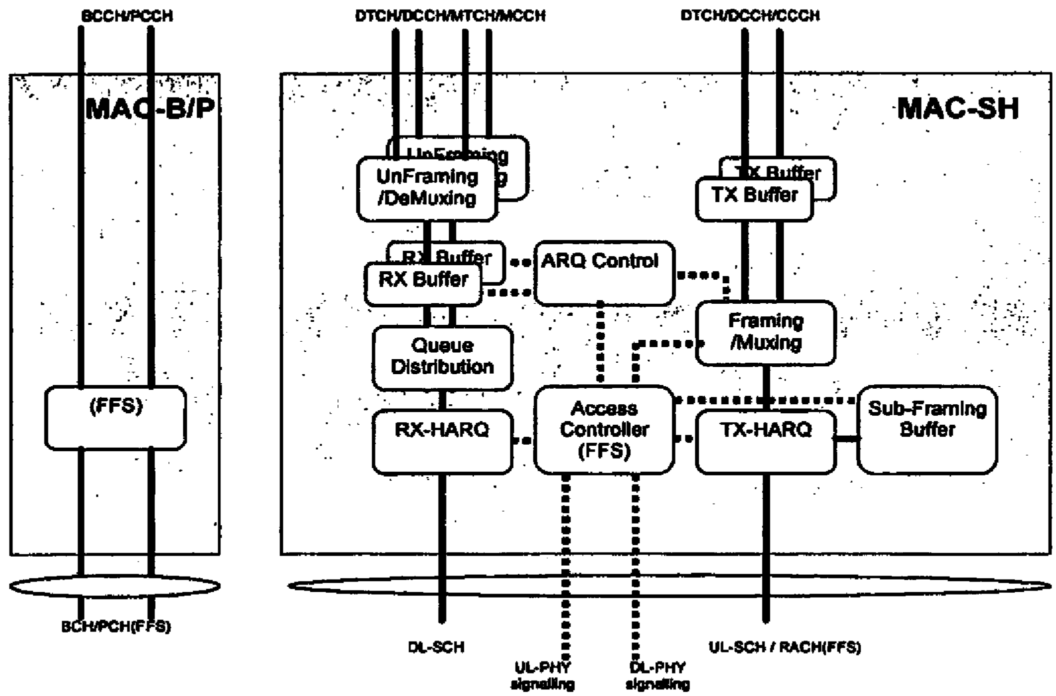


Figure 2. MAC architecture of UE

In the following sections, the role and function of each entity in Figure 2 is shown. One MAC-SH and one MAC-BP are established in UE.

2.1.1 Entities in MAC-SH

- **TX Buffer:** This is storage for MAC SDUs delivered from upper layer in UE. When one MAC SDU is delivered to Framing/Multiplexing entity, it is removed from TX Buffer. Timer can be used to prevent MAC SDUs from waiting too long in the TX Buffer due to higher priority data of other RBs [FFS]. This TX Buffer is established per RB.

- **Framing/Multiplexing:** This entity composes MAC PDUs from MAC SDUs according to size and priority information from Access Controller. One MAC PDU includes data from RBs indicated by scheduler. And TSN setting is also done in this entity. RBs with same QoS or same priority are multiplexed into single MAC-I (MAC internal) flow. This flow is matched with one RX buffer in the ENode-b. The RBs which can be multiplexed together is configured by RRC. In one TTI, at most one MAC PDU is generated.

- **TX-HARQ:** This entity performs HARQ transmission as indicated by Access Controller. When it is ordered to perform HARQ retransmission, the TX HARQ entity performs HARQ retransmission. When it is ordered to perform new HARQ transmission, it starts new HARQ operation using the new MAC PDU received from Framing/multiplexing entity. When one HARQ process starts transmission for new MAC PDU, previous MAC PDU of that process is moved into SubFraming Buffer. When Access Controller requests for TX-HARQ entity to perform transmission of MAC PDU in SubFraming Buffer, TX-HARQ entity receive appropriate MAC SubPDU from SubFraming buffer and start transmission. Because of scheduled uplink resource and UE power limitation, the original MAC PDU may be divided into several MAC SubPDUs. In this case MAC SubPDU is transmitted instead of original MAC PDU. But same TSN is used. See details in [1]. Several processes can be used to support high data rate.

- **SubFraming buffer**: This buffer has similar functionality of Re-TX buffer of Node-b. But this buffer has additional functionality of re-framing of original MAC PDU. When the allocated resource is less than what is needed for the transmission of original MAC PDU, the original MAC PDU has to be divided into MAC SubPDU. Thus Re-framing buffer performs subframing of original MAC PDU. Until ARQ Control entity receives indication of successful reception for a MAC PDU, the MAC PDU is stored in SubFraming Buffer. After ARQ acknowledgement from peer entity, the MAC PDUs are removed from this entity. This entity is only in UE. This entity is established per MAC-I flow.

- **Rx-HARQ**: This entity performs HARQ operation for the reception of uplink. Depending on the result of decoding, it generates ACK or NACK. How ACK/NACK is transmitted over physical channel is FFS. If a MAC PDU is decoded successfully, Rx-HARQ entity forwards the MAC PDU to Queue Distribution entity. Ack/Nack information is also delivered to Access Control entity [FFS].

- **Buffer Distribution**: This entity distributes the successfully decoded MAC PDUs to appropriate RX buffer. MAC PDU includes appropriate information such as TSN and MAC-I flow identity to assist distribution function. There is one to one match between RX buffer and MAC-I flow..

- **RX Buffer**: This is buffer for the received MAC PDUs. Until all the appropriate MAC PDUs for one MAC SDU are received, the MAC PDU stays in this buffer. When all the appropriate MAC PDUs are received for one MAC SDU and lower number MAC PDUs are processed, this MAC PDUs are delivered to UnFraming/DeMultiplexing entity. Because In-order sequence delivery is supported in this entity, this entity performs virtually re-ordering functionality. If this entity detects a missing MAC PDU, this information is delivered to ARQ Control entity. When ARQ status report is included in the MAC PDU, this information is delivered to ARQ Control entity. RX Buffer entity is established per MAC-I flow.

- **UnFraming/DeMultiplexing** : Using header information, MAC SDUs is reassembled from MAC PDUs. And the MAC SDUs are delivered to upper layers via appropriate RBs. When several RBs are multiplexed in a MAC-I flow, the reassembled MAC SDU are forwarded to appropriate RB using field like C/T as in R99. This entity is established per UE and per MAC-I flow.

- **ARQ Control**: When missing MAC PDUs in RX buffer are detected, ARQ control entity generates ARQ status report. And this information is delivered to Framing/multiplexing entity and included into MAC PDU. When ARQ status report is received from peer entity, ARQ Control entity notifies Access Controller of MAC PDUs that should be retransmitted.

- **Access Controller**: This entity decides when to transmit what. Access Controller entity informs Framing/Multiplexing entity the size of new MAC PDU and the priority of RBs that should be included in the MAC PDU. The Access Controller informs TX-HARQ entity whether to perform new MAC PDU transmission or HARQ retransmission or ARQ retransmission as well as timing. Unlike Node-b scheduler, Access Controller do secondary scheduling, in other words, Access Controller in UE performs second scheduling using radio resource allocated by ENode-b. Accordingly, scheduler in ENode-b performs primary scheduling. Access Controller retrieves information about its scheduled resources from physical layer.

2.2.2 Entities in MAC-BP

MAC-BP entity delivers paging information and system information from physical layer to RRC. The detailed architecture is FFS

3. Conclusion

- It is proposed to discuss MAC Architecture shown above, and include section 2 into LTE TR.

4. Reference

[1] R2-060106, HARQ and ARQ operation of LTE MAC, LG Electronics

3GPP TSG RAN WG2 Meeting #50 **R2-060107**

Source: LG Electronics

Title: Intra-Access System (E-UTRAN) Mobility for LTE Active state

Agenda Item: 9

Document for: Discussion & Decision

1. Introduction

This document shows our view on the intra-Access System (E-UTRAN) mobility for LTE Active state. We propose some consideration point for handover and example procedure to discuss and progress on the mobility issue.

2. Discussion

LTE Architecture

Figure 1 shows LTE architecture based on the current agreement.

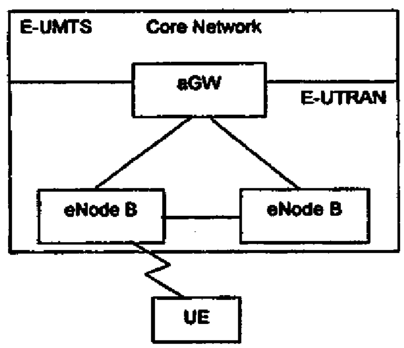


Figure1. LTE architecture (U and C plane split is FFS)

In the following, handover procedure is described based on the LTE architecture in the Figure 1. We assume that the aGW has both user and control plane function. Interface between eNodeB is also assumed.

Handover functionalities:

In the following, we describe handover procedure elements.

- Handover decision by Source eNodeB

UE measures the radio condition of source eNodeB and the adjacent cells. When certain conditions are met, the UE reports the measurement result to source eNodeB. Source eNodeB will make handover decision based on the measurement report from UE and available resource information of candidate cells.

- Handover preparation

Source eNodeB transfers UE context (e.g. RB info, security info, buffer occupancy, etc) to target eNodeB within Handover Preparation request to reserve resources for the UE. And source eNodeB sends handover preparation request to aGW to reduce the interruption time and the amount of traffic forwarding between eNodeBs. For example, after receiving handover preparation request from source eNodeB, the amount of data from aGW to source eNodeB will be reduced.

- <u>User Traffic transfer from source eNodeB to target eNodeB</u>

After sending the handover command to the UE, source eNodeB forwards unacknowledged user data to target eNodeB. Based on the QoS requirement of each RB, the source eNodeB will selectively forward remaining user data to target eNodeB.

- <u>Fast path switch for user traffic</u>

After receiving Handover preparation request from source eNodeB, aGW waits for the path switch request from target eNodeB. Because it is assumed that target eNodeB send path switch request only when it accepts handover request from source eNodeB, the aGW can immediately change the routing path for the user traffic from source eNodeB to target eNodeB regardless of whether UE's access to target eNodeB To align data from source eNodeB and data from aGW, target eNodeB should buffer user traffic from aGW until source eNodeB completes data forwarding..

Feasible Handover procedure example

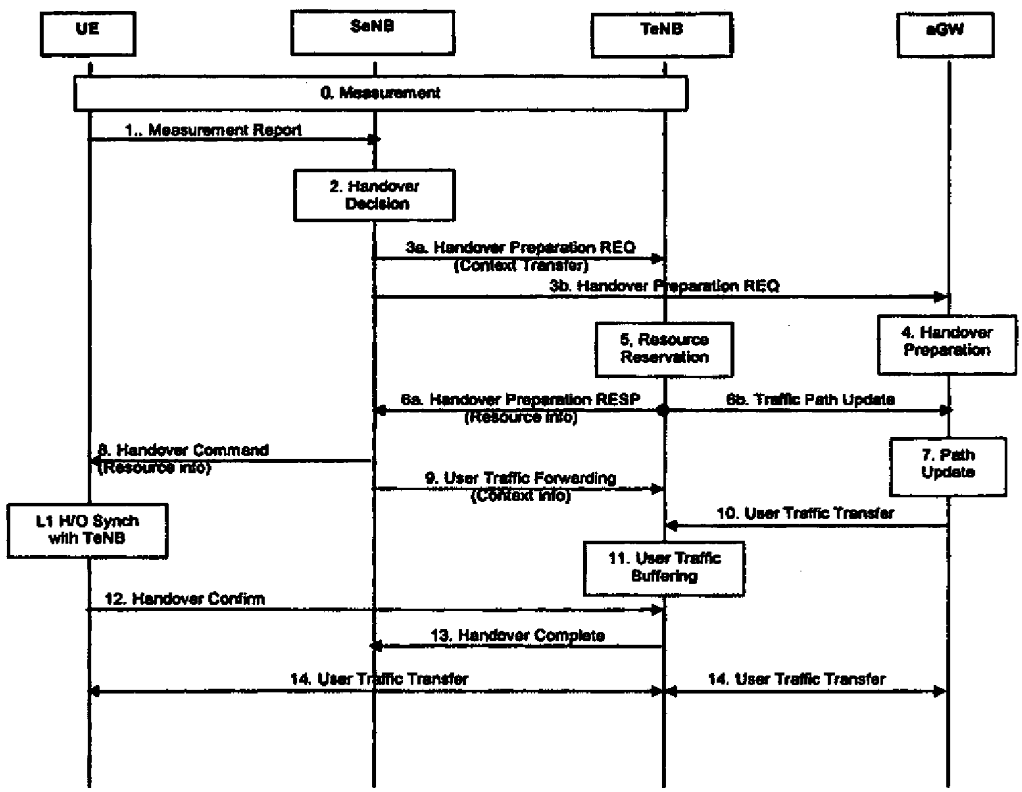


Figure2. Handover Procedure example (Inter eNodeB case)

0. Measurement: UE measures the radio condition of the serving cell and adjacent cells.

1. Measurement Report: UE send measurement report to SeNB (Source eNodeB) when conditions are met.

2. Handover Decision: After receiving the measurement report, SeNB makes a decision and executes handover. Resource availability and processing load will also be considered in handover decision process. To perform fast handover, source eNodeB should keep such information up-to-date. The detailed mechanism is [FFS].

3. Handover preparation request: There are two handover preparation requests. First one is to request the resource for the UE in the Target eNodeB (TeNB) (**step 3a**). In this case, SeNB send handover preparation REQ message containing the UE context. After receiving handover preparation REQ, TeNB allocate some resource for the UE and send handover preparation RESP with assigned resource information (**step 6a**). Second one is handover preparation request sent to aGW (**Step 3b**).

4. Handover preparation: After receiving handover preparation REQ, aGW can take flow control to minimize user traffic that would be sent from SeNB to TeNB. The detailed functions are FFS.

5. Resource reservation: Target eNodeB allocates resource for the UE based on the UE context from the SeNB.

6a. Handover preparation response: After receiving handover preparation REQ, TeNB allocate some resource for the UE and send handover preparation RESP with assigned resource information. Handover preparation response can contain the allocated resource information.

6b. Traffic Path Update: After allocating resource for the UE, TeNB sends Traffic path update request to aGW to change routing path. .

7. Path Update: After receiving traffic path update, aGW changes the routing path for the UE from SeNB to TeNB.

8. Handover command: SeNB sends handover command to the UE. There is no more connection between SeNB and the UE. After receiving handover command, the UE start L1 HO synchronization with target cell.

9. User traffic forwarding: After sending handover command to the UE, SeNB send unacknowledged user traffic to TeNB. Packet sequence number and HARQ related information can be transferred together [FFS].

10. User Traffic Transfer: After path switch is done, the aGW forward downlink user data to target eNodeB.

11. User traffic buffering: Before receiving the handover complete message from the UE, TeNB should buffer the received user traffic from SeNB and aGW.

12. Handover confirm: After completing the L1 H/O, the UE send handover confirm to TeNB. It is possible to send user traffic to the UE from this point.

13. Handover complete: TeNB send handover complete message to source eNodeB after receiving Handover confirm from the UE. And then, SeNB delete the UE context and release resource.

3. Conclusion

In this contribution, we proposed the intra-access system mobility (inter-eNobe B mobility) procedure for LTE Active State. It is proposed to discuss and include the procedure into the TR.

TSG-RAN Working Group 2 #50 ***R2-060108***

Agenda Item : 6.2
Source : LG Electronics
Title : Issues on LTE Channels
Document for : Discussion and Decision

1. Introduction

Regarding transport channels, in the RAN2#48bis meeting, some issues were identified:

- Whether PCCH is mapped to PCH or SCH i.e. whether a paging message is transferred on PCH or SCH.
- Whether CTCH/MTCH is mapped to SCH or MCH
- Whether SCH needs to be divided to two types of SCH or not

This document discusses the identified issues.

2. Paging Channel

UE in idle mode will receive paging messages, but UE in active mode wouldn't. On the other hand, UE in active mode will receive dedicated services on SCH (Shared Channel), but UE in idle mode wouldn't.

If SCH carries pagings, one signalling message on SCCH (Shared Control Channel) could be heavy because SCCH would carry control information related with paging e.g. paging indicator as well as other data on SCH. In this case, UE in idle mode could receive unnecessary control information of active mode because UE in idle mode does not need most of control information about active mode operation. Also, while UE is in actve mode, UE may not need control information about idle mode operation.

For the reason above, a benefit of transferring pagings on SCH is not so clear. Thus, it is proposed to specify a paging channel different from SCH i.e. PCH (Paging Channel). That means a logical channel PCCH is mapped to a transport channel PCH, rather than SCH.

In the meantime, how to notify MBMS service (e.g. MICH) needs to be discussed. One solution of LTE MBMS notification could be utilizing LTE paging schemes. Further study is needed.

A logical channel PCCH is to be mapped to different transport channel (i.e. PCH) from downlink SCH.

3. Multicast Traffic Channel

In TR 25.913 simultaneous reception of voice service and the MBMS is required: "*Voice and MBMS – the E-UTRA approach to MBMS should permit simultaneous, tightly integrated and efficient provisioning of dedicated voice and MBMS services to the user*". Thus, in order to meet this requirement it seems to be better that the same type of downlink channel i.e. the downlink SCH is used for MBMS transmissions as well as dedicated transmissions.

If the downlink SCH is used for MBMS, a downlink SCCH can be shared by a SCH carrying MBMS service and a SCH carrying dedicated service. In this case, UE would rely on only one control channel i.e. downlink SCCH to receive control information about dedicated service and MBMS service transmitted on downlink SCH channels. Thus, operation of UE receiving both MBMS and dedicated service would be simple.

However, since generally there is no HARQ for MBMS transmissions, a downlink SCH for MBMS service needs to be different from a downlink SCH for dedicated service. Thus, UE supporting MBMS may need to support simultaneous reception of two transport channels.

A logical channel CTCH/MTCH is to be mapped to downlink SCH for multicast/broadcast transmissions.

4. Localized & Distributed Shared Channel

In RAN2#48bis in Cannes, some companies proposed two types of SCH: Localized SCH and Distributed SCH. To our understanding, two types of SCH are related with different types of resource allocations. Thus, they could be differentiated by different attributes or different resource allocation. In this sense, we think there is no need for having different types of SCH.

Only one type of SCH is to be specified for simplicity.

3. Conclusion

We propose that the above are captured in RAN2 LTE TR.

3GPP TSG RAN WG2 Meeting #50 **R2-060109**

Source: **LG Electronics**

Title: **LTE MAC scheduling and signaling parameters**

Agenda Item: **8.3**

Document for: **Discussion & Decision**

1. Introduction

This document discusses MAC scheduling and scheduling related signalling parameters for LTE system.

2. Discussion

Scheduling Period for Shared Channel

E-NB periodically transfers 'Scheduling Information' every scheduling period for Shared Channels. The Scheduling Information may be transmitted using fixed position of radio resource at each TTI (0.5 ms). Thus, E-NB could schedule transmissions every TTI for several users.

However, per TTI scheduling for one UE seems to cause much overhead. For this reason, the scheduling information for one UE is not transmitted in every TTI. As one scheduling grant is used for all the active processes in HSUPA, several TTI may be combined to form one scheduling period. E-NB may allocate the start of scheduling period of different UEs to different TTI in order to distribute signalling overhead over several TTIs.

E-NB may be able to configure length and offset of scheduling period for each UE based on UE/NB capabilities. Also, E-NB could take into account UE DRX operation to determine length and offset of scheduling period for the UE.

It should be studied whether or not scheduling period of DL transmission is always related to scheduling period of UL transmission for one UE. If scheduling period for DL/UL transmissions are same for one UE, signalling overhead for DL/UL scheduling information could be reduced.

Feedback for Shared Channel Transmissions

To control AMC, frequent channel quality reporting like CQI should be supported in uplink. Also, ACK/NACK signalling is needed for HARQ in both directions.

To transmit CQI and ACK/NACK for DL traffic, an uplink control channel for DL traffic is needed. Also, to transmit ACK/NACK for UL traffic, a downlink ACK/NACK channel for UL traffic may need to be introduced. It is assumed that time difference between a packet and its ACK/NACK is fixed at least in terms of TTI for both uplink and downlink.

In uplink, CQI could be reported every TTI (0.5 ms) in case radio channel is fast varying. If CQI reporting is very frequent from several users, radio resource used for CQI transmissions would suppress the amount of traffic transmitted in uplink. Thus, optimized way of CQI transmission needs to be studied.

When E-NB schedules data transmissions, E-NB could control CQI reporting. Also, E-NB could re-assign radio resources for CQI reporting and ACK/NACK transmissions of scheduled data.

Scheduling of Paging & System Information

If PCH channel always uses fixed radio resource i.e. frequency and time, E-NB has less flexibility of SCH scheduling. Thus, we could consider that E-NB schedules PCH channel as well as SCH channel within a UE specific paging occasion of every paging DRX cycle. A paging indication within the paging occasion could inform the UE of whether or not a paging message for the UE is scheduled within the paging occasion. Also, the paging indication could signal scheduled time/frequency of the paging message like the SCH scheduling.

In case of system information, MIB should use a fixed resource because LTE UE cannot presumably acquire any control information before receiving MIB in a cell. However, E-NB could schedule SIBs like SCH within a specific TTI indicated by MIB. If a certain SIB is scheduled within a certain TTI, control information of the TTI could indicate existence of SIB in the TTI and scheduled time/frequency of SIB. By this way, E-NB could have more flexible size of SIB within a range of minimum UE capability. Also, E-NB can have more flexibility of SCH scheduling.

Scheduling of Multicast & Broadcast

It is suggested that MBMS is transmitted on DL SCH channel. In this case, scheduling information of MBMS transmissions are provided on scheduling information of DL SCH channel. Thus, there may be no need for R6 MSCH like channel. Further study on this is needed.

DL SCH for MBMS would be different from DL SCH for dedicated services. For example, it is difficult to use ACK/NACK and CQI reporting for MBMS transmissions. Thus, multiplexing of MBMS and dedicated services on the same SCH should not be allowed for simplicity. But, scheduling of MBMS and dedicated services at the same TTI does not need to be prevented in order to give more freedom to E-NB scheduler.

3. Scheduling related Signalling Parameters

The following signalling parameters are proposed for MAC or L1 signalling. Details of parameters are FFS. Additional information can be included in this list.

Information transmitted on DL for DL SCH transmission

1. List of Scheduled UE/Service
   - UE identity (cell level identity or TA level identity [FFS])
   - Service identity (for MBMS)
2. HARQ/ARQ information for each UE identity [Details are FFS]
3. DL TFRI information for each UE/Service identity
   - Modulation and coding info
   - Transport block size (= Transport block set size)
   - Time and frequency for scheduled DL transmission
4. Feedback information for each UE identity
   - Time and frequency for UL feedback of scheduled DL transmission (i.e. UL resource allocation of ACK/NACK/CQI transmissions for scheduling period)

Information transmitted on UL for DL SCH transmission

1. CQI reporting

Information transmitted on DL for UL SCH transmission

1. List of scheduled UE
   - UE identity (cell level identity or TA level identity [FFS])
   - UE Group identity [FFS] (like R6 secondary E-RNTI)
2. Scheduling grant for each identity [Contents of scheduling grant are FFS]

Information transmitted on UL for UL SCH transmission

1. Scheduling Information
   - Logical channel Identity [Details are FFS]
   - UE buffer occupancy [Details are FFS]

- Further information is FFS

2. UL TFCI information
   - Modulation and coding info
   - Transport block size (= Transport block set size)
3. HARQ/ARQ information [Details are FFS]
4. Happy bit [FFS]

4. Conclusion

It is proposed to capture MAC scheduling aspects and parameters above in TR 25.813.

TSG-RAN Working Group 2 #49 *R2-06xxxx*

Agenda Item :
Source : S.J. PARK
Title :
Document for : Discussion and Decision

1. Introduction

This document describes several issues for random access. The issues are as follows.

- Transmission for scalable multiple bandwidths
- CDMA code domain devision according to purpose
- Basic procedures according to purpose
- Localization and distribured resource allocation
- Connectivity on uplink
- Ack/Nack information

2. Random Access Transmission for Scalable Multiple BWs

In E-UTRA, the scalable multiple transmission bandwidth from 1.25 to 20MHz was adopted. The bandwidth of the random access should be wide enough to allow for a sufficiently accurate timing estimate. An estimation accuracy of less than the cyclic prefix is need, e.g., the accuracy should be in the order of 1us. This requires a bandwidth of the RACH burst of around 1MHz, which is in line with the smallest supported E-UTRA spectrum allocation of 1.25MHz. For E-UTRA deployments using larger spectrum allocations, either multiple 1.25MHz random access channels can be defined, or higher RACH bandwidth can be defined for these cases. The former has the advantage of resulting in a single RACH procedure, regardless of the system bandwidth, while the latter may have a diversity benefit.

This document describes several alternatives for dynamic bandwidth for random access based on assumption that system can support 1,25MHz and multiple 1.25MHz for randwom access.

Alternative 1 :

Paging message could be used for indication of bandwidth information for random access. Basically, UE would acquire 1.25MHz bandwidth for random access because network cannot know which UE can use multiple 1.25 MHz for random access. (However, though receved bandwidth information for random access is higher than UE capability, UE may use appropriate bandwidth according to its capability).

Therefore, this information could be involved in paging message. Then after receiving paging message UE could use bandwidth based on associated configuration. And network may control this configuration according to situation.

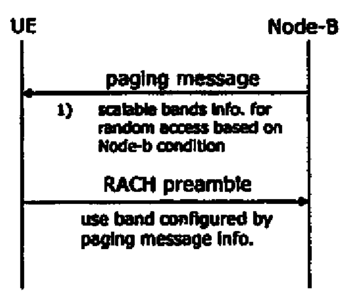


Fig.1 example procedure on indication of scalable bands.

3. CDMA code domain devision

UE could send preamble (PRACH preamble like) for initial accress. And this preamble may become CDMA code. Therefore, The UE, after acquiring downlink synchronization and uplink transmission parameters, would choose randomly a access slot, then it choose randomly a CDMA code and sends it to the network.

This document describles set of CDMA codes based on purpose of random access. The usage of random access could roughly divide 3 parts. : 1) initial cell access 2) maintenance synchronization with network 3) resource request.

Namely, CDMA codes could be divided into several sets of purpose of the usage of random access. Then UE could choose randomly CDMA code from associated set. Therefore, network can know which purpose of request was sent. Then network would send response message of this request. And this message could contain the resource request as well as needed adjustment(e.g., time, power and possible frequency correction) and cell specific information (e.g, C-RNTI and so on). For example, if UE need to achieve synchronization with network, UE choose CDMA code from initial cell access domain and send it to network. The network, after receiving this request, could know that UE used this code from initial cell access domain need initial cell access. Then response message of random access would contain appropriate resource grant for initial cell access (e.g., RRC_Connection_Reqeust). Then, UE directly can send connection messages without

[Comments]

1. CDMA code could be also divided according to frequency.

2. access class.

4. procedures A

In case of the network-initiated call, we need to consider whether operation of UE for initial access has to be same with UE-initiated calls or not. This is because UE could receive RACH information related to initial access on paging channel. Therefore, it is possible to consider to signal the RACH system information in each paging message in order to provide the UE with set of signature or persistency test value and so on for fast initial access.

And if network send ACK of PRACH preamble with resource grant of uplink transmission, the delay of initial access could be reduced because there would be no signal flows on PRACH message part and explicit resource grant message.

In this documents, we propose that it is possible to consider the below points in the LTE study

- RACH system information can be included in paging message
- Only PRACH preamble part can be used for initial access without message part
- Resource allocation of uplink transmission can be included in ACK message

We show the example procedure for the case of network-initiated call as follows :

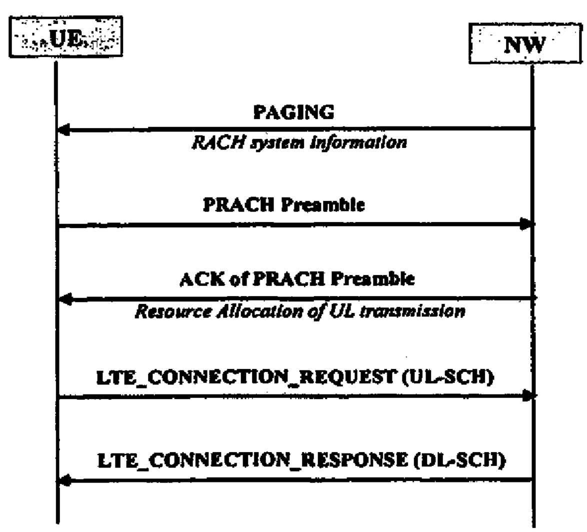


Figure 1. Network-initiated call procedure

1. NW send paging on Tranking Area (with RACH system information)
2. UE send PRACH preamble based on contention.
3. NW send ACK of PRACH preamble (like AICH) with resource allocation of UL transmission (e.g. UL-SCH grant)
4. UE send LTE_CONNECTION message on the allocated UL resource on UL-SCH.
5. NW send LTE_CONNECTION_RESPONSE message

4. procedures B

Random access procedure could be different according to the usage above described. If UE send it for initial request, network could allocate resource because size of resource needed would be fixed. Then in this case, when network send response message of random access for initial access, this message could contain information of appropriate resource. Then UE, after receiving this message, could directly send connection message (e,g, rrc_connection). And in case of maintenance synchronization with network, network would only send needed adjustment. These procedures for two purpose above is almost same. But if UE need bandwidth request, UE would have to send information of amount of bytes.

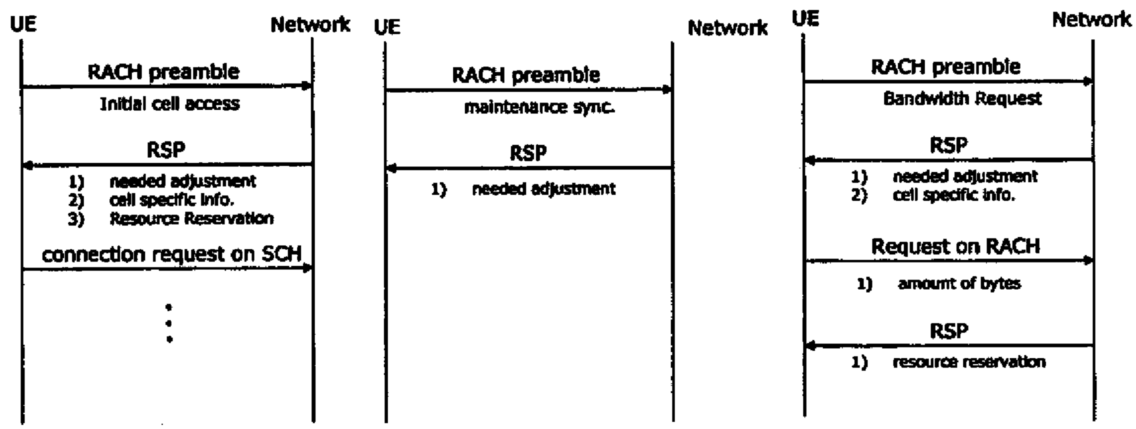


Fig.2. Example procedures 1) initial cell access 2) maintaince synchronization with network 3) bandwidth reuqest.

[Commnets]

Actually, procedure 1 and 3 are same. And connetion request message and cell update message were not fixed size.

5. Localization and distributed resource allocation in uplink

The use of SC-FDMA for uplink transmission has been accepted and this impiles that UEs will be allocated combinations of tones(chunks) and transmission time. Two distinct basis for resource allocation have been identified in RAN1, distributed and localized resource allocation

- Distributed resource allocation allocates set of tones that don't form contiguous blocks and allocations are made without taking account of interference measurement reports made by UEs as is the case for localized resource allocation. The expected application of distributed resource allocation is for fast moving UEs or channels that are relatively static.
- Localized resource allocation refers to the practice of allocation block of contiguous tones based on UE reported measurements of interferenece for all candidate blocks. The intention is to allocate the best resource to the UE but the allocation will be valid for only a short period of time, a TTI or a small number of TTIs

Hence, it could be adopted to request bandwidth through random access. For example, in case of random access for bandwith request, UE, after successfully receiving RSP of CDMA codes, could send request message for indication of information about needed amount of bytes of bandwidth. At that time, this message could contain whether UE want to be allocated localized or distributed resource allocation. Basically, UE well know status of itself because UE can determine its channel status or its moving by measurement of reference signal (e.g., pilot).

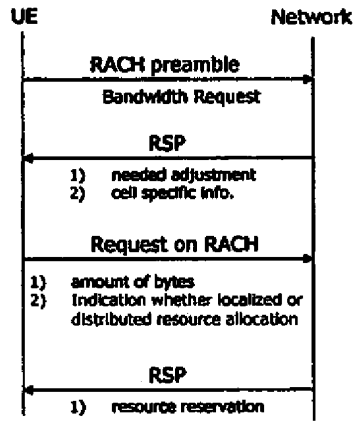


Fig.3 Example procedure on localized/distributed resource allocation

[Comments]

It was commented that UE should has had feedback about uplink channel state.

However, in case of bandwidth request, network cannot know the UE uplink channel status when network assigns resource. It is because there is no uplink reference signal. Therefore, when network determine whether UE is allocated localized resource or distributed resource, some information is needed for this determination.

In this proposal, network could determine roughly the uplink channel status from rach preamble. Than network send this information on RSP of RACH. Then UE could determine according to this information and send request about localized or distributed resource.

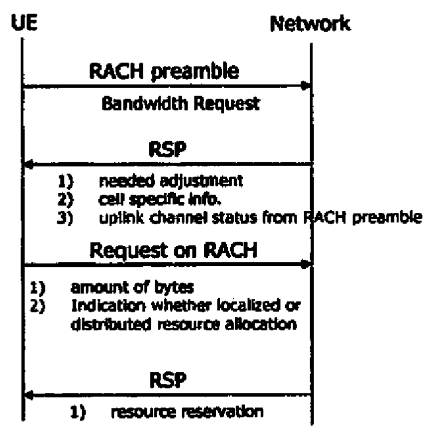


Fig.4 Modified procedure.

Of couse, network, after resource allocation, could change dynamically based on uplink reference signal.

6. connectivity on uplink

In the RAPS discussion, it was discussed how to schedule the uplink resource when UE, after certain period in no uplink transmission, want to send packet.

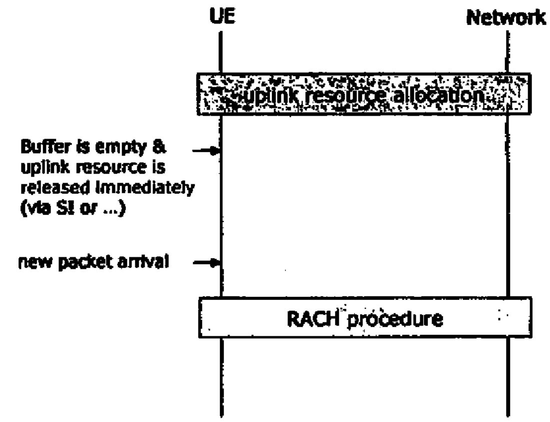


Fig.5

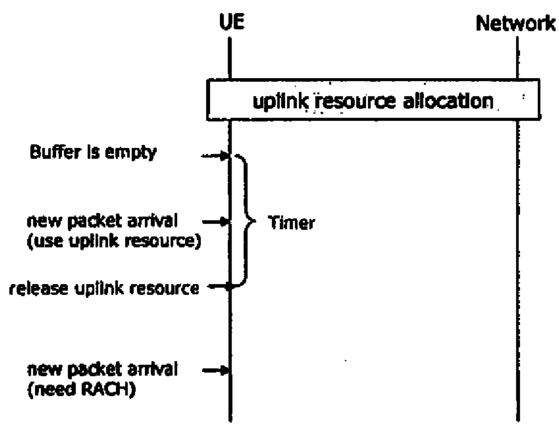


Fig.6

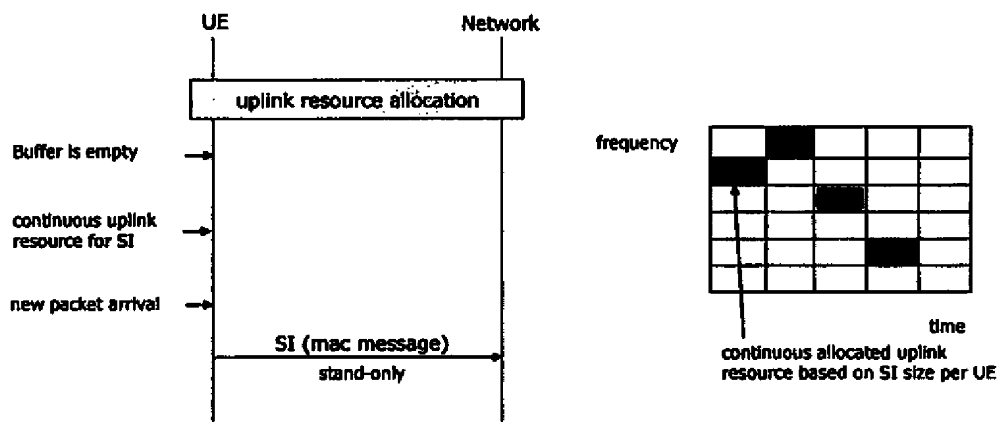


Fig.7 small size (stand only SI) continusous reservation as against Fig.6

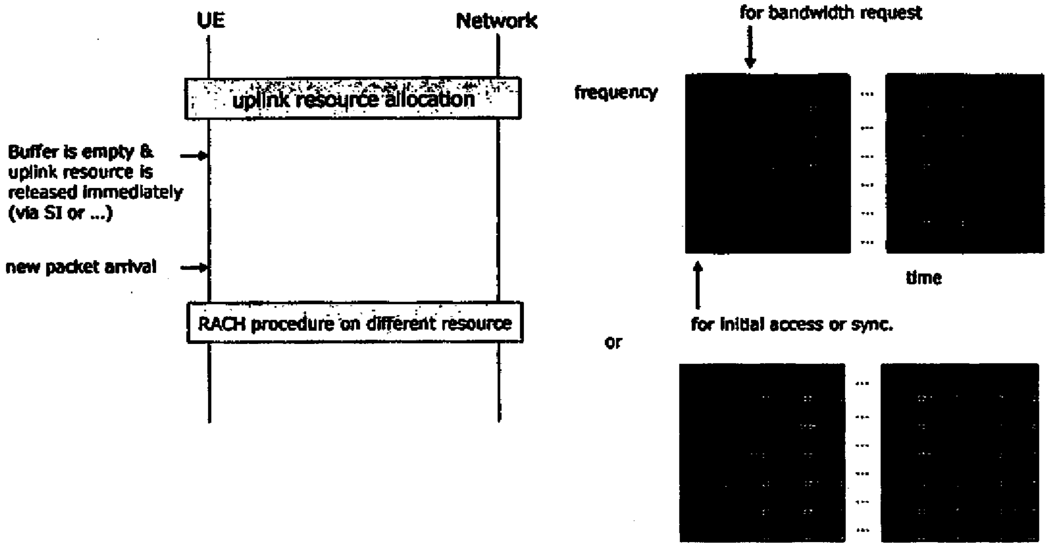


Fig.8

7. ACK/NACK info.

Basically, it was agreed that uplink and downlink HARQ prcesses are synchronous in last RAPS metting, However, several schemes about transmission of ack and nak information were raised.

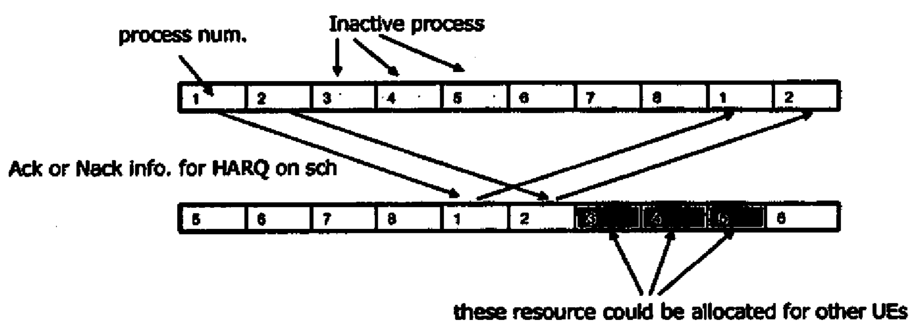


Fig.9

However, retransmission is not clear where it is synchronous or asynchronous.

8. operation for random access

9. RACH message.

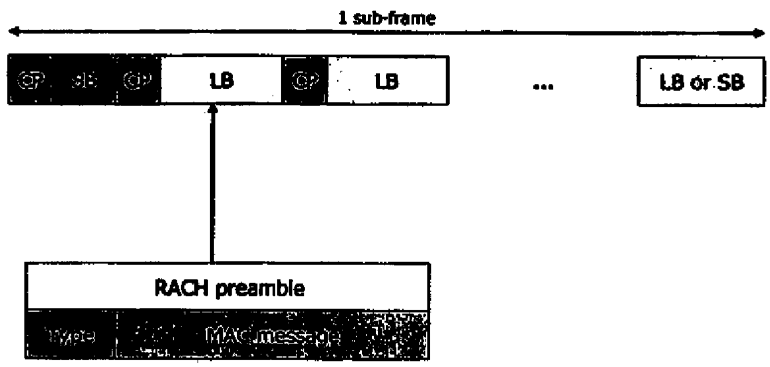


Fig. 10

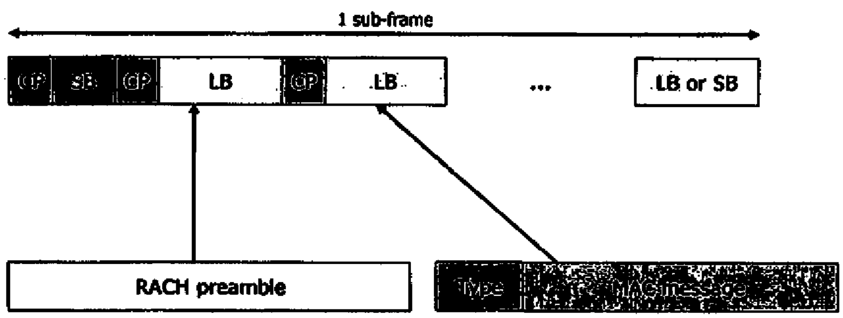


Fig.11

Fig. 10 and 11 illustrate two possible methods of transmitting RACH preamble and MAC message. This message could contain information on initial access. (e.g, buffer status, cause value, identifier).

Fig 10 shows that it is to be used combined between RACH preamble and MAC message. and Fig 11 shows that UE, after sending preamble at previous symbol, sends mac message according to specific resource(chunk)

10. RACH

- Resource Grant Channel
- Access Service Class selection : The physical RACH resource(i.e. access slot and preamble signatures) may be divided between different Access Service Class in order to provide different priorities of RACH usage. It is possible for more than one ASC or for all ASCs to be assigned to the same access slot. CMAC-Config-REQ primitive(A set of ASC parameters),
- Genenral procedures(in RRC): Establishment of Access Service Class, Mapping of Access Class to Access Service Classes, PRACH selection, Measured results on RACH
- RACH transmission control procedure (Access Controller ?)

Logical channels to be used for RACH may are CCCH/DTCH.

In the R99, when UE sends data through RACH, UE chooses the the parameter configured by RRC, especially a set of access service class. ASC consists NumASC and persistenct value.

ASC/AC

MLP(MAC Logical channel Priority) :

Persistence values

RACH transmission control parameters from RRC

  - A set of Access Class (ASC) parameters

- Maximum number of preamble ramping cycles M_max
- T_BO1, N_BO1MAX, N_N_BO1MIN

11. General description

1) For random access, UE could only send preamble. Therefore, RACH message part couldnt be needed.

2) when NB successfully receives preamble from UE, NB sends RSP(Response), which contains specific chunk information(freqeucy/time block) to be used for the UE. And UE, after receiving RSP, could send RRC message or user traffic to NB.

3) Preamble could contain MAC message. MAC message could consists of type of MAC message and MAC message content. MAC message could include user identifier, buffer status of UE, cause value. Thus, if UE send preamble with this MAC message, NB coud know which UE sent preamble.

4) The chunk to be used for random access could be also used for data traffic.

5) RACH process could be based on contention-based.

6) RSP message instead of ACK or/and NACK could be used. The resource allocated for ACK and NACK could be fixed. Physical Indicator in order to indicate ACK or NACK to UE could be used. The information of ACK and NACK on RACH process, especially preamble, coud be sent through DL-MAP or UL-MAP. DL-MAP and UL-MAP could be included in system information on BCCH. UL-MAP could contain information of resource allocation associated preamble. This preamble could be identified by using random codes or user specific identifier.

7) RACH could consist of preamble part and message part. This preamble part and message part could be used same channel or chunk.

9) In the R99, during rach prcess. UE shall select access service class. At the moment, this selection is affected by MLP(MAC Logical channel Priority). For LTE, instead of MLP, this priority could be configured according to usage of RACH.

10) persistence values couldn't be used.

11) In case of network initiated call, RACH transmission control parameters or indication changed information could be involved in paging message.

12) For calculation of waiting time according to the collision, exponential back off time could be used. It means that wating time increase when the number of collision increase.

13) persistence value could be affected by the number of occurred collision per UE. It means that persistence value will decrease when the number of collision increase.

14) access slot could be divided between frequcney domain. It means that UE can choose the frequency band for random access at one TTI. For example, at one TTI, frequency band becomes access slot. Namely, freqeucny band 1,2 and 3 could become access slot 1.2 and 3.

LG

Title : **Background_Art_General**
Author : **Patrick FISCHER (pfischer@lge.com)**
Reference : **RDE-0505-PFI-081**
Date: **16/06/2005**
Revision: **16/06/2005**
Version : **V1.1**
To : **general purpose**

1 UMTS Architecture

In general a UMTS system is composed of a UE, NodeB, RNC, SGSN, MSC and other Nodes. The different interfaces are shown in Figure 1:

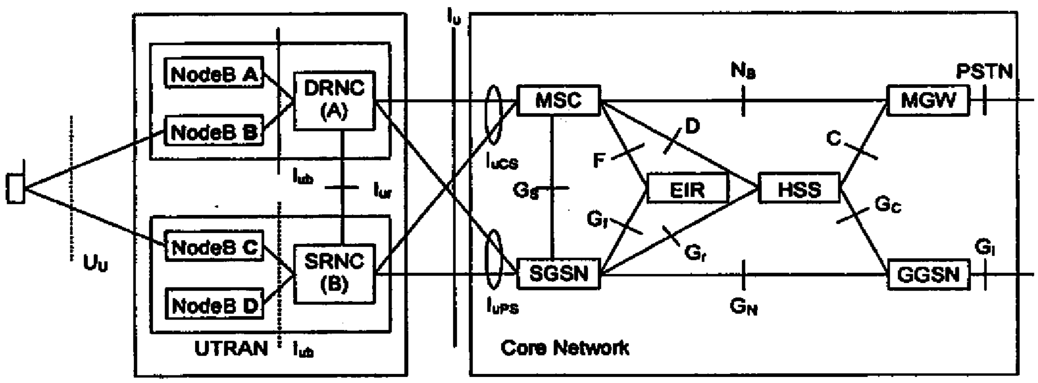


Figure 1: Network elements

A universal mobile telecommunication system (UMTS) is a European-type, third generation IMT-2000 mobile communication system that has evolved from a European standard known as Global System for Mobile communications (GSM). UMTS is intended to provide an improved mobile communication service based upon a GSM core network and wideband code division multiple access (W-CDMA) wireless connection technology. In December 1998, a Third Generation Partnership Project (3GPP) was formed by the ETSI of Europe, the ARIB/TTC of Japan, the T1 of the United States, and the TTA of Korea. The 3GPP creates detailed specifications of UMTS technology. In order to achieve rapid and efficient technical development of the UMTS, five technical specification groups (TSG) have been created within the 3GPP for standardizing the UMTS by considering the independent nature of the network elements and their operations. Each TSG develops, approves, and manages the standard specification within a related region. Among these groups, the radio access network (RAN) group (TSG-RAN) develops the standards for the functions, requirements, and interface of the UMTS terrestrial radio access network (UTRAN), which is a new radio access network for supporting W-CDMA access technology in the UMTS.

Figure 1 gives an overview of the UMTS network, including the UE, the UTRAN and the core network.
The UTRAN is composed of several RNCs and NodeBs which are connected via the Iub interface. Each RNC controls several NodeBs. Each NodeB controls one or several cells, where a cell is characterised by the fact that it covers a given geographical area on a given

frequency. Each RNC is connected via the Iu interface to the CN, i.e. towards the MSC (Mobile-services Switching Centre) entity of the CN and the SGSN (Serving GPRS Support Node) entity. RNCs can be connected to other RNCs via the Iur interface. The RNC handles the assignment and management of radio resources and operates as an access point with respect to the core network.
The NodeBs receive information sent by the physical layer of the terminal through an uplink and transmit data to the terminal through a downlink. The Node-Bs operate as access points of the UTRAN for the terminal. The SGSN is connected via the Gf interface to the EIR (Equipment Identity Register), via the GS interface to the MSC, via the GN interface to the GGSN (Gateway GPRS Support Node) and via the GR interface to the HSS (Home Subscriber Server). The EIR hosts lists of mobiles which are allowed or are not allowed to be used on the network. The MSC which controls the connection for CS services is connected via the NB interface towards the MGW (Media Gateway), via the F interface towards the EIR, and via the D interface towards the HSS. The MGW is connected via the C interface towards the HSS, and to the PSTN (Public Switched Telephone Network), and allows to adapt the codecs between the PSTN and the connected RAN.
The GGSN is connected via the GC interface to the HSS, and via the GI interface to the Internet. The GGSN is responsible for routing, charging and separation of data flows into different RABs. The HSS handles the subscription data of the users.
Other connections exist that are not important for the current invention.

The UTRAN constructs and maintains a radio access bearer (RAB) for communication between the terminal and the core network. The core network requests end-to-end quality of service (QoS) requirements from the RAB, and the RAB supports the QoS requirements the core network has set. Accordingly, by constructing and maintaining the RAB, the UTRAN can satisfy the end-to-end QoS requirements.
The services provided to a specific terminal are roughly divided into the circuit switched (CS) services and the packet switched (PS) services. For example, a general voice conversation service is a circuit switched service, while a Web browsing service via an Internet connection is classified as a packet switched (PS) service.
For supporting circuit switched services, the RNCs are connected to the mobile switching center (MSC) of the core network and the MSC is connected to the gateway mobile switching center (GMSC) that manages the connection with other networks. For supporting packet switched services, the RNCs are connected to the serving general packet radio service (GPRS) support node (SGSN) and the gateway GPRS support node (GGSN) of the core network. The SGSN supports the packet communications with the RNCs and the GGSN manages the connection with other packet switched networks, such as the Internet.

2 UTRAN Functions

LG

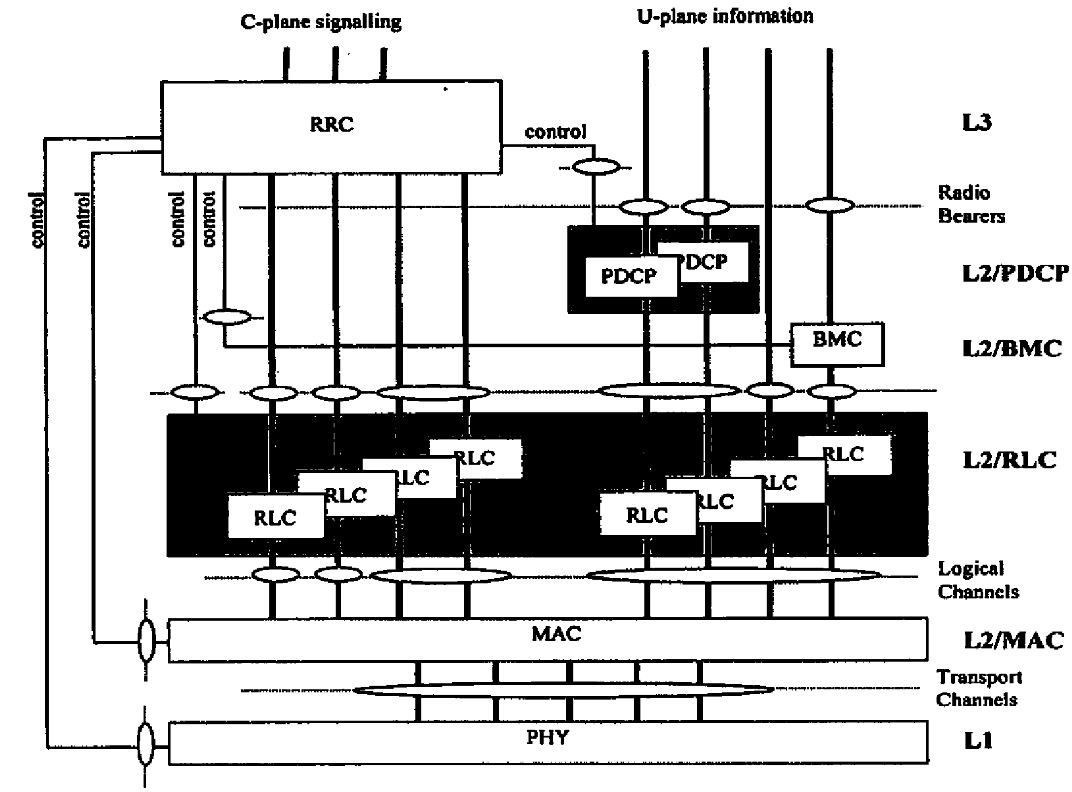


Figure 2: Functions of the RAN

Figure 2 illustrates a structure of a radio interface protocol between the terminal and the UTRAN according to the 3GPP radio access network standards. As shown in Figure 2, the radio interface protocol has horizontal layers comprising a physical layer, a data link layer, and a network layer, and has vertical planes comprising a user plane (U-plane) for transmitting user data and a control plane (C-plane) for transmitting control information. The user plane is a region that handles traffic information with the user, such as voice or Internet protocol (IP) packets. The control plane is a region that handles control information for an interface with a network, maintenance and management of a call, and the like. The protocol layers in Figure 2 can be divided into a first layer (L1), a second layer (L2), and a third layer (L3) based on the three lower layers of an open system interconnection (OSI) standard model. The first layer (L1), namely, the physical layer, provides an information transfer service to an upper layer by using various radio transmission techniques. The physical layer is connected to an upper layer called a medium access control (MAC) layer, via a transport channel. The MAC layer and the physical layer exchange data via the transport channel. The second layer (L2) includes a MAC layer, a radio link control (RLC) layer, a broadcast/multicast control (BMC) layer, and a packet data convergence protocol (PDCP) layer. The MAC layer handles mapping between logical channels and transport channels and provides allocation of the MAC parameters for allocation and re-allocation of radio resources. The MAC layer is connected to an upper layer called the radio link control (RLC) layer, via a logical channel. Various logical channels are provided according to the type of information transmitted. In general, a control channel is used to transmit information of the control plane and a traffic channel is used to transmit information of the user plane. A logical channel may be a common channel or a

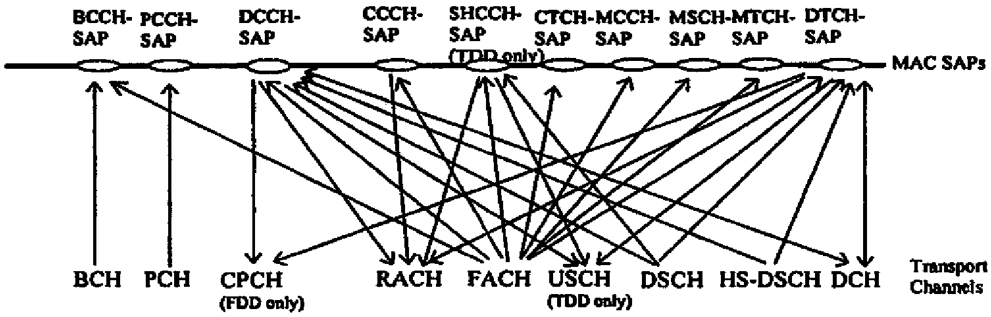


Figure 4: Logical channels mapped onto transport channels, seen from the UE side

The possible mapping between the logical channels and the transport channels from a UTRAN perspective is given in Figure 5.

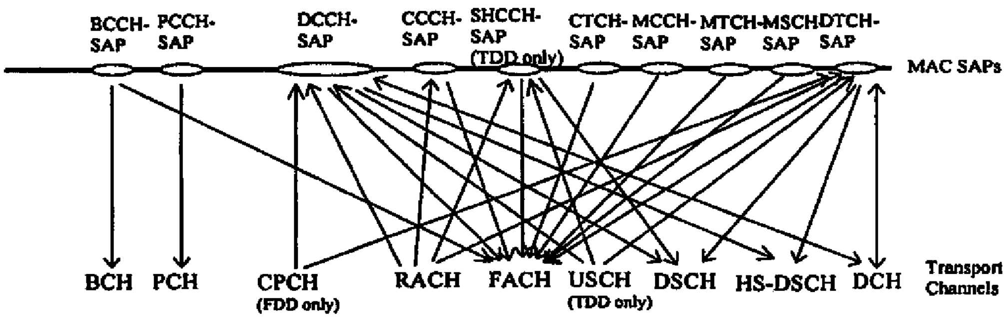


Figure 5: Logical channels mapped onto transport channels, seen from the UTRAN side

The MAC-d sub-layer manages a dedicated channel (DCH), which is a dedicated transport channel for a specific terminal. The MAC-d sublayer is located in a serving RNC (SRNC) that manages a corresponding terminal, and one MAC-d sublayer also exists in each terminal. The RLC layer, depending of the RLC mode of operation supports reliable data transmissions and performs segmentation and concatenation on a plurality of RLC service data units (SDUs) delivered from an upper layer. When the RLC layer receives the RLC SDUs from the upper layer, the RLC layer adjusts the size of each RLC SDU in an appropriate manner based upon processing capacity and then creates data units by adding header information thereto. The data units, called protocol data units (PDUs), are transferred to the MAC layer via a logical channel. The RLC layer includes a RLC buffer for storing the RLC SDUs and/or the RLC PDUs.

The BMC layer schedules a cell broadcast (CB) message transferred from the core network and broadcasts the CB message to terminals positioned in a specific cell or cells.

The PDCP layer is located above the RLC layer. The PDCP layer is used to transmit network protocol data, such as the IPv4 or IPv6, efficiently on a radio interface with a relatively small bandwidth. For this purpose, the PDCP layer reduces unnecessary control information used in a wired network, a function called header compression.

The radio resource control (RRC) layer located at the lowest portion of the third layer (L3) is only defined in the control plane. The RRC layer controls the transport channels and the physical channels in relation to setup, reconfiguration, and the release or cancellation of the radio bearers (RBs). The RB signifies a service provided by the second layer (L2) for data transmission between the terminal and the UTRAN. In general, the set up of the RB refers to the process of stipulating the characteristics of a protocol layer and a channel required for providing a specific data service, and setting the respective detailed parameters and operation methods. Additionally the RRC handles user mobility within the RAN, and additional services, e.g. location services.

The different possibilities that exist for the mapping between the radio bearers and the transport channels for a given UE are not all possible all the time. The UE /UTRAN deduce the possible mapping depending on the UE state and the procedure that the UE / UTRAN is executing. The different states and modes are explained in more detail below, as far as they concern the present invention.

The different transport channels are mapped onto different physical channels. The configuration of the physical channels is given by RRC signalling exchange between the RNC and the UE.

4 RRC states

The RRC mode refers to whether there exists a logical connection between the RRC of the terminal and the RRC of the UTRAN. If there is a connection, the terminal is said to be in RRC connected mode. If there is no connection, the terminal is said to be in idle mode. Because an RRC connection exists for terminals in RRC connected mode, the UTRAN can determine the existence of a particular terminal within the unit of cells, for example which cell or set of cells the RRC connected mode terminal is in, and which physical channel the UE is listening to. Thus, the terminal can be effectively controlled.

In contrast, the UTRAN cannot determine the existence of a terminal in idle mode. The existence of idle mode terminals can only be determined by the core network to be within a region that is larger than a cell, for example a location or a routing area. Therefore, the existence of idle mode terminals is determined within large regions, and, in order to receive mobile communication services such as voice or data, the idle mode terminal must move or change into the RRC connected mode. The possible transitions between modes and states are shown in Figure 6.

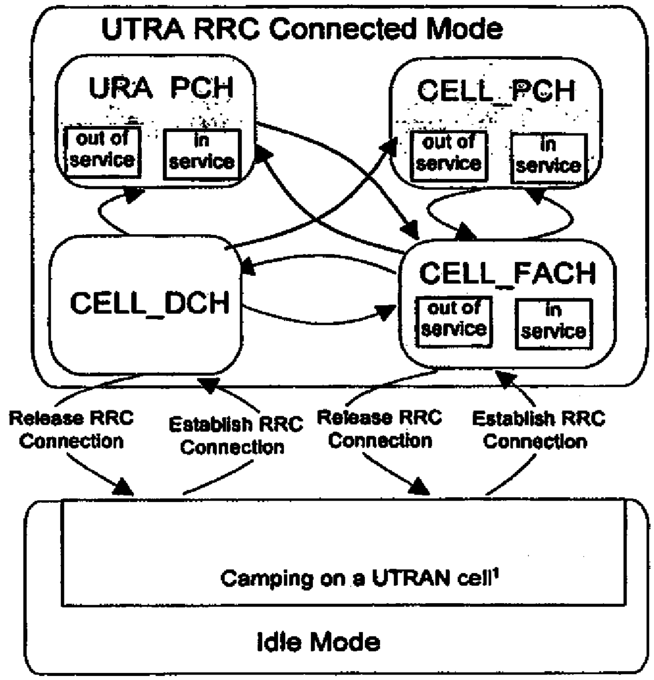


Figure 6: State Transitions

A UE in RRC connected mode can be in different states, e.g. CELL_FACH state, CELL_PCH state, CELL_DCH state or URA_PCH state. Other states could be envisaged of course. Depending on the states the UE carries out different actions and listens to different channels. For example a UE in CELL_DCH state will try to listen (amongst others) to DCH type of transport channels which comprises DTCH and DCCH transport channels and which can be mapped to a certain DPCH, DPDSCH, or other physical channels. The UE in CELL_FACH state will listen to several FACH transport channel which are mapped to a certain S-CCPCH, the UE in PCH state will listen to the PICH channel and to the PCH channel which is mapped to a certain S-CCPCH physical channel.

5 Reading of system information

The main system information is sent on the BCCH logical channel which is mapped on the P-CCPCH (primary Common Control Physical Channel). Specific system information blocks can be sent on the FACH channel. When the system information is sent on FACH the UE receives the configuration of the FACH either on the BCCH that is received on P-CCPCH or on a dedicated channel. The P-CCPCH is always sent using the same scrambling code as the P-CPICH (primary common pilot channel) which is the primary scrambling code of the cell. The spreading code that is used by the P-CCPCH is always of a fixed SF (spreading factor) 256 and the number is always the number 1 as defined in **Error! Reference source not found.**. The UE knows about the primary scrambling code either by information sent from the network on system information of neighbouring cells that the UE has read, by messages that the UE has received on the DCCH channel, or by searching for the P-CPICH, which is always sent using the fixed SF 256, the spreading code number 0 and which always transmits a fixed pattern.

The system information comprises information on neighbouring cells, configuration of the RACH and FACH transport channels, and the configuration of MICH and MCCH which are channels that are dedicated channels for the MBMS service.
Each time the UE is changing the cell it is camping (in idle mode) or when the UE has selected the cell (in CELL_FACH, CELL_PCH or URA_PCH state) the UE verifies that it has valid system information. The system information is organized in SIBs (system information blocks), a MIB (Master information block) and scheduling blocks. The MIB is sent very frequently and gives timing information of the scheduling blocks and the different SIBs. For SIBs that are linked to a value tag the MIB also contains information on the last version of a part of the SIBs. SIBs that are not linked to a value tag are linked to an expiration timer. SIBs linked to an expiration timer become invalid and need to be reread if the time of the last reading of the SIB is bigger than this timer value. SIBs linked to a value tag are only valid if they have the same value tag as the one broadcast in the MIB. Each block has an area scope of validity (Cell, PLMN, equivalent PLMN) which signifies on which cells the SIB is valid. A SIB with area scope "Cell" is valid only for the cell in which it has been read. A SIB with area scope "PLMN" is valid in the whole PLMN, a SIB with the area scope "equivalent PLMN" is valid in the whole PLMN and equivalent PLMN.

In general UEs read the system information when they are in idle mode, CELL_FACH state, CELL_PCH state or in URA_PCH state of the cells that they have selected / the cell that they are camping on. In the system information they receive information on the neighbouring cells on the same frequency, different frequencies and different RAT (Radio access technologies). This allows the UE to know which cells are candidate for cell reselection.

In CELL_DCH state the UE is already listening to the different radio links that the UE is using. It increases the complexity for the UE to read in addition also the BCCH channels. Therefore the information on neighbouring cells is received in general in a dedicated message from the RNC, and only for some very specific functions. However it could be imagined that also in CELL_DCH state UEs read system information sent on the P-CCPCH channel or other transport channels.

6 MBMS

The 3GPP system can provide multimedia broadcast multicast service (MBMS), which is a new type of service in Release 6. The 3GPP TSG SA (Service and System Aspect) defines various network elements and their functions required for supporting MBMS services. A cell broadcast service provided by the conventional Release 99 is limited to a service in which text type short messages are broadcast to a certain area. The MBMS service provided by Release 6 is a more advanced service that multicasts multimedia data to terminals (UEs) that have subscribed to the corresponding service in addition to broadcasting multimedia data.
The MBMS service is a downward-dedicated service that provides a streaming or background service to a plurality of terminals by using a common or dedicated downward channel. The MBMS service is divided into a broadcast mode and a multicast mode.
The MBMS broadcast mode facilitates transmitting multimedia data to every user located in a broadcast area, whereas the MBMS multicast mode facilitates transmitting multimedia data to

a specific user group located in a multicast area. The broadcast area signifies a broadcast service available area and the multicast area signifies a multicast service available area.

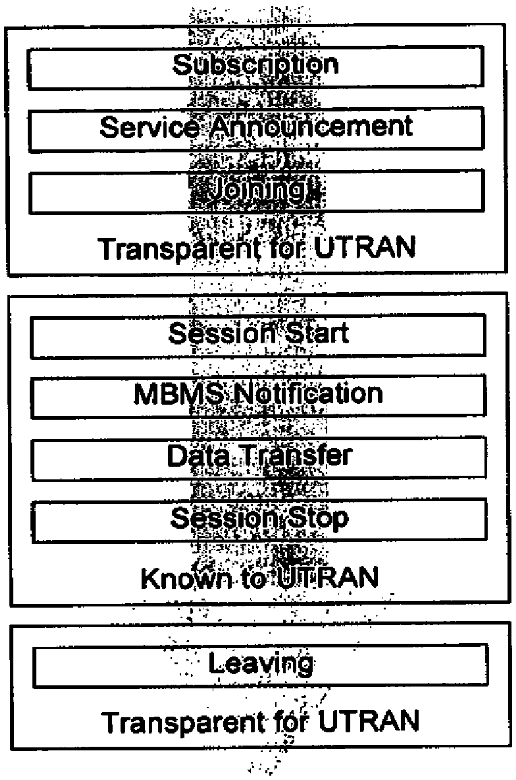


Figure 7: Provision of multicast services

Figure 7 illustrates a process of providing a particular MBMS service, by using multicast mode.
The procedure can be split into 2 types of actions, those that are transparent and those that are not transparent to the UTRAN.
The transparent actions are described in the following:
A user desiring to receive the MBMS service, first needs to subscribe in order to be allowed to receive MBMS services and information on MBMS services and to join a certain set of MBMS services. Then the service announcement provides the terminal with a list of services to be provided and related information. The user can then join these services which means that the user wants to receive information that are linked to the services that the user has joined and becomes part of the multicast service group. When a user is not interested in a given MBMS service any more the user leaves the service, i.e. it is not part of the multicast service group. These actions can be taken by using any means of communication, i.e. this could be done by using SMS (Short Messaging Service), or b internet access and does not necessarily need to be done using the UMTS system.

In order to receive a service for which the user is in a multicast group the following actions that are not transparent to the UTRAN any more are executed: The SGSN informs the RNC about the sessions start. Then the RNC notifies the UEs of the multicast group that a given

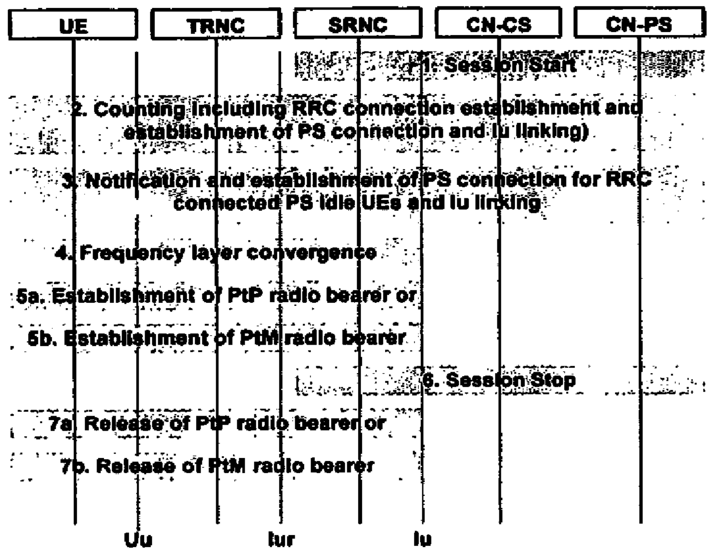


Figure 9: Typical Session Sequence

1. The SGSN informs the RNC about the session start
2. The RNC performs the counting procedure which enables to trigger that a part of the UEs establish a connection to the PS domain, and by this initiates the establishment of an RRC connection for these UEs. This allows the RNC to estimate the number of UEs in a given cell that are interested in this service. When the UE has established the PS connection the SGSN initiates the Iu linking procedure which gives the list of multicast services that the UE has joined to the RNC.
3. For UEs that have an RRC connection established and which are interested in the given MBMS service, but which are not connected to the PS domain the RNC notifies them by sending a specific message in order to trigger that they establish a PS connection. When the UE has established the PS connection the SGSN initiates the Iu linking procedure which gives the list of multicast services that the UE has joined to the RNC. In general for UEs the RNC informs the UEs when a session for a service the UE has joined starts.
4. For UEs that are not in CELL_DCH state the frequency layer convergence scheme allows the RNC to initiate that UEs change the frequency to which they listen, e.g. when a service is sent only on a frequency different to the frequency the UEs have selected.
5. Depending on the RRM (Radio Resource Management) scheme the RNC establishes PtM or PtP bearers for the delivery of the MBMS service and delivers the data that is received from the SGSN to the UEs that are part of the multicast group.
6. After the transmission of the data the SGSN informs the RNC about the sessions stop.
7. The RNC releases then the PtP or PtM bearers that were used for the transmission of MBMS data.

For UEs that are in RRC connected state there are in general two possibilities, either they have a connection established with the PS domain (PMM connected) or they have no connection established to the PS domain (PMM idle mode). When there is no connection

ACCESS INFORMATION. Changes to critical information are only applied at the first MCCH transmission of a modification period and in the beginning of each modification period UTRAN transmits the MBMS CHANGE INFORMATION including MBMS services ids whose MCCH information is modified at that modification period. MBMS CHANGE INFORMATION is repeated at least once in each repetition period of that modification period. Changes to non-critical information can take place at any time.
The Figure 10 below illustrates the schedule with which the MBMS SERVICE INFORMATION and RADIO BEARER INFORMATION would be transmitted. Different colours indicate potentially different MCCH content.

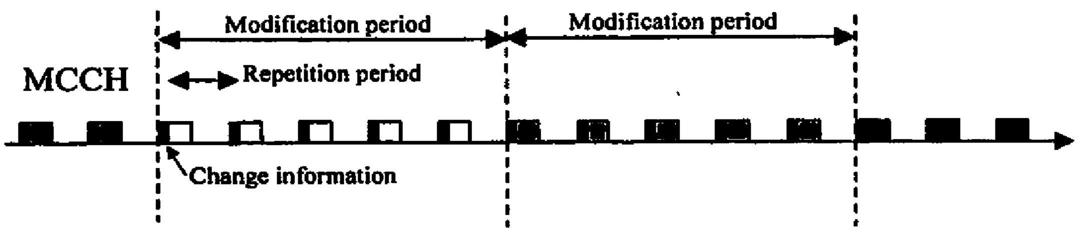


Figure 10: MCCH Information Schedule

6.4 MBMS Notification

The MBMS notification mechanism is used to inform UEs of an upcoming change in critical MCCH information. Notifications are based on service groups. The mapping between service IDs and service groups is based on a hashing mechanism.
The MBMS notification indicators are sent on an MBMS specific PICH, called the MICH. A single MICH frame is able to carry indications for every service-group.
Critical MCCH information can only be changed at the beginning of a modification period. The MBMS notification indicator corresponding to the service group of every affected service is set continuously during the entire modification period preceding the first change in MCCH information related to a given service. Subsequent changes in the MCCH information in the next modification period related to the same service can be signaled on the MCCH.
UEs which are not receiving any MBMS service on MTCH or p-t-p channel are free to read the MBMS notification at any time.
Upon detecting the MBMS notification indication for a service group, UEs interested in a service corresponding to this group start reading the MCCH at the beginning of the next modification period. The UE reads at least MBMS MODIFIED SERVICES INFORMATION.
The Figure 10 below illustrates the timing relation between the setting of the MICH and the first MCCH critical information change. The green colour for the MICH indicates when the NI is set for the service. For the MCCH, different colours indicate MCCH content related to the notification of different services.
UEs, which are receiving MBMS service(s) on MTCH in idle mode or URA_PCH, CELL_PCH, or CELL_FACH state read the MCCH at the beginning of the each modification period to receive the MBMS MODIFIED SERVICES INFORMATION, which will indicate MBMS service Ids and optionally MBMS Session ID whose MCCH information is modified at that modification period. If MBMS service Id and optionally MBMS Session ID, which UE has activated, is indicated in MBMS MODIFIED SERVICES INFORMATION the UE shall read the rest of the MCCH information.

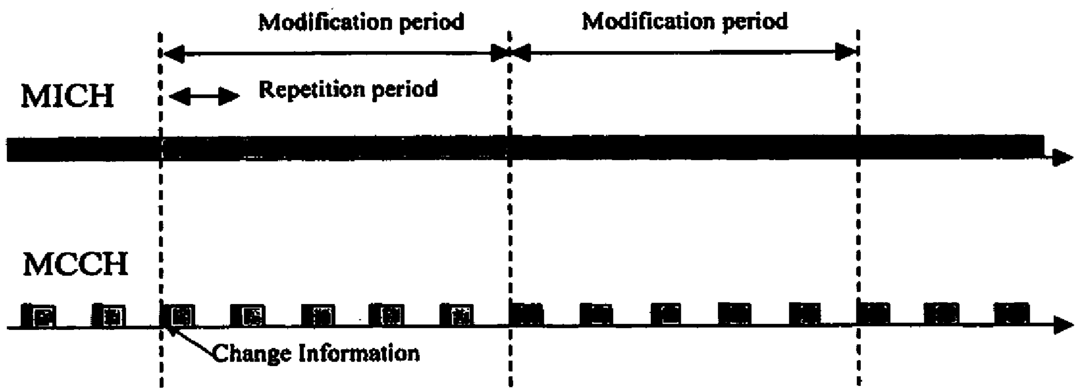


Figure 11: Illustration of MICH timing relative to Modification period

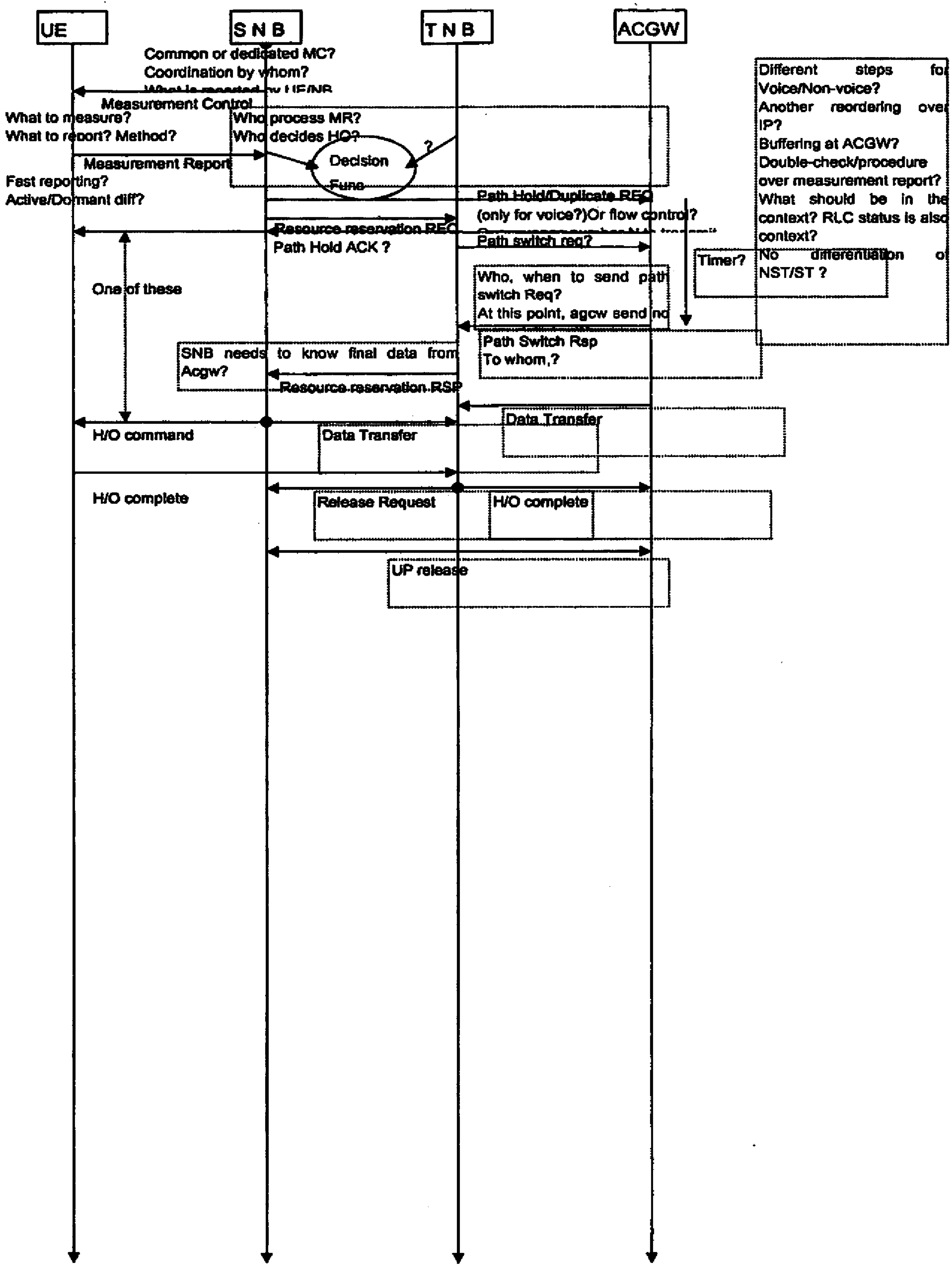
6.5 Reception of PtM bearer

The way the UE can receive the information about the configuration of the PtM radio bearer is shown in **Error! Reference source not found.**.

When a UE in CELL_FACH state wants to receive a PtM bearer the UE first needs to receive the system information on the BCCH channel which is sent on the P-CCPCH channel in order to know the configuration of the MCCH of the cell that the UE has selected. Therefore the UE needs to know the primary scrambling code as mentioned above. Once the UE knows the MCCH channel it then reads the MCCH channel in order to obtain the information of the configuration of the PtM radio bearers. In order to know a first starting cell the UE receives either the primary scrambling code of the cell by dedicated messages, it performs a cell search or it tries stored information, or for a UE that had already selected / camped on a cell it uses information on the neighbouring cells in system information of the cell that the UE had selected before.

7 History

Date	Person	Action	New Version
16/06/2005	PFI	Creation of the document	V0.1
18/07/2005	PFI	Addition of information on MBMS	V1.1



UE
S N B
T N B
ACGW
Common or dedicated MC?
Coordination by whom?
Measurement Control
What to measure?
What to report? Method?
Who process MR?
Who decides HO?
?
Decision
Measurement Report
Fast reporting?
Active/Dormant diff?
Path Hold/Duplicate REQ
(only for voice?)Or flow control?
Resource reservation REQ
Path switch req?
Path Hold ACK ?
Timer?
One of these
Who, when to send path switch Req?
At this point, agcw send no
Different steps for Voice/Non-voice?
Another reordering over IP?
Buffering at ACGW?
Double-check/procedure over measurement report?
What should be in the context? RLC status is also context?
No differentiation of NST/ST ?
SNB needs to know final data from Acgw?
Path Switch Rsp
To whom,?
Resource reservation RSP
H/O command
Data Transfer
Data Transfer
H/O complete
Release Request
H/O complete
UP release

1. Title of the Invention
RLC Reporting at cell change

2. Inventor(s) Information
FISCHER Patrick
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92340 Bourg la Reine
France

3. Description of Invention

3.1 Abstract
The invention is to trigger the transmission of information on which data has already been received in the UE and which data needs to be retransmitted upon change of the serving cell mainly in the HS-DSCH in UMTS.

3.2 Background "State-of-the-Art" Information
For general information see "RDE-0505-PFI-081-V1.1_Background_Art_General.doc"

RDE-0505-PFI-081-V1.1_Background_Art_General.zip

Change of the serving cell

During the change of the serving cell the UE normally transmits data. Since during the change of the serving cell it is possible that the new serving cell is located in another NodeB this implies that the data that has been sent to this NodeB and that has not yet been transmitted will be lost.

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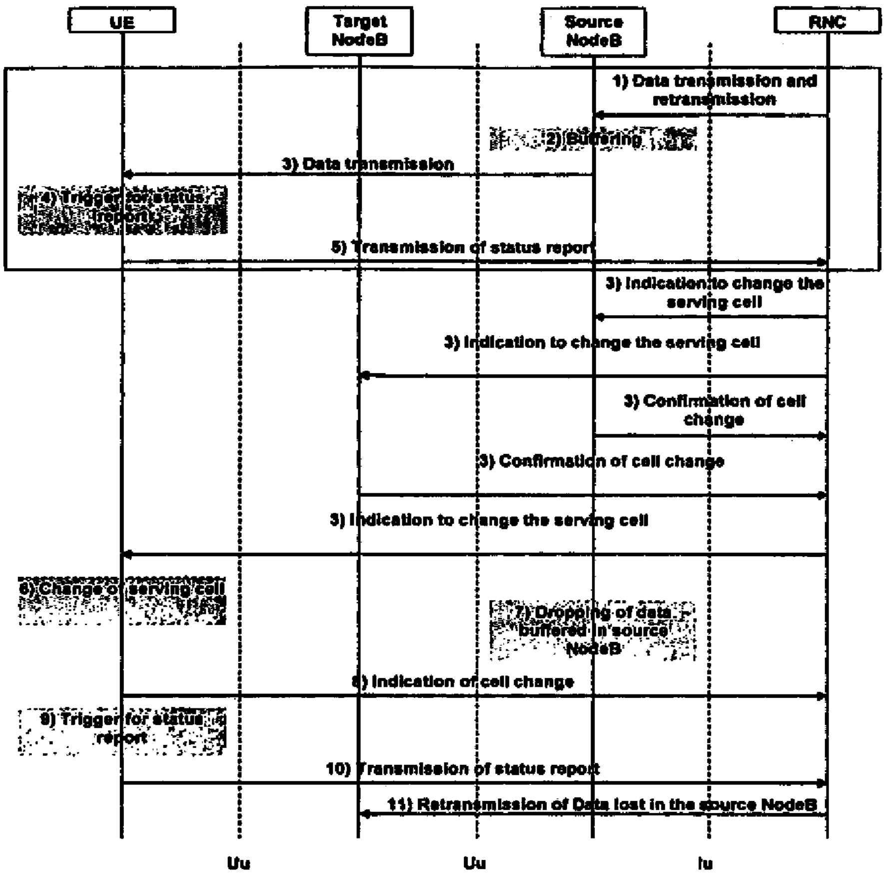

Figure 1: Change of HS-DSCH serving cell

In Figure 1 the UE changes the serving HSDPA cell. During step 1 to 5 data is transmitted from the RNC to the UE. RLC PDUs are sent from the RNC to the NodeB in 1 continuously containing first transmissions and retransmissions. The NodeB in step 2 buffers the arriving data and transmits it to the UE in step 3 depending on the available transmission resources and the priority of the UE. The UE re-assembles the data to RLC SDUs, and indicates periodically to the transmitter in the RNC which PDUs are missing and need to be retransmitted in step 5 by sending a status report.

In step 5 the UE decides or is ordered to change the serving cell. This implies that the UE might start receiving the HS-DSCH from another NodeB. In the source NodeB data has been buffered depending on the availability of the channel resource, and thus it is possible that a large amount of data is buffered. This data in the source NodeB is then dropped as explained in step 6. Due to the fact that the RNC can not know which part of the data buffered in the NodeB has or has not been received by the UE in order to avoid to transmit data that has already been received by the UE the RNC needs to interrupt the transmission of data until it knows which data has already been received.

The UE might indicate the successful cell change to the RNC which indicates that the UE is now listening to the HS-DSCH on the target NodeB.

However due to the fact that the RNC can not know which data has already been received by the UE the RNC can restart the transmission to the NodeB only after the UE has sent a status report indicating the received or not received PDUs.

Timer Poll Prohibit

The "Timer Poll Prohibit" functionality is used in order to prevent that the transmitter requests another status report before all data from the former status report has been transmitted to the UE.

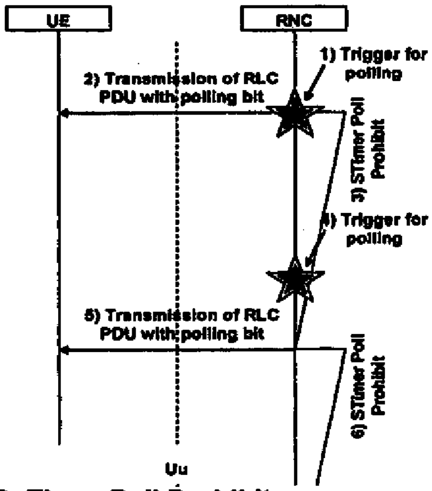

Figure 2: Timer Poll Prohibit

The basic operation is shown in Figure 2. When the transmitter requests a status report by setting the "Polling bit" in a RLC PDU transmitted to the UE as shown in step 2 the transmitter starts a timer "Timer Poll Prohibit" as shown in step 3. In the case a trigger for transmitting an RLC PDU with the "Polling bit" set as shown in step 4 becomes active the setting of the polling bit in a RLC PDU is delayed until the timer "Timer Poll Prohibit" expires as shown in step 5. At transmission of a PDU with the "Polling bit" set the timer "Timer Poll Prohibit" is restarted.

Timer Status Prohibit

The "Timer Status Prohibit" functionality is used in order to prevent that the receiver transmits a status report before the transmitter has a chance to transmit all data from the former status report to the UE.

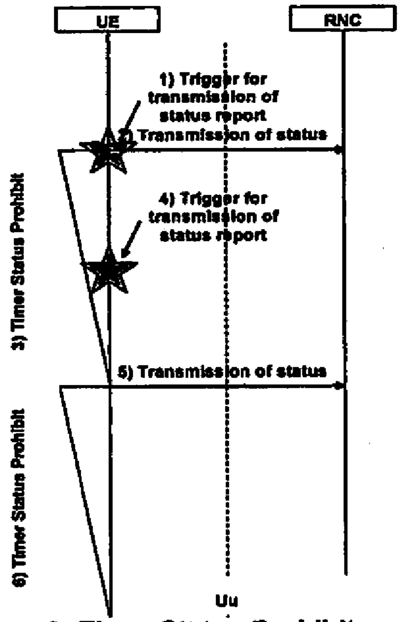

Figure 3: Timer Status Prohibit

The operation is shown in Figure 3. As can be seen when a trigger as shown in step 1 triggers the transmission of the status report the status report is transmitted from the receiver to the transmitter as shown in step 2, and the timer "Timer Status Prohibit" is started as shown in step 3. In the case that a trigger as shown in step 4 triggers the transmission of another status report the actual transmission of the next status report is delayed until the expiry of the timer "Timer Status Prohibit".

3.3 Problem addressed

In UMTS HSDPA data is sent from the RNC where the RLC entity (Radio link Control) managing retransmission is located to the NodeB which buffers the data and forwards it to the UE. RLC is handling retransmissions between the RNC and the UE. At HS-DSCH cell change the data buffered in the NodeB is lost and must be retransmitted from the RNC. In order to trigger the transmission from the RNC to the NodeB the UE must send a "status report" to the RNC in order to indicate to the RNC which data is still missing. The transmission of the status report is today mostly based on timers which don't take into account the special case that the data buffered in the NodeB is lost at cell change.

3.4 General description

The principal idea of this invention is to transmit status information of received and not received data from the receiver to the transmitting entity that handles retransmissions when the serving cell changes, or when a buffer between the transmitter or receiver is reset for any other reason.

Further the invention proposes to give an indication to the receiver when the change of the serving cell means that data in the queue has been flushed.

In addition the transmitter might request the transmission of status information as soon as the serving cell changes / queued data has been flushed.

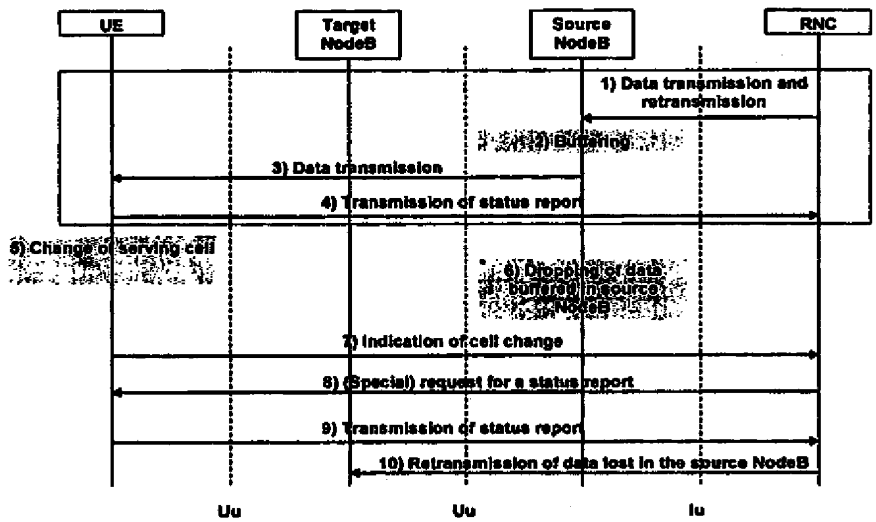

Figure 4: Optimised change of HS-DSCH serving cell

Contrary to the prior art in Figure 1 the transmission of the status report is not triggered by the legacy trigger / timeout, but by a special trigger with relation to the change of the serving cell.

Alternatively the buffering entity could indicate to the retransmitting entity (in the specific example the NodeB and the RNC) which PDUs are discarded i.e. which data has NOT been transmitted to the receiver, such that the transmitter can immediately know which PDUs should be retransmitted.

3.5 Detailed description

Ignoring the Timer Poll Prohibit

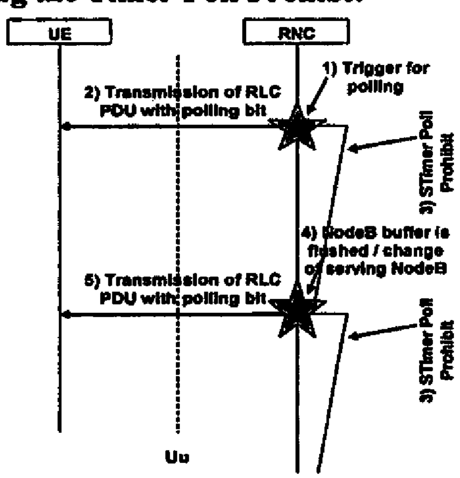

Figure 5: Timer Poll Prohibit

Ignoring the timer Status prohibit

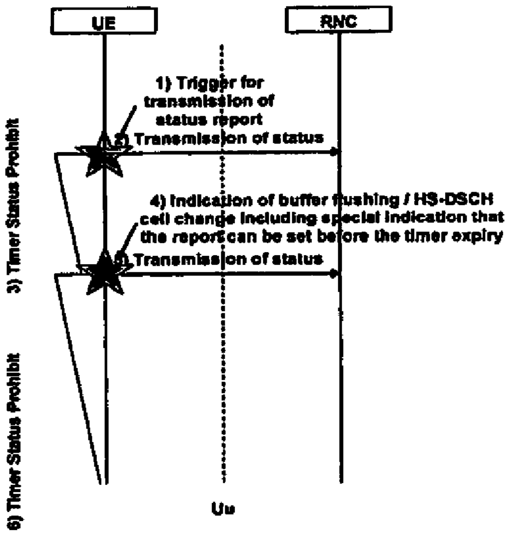

Figure 6: Timer Status Prohibit

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International filing date: 05 January 2007 (05.01.2007)

Document type: Certified copy of priority document

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Number: 60/783,250
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APPLICATION NUMBER: ***60/783,250***
FILING DATE: ***March 16, 2006***

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET – Page 1 of 2

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. EV 656512228 US

INVENTOR(S)		
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Sung-Duck	Chun	Seoul, Korea
Sung-Jun	Park	Gunpo, Korea
Patrick	Fischer	Bourg la Reine, France

Additional inventors are being named on the ______ *separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max):

OVERALL CONSIDERATION FOR THE LTE SYSTEM

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ENCLOSED APPLICATION PARTS ***(check all that apply)***

☐ Application Data Sheet. See 37 CFR 1.76

☐ CD(s), Number of CDs ______

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(if appropriate)

TELEPHONE 213-623-2221   Docket Number: 2101-9192

Customer No: 035884 Attorney Docket No: 2101-9192

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Young-Dae LEE, Myung-Cheul JUNG, Sung-Duck CHUN, Sung-Jun PARK and Patrick FISCHER	Art Unit: Examiner:
Serial No: Filed: Herewith For: OVERALL CONSIDERATION FOR THE LTE SYSTEM	

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PROVISIONAL APPLICATION FOR
UNITED STATES PATENT
IN THE NAMES OF

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Sung-Duck CHUN, Sung-Jun PARK, and Patrick FISCHER

for

OVERALL CONSIDERATION FOR THE LTE SYSTEM

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Express Mail No.: EV 656512228 US

Total Number of Pages: 175 (including cover)

표 준 특 허 의 뢰 서

CTO) 이동통신기술연구소 3G 표준화Gr.	발송일: 2006.03.15	TEL : (031) 450-7922
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발명의 명칭	[3G LTE] 차세대 이동통신시스템에서의 무선 단말의 상향 링크 접속 방법 (Uplink access procedure scheme of wireless UE in the LTE System)	

표준화기구	3GPP TSG RAN2, 3	발표예정회의	RAN2 #51 (2006.03.27~03.31)
관련기술분야	Long-term Evolution (LTE)		
관련표준규격	TS25.813 (LTE TR)		

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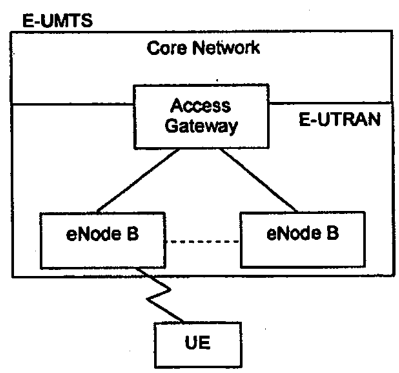


[도 1] E-UMTS (LTE) Network Architecture

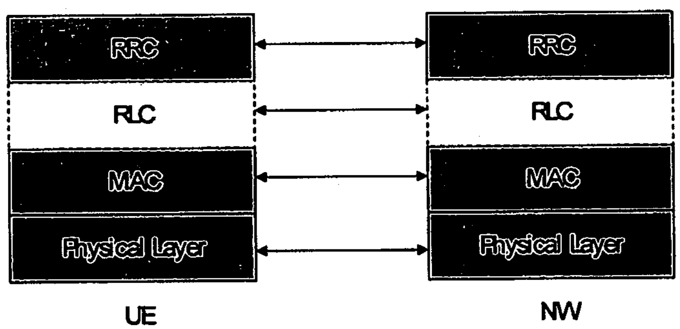
도 1 은 종래 및 본 발명이 적용되는 이동통신 시스템인 E-UMTS(Evolved Universal Mobile Telecommunications System)의 망구조를 나타낸 그림이다. E-UMTS 시스템은 기존 UMTS 시스템에서 진화한 시스템으로 현재 3GPP 에서 기초적인 표준화 작업을 진행하고 있다. E-UMTS 시스템은 LTE(Long Term Evolution) 시스템이라고 할 수도 있다.

E-UMTS 망은 크게 E-UTRAN 과 CN 으로 구분 할 수 있다. E-UTRAN 은 단말(User Equipment; 이하 UE 로 약칭)과 기지국(이하 eNode B 로 약칭), 망의 종단에 위치하여 외부망과 연결되는

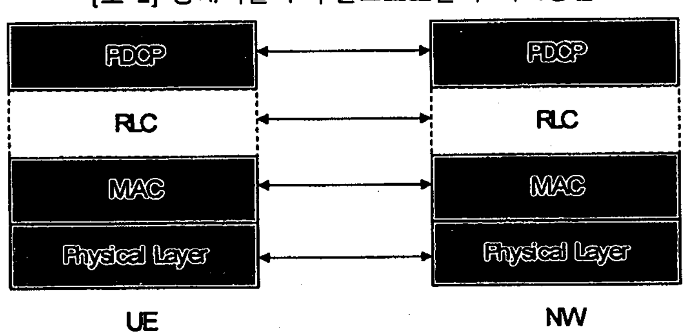
접속게이트웨이(Access Gateway; 이하 AG 로 약칭)로 구성된다. AG 는 사용자 트래픽 처리를 담당하는 부분과 제어용 트래픽을 처리하는 부분으로 나누어 질 수도 있다. 이 때는 새로운 사용자 트래픽 처리를 위한 AG 와 제어용 트래픽을 처리하는 AG 사이에 새로운 인터페이스를 사용하여 서로 통신 할 수도 있다. 하나의 eNode B 에는 하나이상의 셀(Cell)이 존재할 수 있다. eNode B 간에는 사용자 트래픽 혹은 제어 트래픽 전송을 위한 인터페이스가 사용될 수도 있다. CN 은 AG 와 기타 UE 의 사용자 등록 등을 위한 노드 등으로 구성될 수도 있다. E-UTRAN 과 CN 을 구분하기 위한 인터페이스가 사용될 수도 있다.

단말과 망사이의 무선인터페이스 프로토콜 (Radio Interface Protocol)의 계층들은 통신시스템에서 널리 알려진 개방형시스템간상호접속 (Open System Interconnection; OSI)기준모델의 하위 3 개 계층을 바탕으로 L1 (제 1 계층), L2 (제 2 계층), L3(제 3 계층)로 구분될 수 있는데, 이중에서 제 1 계층에 속하는 물리계층은 물리채널(Physical Channel)을 이용한 정보전송서비스(Information Transfer Service)를 제공하며, 제 3 계층에 위치하는 무선자원제어(Radio Resource Control; 이하 RRC 라 약칭함)계층은 단말과 망간에 무선자원을 제어하는 역할을 수행한다. 이를 위해 RRC 계층은 단말과 망간에 RRC 메시지를 서로 교환한다. RRC 계층은 eNode B 와 AG 등 망 노드들에 분산되어 위치할 수도 있고, eNode B 또는 AG 에만 위치할 수도 있다.

도 2는 3GPP 무선접속망 규격을 기반으로 한 단말과 UTRAN (UMTS Terrestrial Radio Access Network) 사이의 무선인터페이스 프로토콜 (Radio Interface Protocol)의 구조를 나타낸다. 도2의 무선인터페이스 프로토콜은 수평적으로 물리계층(Physical Layer), 데이터링크계층(Data Link Layer) 및 네트워크계층(Network Layer)으로 이루어지며, 수직적으로는 데이터정보 전송을 위한 사용자평면(User Plane)과 제어신호(Signaling)전달을 위한 제어평면(Control Plane)으로 구분된다. 도 2의 프로토콜 계층들은 통신시스템에서 널리 알려진 개방형시스템간상호접속 (Open System Interconnection; OSI)기준모델의 하위 3개 계층을 바탕으로 L1 (제1계층), L2 (제2계층), L3(제3계층)로 구분될 수 있다.



[도 2] 종래기술의 무선프로토콜의 제어평면



[도 3] 종래기술의 무선프로토콜의 사용자평면

이하에서 상기 도 2의 무선프로토콜 제어평면과 도3의 무선프로토콜 사용자평면의 각 계층을 설명한다.

제 1 계층인 물리계층은 물리채널(Physical Channel)을 이용하여 상위 계층에게 정보전송서비스(Information Transfer Service)를 제공한다. 물리계층은 상위에 있는 매체접속제어(Medium Access Control)계층과는 전송채널(Transport Channel)을 통해 연결되어 있으며, 이 전송채널을 통해 매체접속제어계층과 물리계층 사이의 데이터가 이동한다. 그리고, 서로 다른 물리계층 사이, 즉 송신측과 수신측의 물리계층 사이는 물리채널을 통해 데이터가 이동한다.

제 2 계층의 매체접속제어 (Medium Access Control; 이하 MAC 로 약칭)는 논리채널(Logical Channel)을 통해 상위계층인 무선링크제어(Radio Link Control)계층에게 서비스를 제공한다. 제 2 계층의 무선링크제어(Radio Link Control; 이하 RLC 로 약칭)계층은 신뢰성 있는 데이터의 전송을 지원한다. RLC 계층의 기능이 MAC 내부의 기능 블록으로 구현될 수도 있다. 이러한 경우에는 RLC 계층은 존재하지 않을 수도 있다. 제 2 계층의 PDCP 계층은 IPv4 나 IPv6 와 같은 IP 패킷 전송시에 대역폭이 작은 무선 구간에서 효율적으로 전송하기 위하여 상대적으로 크기가 크고 불필요한 제어정보를 담고 있는 IP 패킷 헤더 사이즈를 줄여주는 헤더압축 (Header Compression) 기능을 수행한다.

제 3 계층의 가장 상부에 위치한 무선자원제어(Radio Resource Control; 이하 RRC 라 약칭함)계층은 제어평면에서만 정의되며, 무선베어러 (Radio Bearer; RB 라 약칭함)들의 설정(Configuration), 재설정(Re-configuration) 및 해제(Release)와 관련되어 논리채널, 전송채널 및 물리채널들의 제어를 담당한다. 이때, RB 는 단말과 UTRAN 간의 데이터 전달을 위해 제 2 계층에 의해 제공되는 서비스를 의미한다.

망에서 단말로 데이터를 전송하는 하향전송채널로는 시스템정보를 전송하는 BCH(Broadcast Channel)과 그 이외에 사용자 트래픽이나 제어메시지를 전송하는 하향 SCH(Shared Channel)이 있다. 하향 멀티캐스트 또는 방송 서비스의 트래픽 또는 제어메시지의 경우 하향 SCH 를 통해 전송될 수도 있고, 또는 별도의 하향 MCH(Multicast Channel)을 통해 전송될 수도 있다. 한편, 단말에서 망으로 데이터를 전송하는 상향전송채널로는 초기 제어메시지를 전송하는 RACH(Random Access Channel)와 그 이외에 사용자 트래픽이나 제어메시지를 전송하는 상향 SCH(Shared Channel)가 있다.

3. 발명이 이루고자 하는 기술적 과제

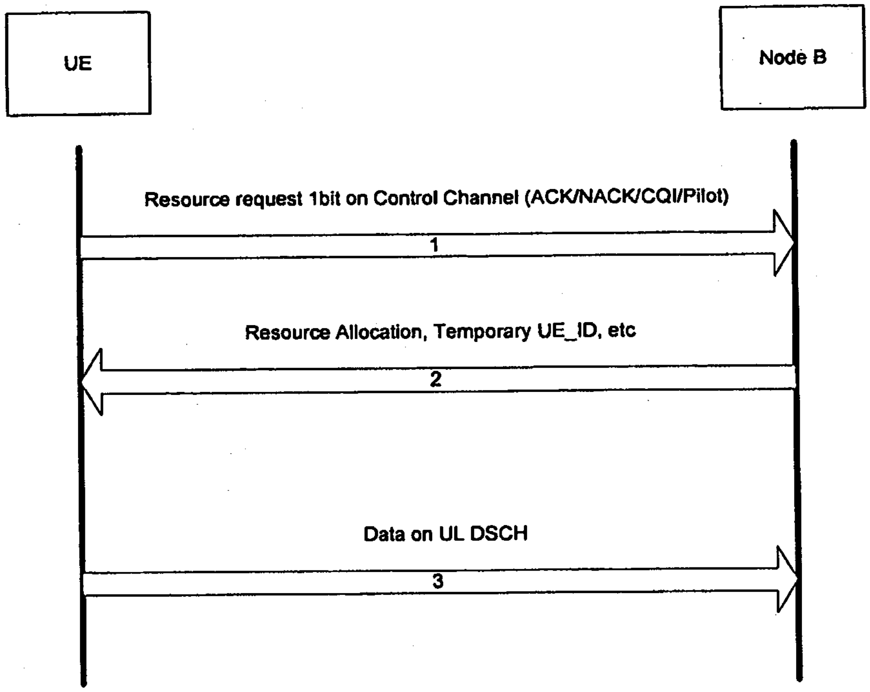
종래의 기술은 무선 단말이 Active 모드 상태에 있을 때 다운링크를 수신하면서 다운링크에 해당 되는 제어 신호를 상향 링크로 전송하기 때문에 상향링크 동기가 유지되고 있고 주파수도 할당된 특정 단일 주파수 대역만 사용하고 있어서 상향 링크 데이터가 전송하려 할 때 특별히 자원 요청을 할 필요가 없이 단말이 초기 접속을 시도 할 때 configuration으로 할당된 Uplink radio resource로 데이터를 바로 전송하면 되었다.

그러나 LTE에서는 다중 대역의 주파수의 자원을 이용한 OFDM 방식으로 데이터를 전송하는 방식이어서 Active 모드의 무선 단말이 데이터를 전송하려 할 때 보낼 데이터 양에 해당되는 자원을 할당 받기 위해 기지국으로 자원을 요청하게 되고 기지국은 무선 단말의 요청 자원에 알맞고 기지국이 할당 가능한 자원을 판단해서 무선 단말이 어느 주파수 대역을 사용하고 어느 시점에 전송할 것인지에 대한 자원을 할당해 주어야 한다. 그리고 LTE 시스템에서는 Active 모드의 무선 단말이 상향 링크 동기가 유지되는 것뿐만 아니라 송수

신이 오랫동안 하지 않더라도 Active 모드 상태를 유지 하려고 하기 때문에 단말이 이 상태에 있을 경우 상향링크 동기를 잃게 된다. 이런 두 상태 (상향링크 동기유지, 상향링크 비동기 상태)에 있을 때 무선 단말이 보낼 데이터가 있을 경우 각각 상태에 따라 자원을 요청 방법을 규명 해야 한다.

4. 발명의 구성 및 작용

따라서, 본 발명은 무선 단말이 Active 모드에 있을 때 단말이 보낼 데이터가 있을 때 기지국으로 자원을 요청하는 것을 특정으로 한다. 상기 자원 요청에 대한 기지국의 자원 할당은 데이터가 보내게 될 주파수, 전송 시간, 그리고 얼마 동안 보내는 지에 대한 기간 등을 포함하는 것을 특징으로 한다. 상기 자원을 요청할 때 상향링크가 동기가 유지될 때 즉 상향링크로 제어 신호 혹은 파일롯 신호가 계속 혹은 주기적으로 보내지고 있을 때와 상향링크 동기가 유지 되지 않을 때 즉 상향링크로 어떤 데이터도 전송되지 않을 때에 따라 각각 자원 요청 방법을 다르게 하는 것을 특징으로 한다. 상기 자원 할당 방법은 상향링크 동기가 유지되었을 때 자원 할당 방법을 도 4에서 도시 하였고 상향링크 동기가 유지되지 않을 때 자원 할당 방법을 도 5에 도시 하였다 각각 도를 보면서 자원 할당 과정을 설명하도록 한다.



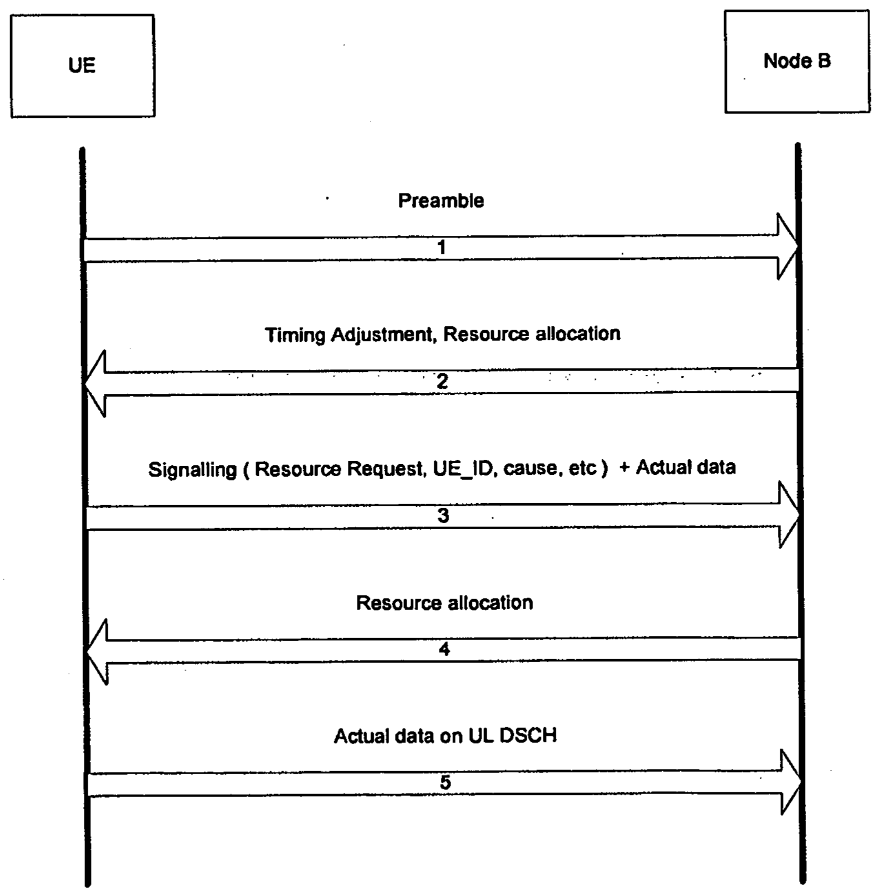
[도 4]. 상향 링크 동기가 유지되고 있을 때 자원 할당 방법

0. 무선 단말은 다운링크 데이터를 수신하고 있으면서 상향 링크로 제어 신호를 전송하고 있는 상태로 Active 모드 상태에서 상향 링크 동기가 유지되고 있는 상태이다. 이때 무선 단말이 기지국으로 보낼 데이터가 발생된 상태.

1. 상향 링크 물리 채널의 제어 채널을 이용해 자원 요청을 한다. 자원 요청 정보는 1bit로 제어 신호(ACK/NACK or CQI or Pilot)에 포함하여 전송한다.

2. 자원 요청 정보를 수신한 Node B는 제어 채널 정보가 dedicated된 신호이기 때문에 재어 채널을 전송한 단말 정보를 알게 됨으로 자원 할당 정보를 자원을 요청한 단말에게 dedicate하게 알려주기 위해 Temporary UE_ID정보를 포함해서 자원을 할당해 준다. 상기 자원 할당 정보는 주파수 정보, 전송 시점 정보, 전송기간 정보 등등을 포함하는 것을 특징으로 한다.

3. 단말이 자원할당 정보를 수신하고 자원 할당 정보에 따라 상향 링크 전송 채널로 보낼 데이터를 전송한다.



[도 5]. 상향 링크 동기가 유지하지 않을 때 자원 할당 방법

0. 무선 단말은 다운링크 데이터를 긴 주기를 갖는 DRX로 데이터를 수신하고 있고 이때 상향 링크는 어떤 데이터도 전송하지 않은 상태이다. 즉, 긴 시간 동안 상향링크 데이터를 전송하지 않았기 때문에 대부분 상

향링크 동기가 잃게 된 상태이다. 이 상태에서 무선 단말이 기지국으로 보낼 데이터가 있는 상태.

1. 무선 단말의 상향링크가 동기가 깨졌다고 보고 자원 요청 정보를 보내기 전에 상향 링크 동기를 유지할 필요가 있다. 그래서 단말이 자원 요청 정보를 보내기 전에 Preamble를 먼저 보내 기지국이 상향링크를 동기를 획득 하도록 한다.

2. 기지국은 Preamble을 수신하고 상향링크 동기를 맞추기 위해 Time Adjustment정보를 단말로 보낸다. 그리고 단말이 자원 요청 정보 메시지를 보낼 수 있도록 자원을 할당해주는 정보를 보낸다. 이때 할당해 주는 자원은 단말이 자원 요청 정보를 포함한 signaling 메시지를 보낼 수 있을 정도의 최소 자원 i.g. one resource block 을 할당해 준다.

3. 무선 단말은 기지국이 할당해준 자원을 통해 signaling 메시지 (자원 요청 정보, UE_ID정보, cause 정보, 등등) 및 실제 데이터를 보내는 것을 특징으로 한다. 기지국이 할당한 자원이 단말이 보내는 signaling 메시지를 보내고 남을 경우 실제 보내고자 하는 데이터를 같이 전송해서 자원의 낭비를 막는 것을 특징으로 한다. 상기 UE_ID정보는 단말이 기지국으로부터 Temporary UE_ID (i.g. C-RNTI)를 할당 받고 다른 Node B로 이동하지 않을 경우 기지국으로 할당 받은 Temporary UE_ID를 사용한다. 만약 단말이 다른 Node B로 이동하게 되면 UE_ID는 아직 이동한 Node B에서 새로운 Temporary UE_ID를 할당 받지 않았다면 단말의 Static UE_ID (i.g. IMSI)를 사용하는 것을 특징으로 한다.. 상기 cause 정보는 단말이 Initial access인지, Active mode 상태에서 자원 요청인지, 다른 Node B로의 Handover에 따른 자원 요청 등등을 알려주는 정보를 특징으로 한다.

4. 자원 요청 정보를 수신한 Node B는 단말로 수신한 signaling 메시지 내에 UE_ID 정보가 포함 되어 있어서 자원을 요구한 단말로 dedicate하게 자원 할당 정보를 보낼 수 있는 것을 특징으로 한다. 상기 자원 할당 정보는 주파수 정보, 전송 시점 정보, 전송 기간 정보 등등을 포함하는 것을 특징으로 한다.

5. 단말이 자원 할당 정보를 수신하고 자원 할당 정보에 따라 상향 링크 전송 채널로 보낼 데이터를 전송한다.

5. 본 발명의 효과

이상 설명한 바와 같이 본 발명은,

6. 특허 청구범위

[1]

표 준 특 허 의 뢰 서

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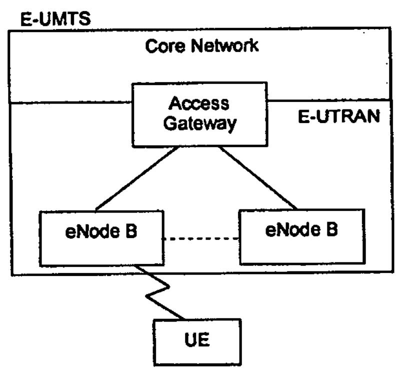
발명의 명칭	[3G LTE] 차세대 이동통신시스템에서의 무선 단말의 상향 링크 접속 방법 (Uplink access procedure scheme of wireless UE in the LTE System)	

표준화기구	3GPP TSG RAN2, 3	발표예정회의	RAN2 #51 (2006.03.27~03.31)
관련기술분야	Long-term Evolution (LTE)		
관련표준규격	TS25.813 (LTE TR)		

1. 발명의 목적

본 발명은 무선통신을 제공하는 무선 통신 시스템과 단말에 관한 것으로, LTE에서 Active 모드에 있는 무선 단말은 상향링크 동기가 유지된 상태와 동기가 유지되지 않은 상태가 존재하게 되는데 Active 모드에 있는 단말이 전송할 데이터가 있어 기지국으로 상향 링크 자원을 요청 할 때 상향링크 동기가 유지된 상태와 동기가 유지되지 않은 상태에 있을 때에 따라 각각 상향 링크 자원 요청 하는 방법을 적절하게 규명해야 한다.

2. 발명이 속하는 기술분야 및 그 분야의 종래기술



[도 1] E-UMTS (LTE) Network Architecture

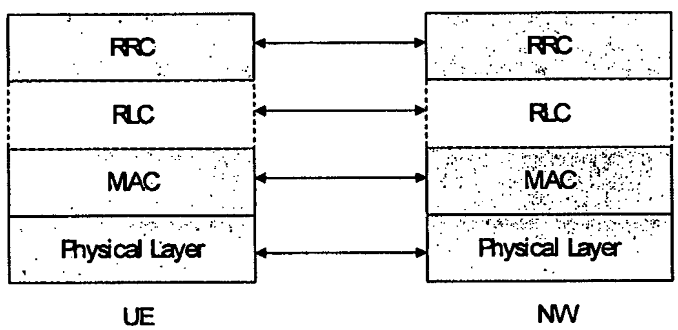
도 1 은 종래 및 본 발명이 적용되는 이동통신 시스템인 E-UMTS(Evolved Universal Mobile Telecommunications System)의 망구조를 나타낸 그림이다. E-UMTS 시스템은 기존 UMTS 시스템에서 진화한 시스템으로 현재 3GPP 에서 기초적인 표준화 작업을 진행하고 있다. E-UMTS 시스템은 LTE(Long Term Evolution) 시스템이라고 할 수도 있다.

E-UMTS 망은 크게 E-UTRAN 과 CN 으로 구분 할 수 있다. E-UTRAN 은 단말(User Equipment; 이하 UE 로 약칭)과 기지국(이하 eNode B 로 약칭), 망의 종단에 위치하여 외부망과 연결되는

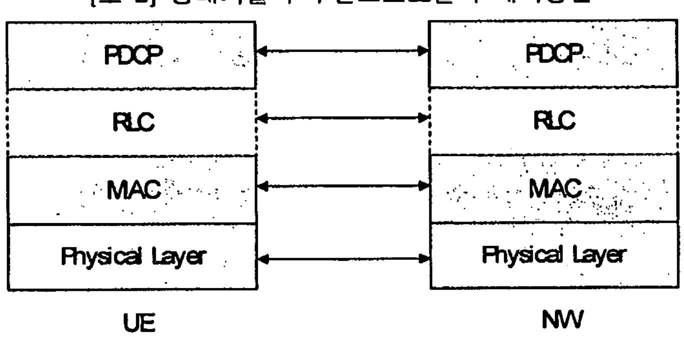
접속게이트웨이(Access Gateway; 이하 AG 로 약칭)로 구성된다. AG 는 사용자 트래픽 처리를 담당하는 부분과 제어용 트래픽을 처리하는 부분으로 나누어 질 수도 있다. 이 때는 새로운 사용자 트래픽 처리를 위한 AG 와 제어용 트래픽을 처리하는 AG 사이에 새로운 인터페이스를 사용하여 서로 통신 할 수도 있다. 하나의 eNode B 에는 하나이상의 셀(Cell)이 존재할 수 있다. eNode B 간에는 사용자 트래픽 혹은 제어 트래픽 전송을 위한 인터페이스가 사용될 수도 있다. CN 은 AG 와 기타 UE 의 사용자 등록 등을 위한 노드 등으로 구성될 수도 있다. E-UTRAN 과 CN 을 구분하기 위한 인터페이스가 사용될 수도 있다.

단말과 망사이의 무선인터페이스 프로토콜 (Radio Interface Protocol)의 계층들은 통신시스템에서 널리 알려진 개방형시스템간상호접속 (Open System Interconnection; OSI)기준모델의 하위 3 개 계층을 바탕으로 L1 (제 1 계층), L2 (제 2 계층), L3(제 3 계층)로 구분될 수 있는데, 이중에서 제 1 계층에 속하는 물리계층은 물리채널(Physical Channel)을 이용한 정보전송서비스(Information Transfer Service)를 제공하며, 제 3 계층에 위치하는 무선자원제어(Radio Resource Control; 이하 RRC 라 약칭함)계층은 단말과 망간에 무선자원을 제어하는 역할을 수행한다. 이를 위해 RRC 계층은 단말과 망간에 RRC 메시지를 서로 교환한다. RRC 계층은 eNode B 와 AG 등 망 노드들에 분산되어 위치할 수도 있고, eNode B 또는 AG 에만 위치할 수도 있다.

도 2는 3GPP 무선접속망 규격을 기반으로 한 단말과 UTRAN (UMTS Terrestrial Radio Access Network) 사이의 무선인터페이스 프로토콜 (Radio Interface Protocol)의 구조를 나타낸다. 도2의 무선인터페이스 프로토콜은 수평적으로 물리계층(Physical Layer), 데이터링크계층(Data Link Layer) 및 네트워크계층(Network Layer)으로 이루어지며, 수직적으로는 데이터정보 전송을 위한 사용자평면(User Plane)과 제어신호(Signaling)전달을 위한 제어평면(Control Plane)으로 구분된다. 도 2의 프로토콜 계층들은 통신시스템에서 널리 알려진 개방형시스템간상호접속 (Open System Interconnection; OSI)기준모델의 하위 3개 계층을 바탕으로 L1 (제1계층), L2 (제2계층), L3(제3계층)로 구분될 수 있다.



[도 2] 종래기술의 무선프로토콜의 제어평면



[도 3] 종래기술의 무선프로토콜의 사용자평면

이하에서 상기 도 2의 무선프로토콜 제어평면과 도3의 무선프로토콜 사용자평면의 각 계층을 설명한다.

제 1 계층인 물리계층은 물리채널(Physical Channel)을 이용하여 상위 계층에게 정보전송서비스(Information Transfer Service)를 제공한다. 물리계층은 상위에 있는 매체접속제어(Medium Access Control)계층과는 전송채널(Transport Channel)을 통해 연결되어 있으며, 이 전송채널을 통해 매체접속제어계층과 물리계층 사이의 데이터가 이동한다. 그리고, 서로 다른 물리계층 사이, 즉 송신측과 수신측의 물리계층 사이는 물리채널을 통해 데이터가 이동한다.

제 2 계층의 매체접속제어 (Medium Access Control; 이하 MAC 로 약칭)는 논리채널(Logical Channel)을 통해 상위계층인 무선링크제어(Radio Link Control)계층에게 서비스를 제공한다. 제 2 계층의 무선링크제어(Radio Link Control; 이하 RLC 로 약칭)계층은 신뢰성 있는 데이터의 전송을 지원한다. RLC 계층의 기능이 MAC 내부의 기능 블록으로 구현될 수도 있다. 이러한 경우에는 RLC 계층은 존재하지 않을 수도 있다. 제 2 계층의 PDCP 계층은 IPv4 나 IPv6 와 같은 IP 패킷 전송시에 대역폭이 작은 무선 구간에서 효율적으로 전송하기 위하여 상대적으로 크기가 크고 불필요한 제어정보를 담고 있는 IP 패킷 헤더 사이즈를 줄여주는 헤더압축 (Header Compression) 기능을 수행한다.

제 3 계층의 가장 상부에 위치한 무선자원제어(Radio Resource Control; 이하 RRC 라 약칭함)계층은 제어평면에서만 정의되며, 무선베어러 (Radio Bearer; RB 라 약칭함)들의 설정(Configuration), 재설정(Re-configuration) 및 해제(Release)와 관련되어 논리채널, 전송채널 및 물리채널들의 제어를 담당한다. 이때, RB 는 단말과 UTRAN 간의 데이터 전달을 위해 제 2 계층에 의해 제공되는 서비스를 의미한다.

망에서 단말로 데이터를 전송하는 하향전송채널로는 시스템정보를 전송하는 BCH(Broadcast Channel)과 그 이외에 사용자 트래픽이나 제어메시지를 전송하는 하향 SCH(Shared Channel)이 있다. 하향 멀티캐스트 또는 방송 서비스의 트래픽 또는 제어메시지의 경우 하향 SCH 를 통해 전송될 수도 있고, 또는 별도의 하향 MCH(Multicast Channel)을 통해 전송될 수도 있다. 한편, 단말에서 망으로 데이터를 전송하는 상향전송채널로는 초기 제어메시지를 전송하는 RACH(Random Access Channel)와 그 이외에 사용자 트래픽이나 제어메시지를 전송하는 상향 SCH(Shared Channel)가 있다.

3. 발명이 이루고자 하는 기술적 과제

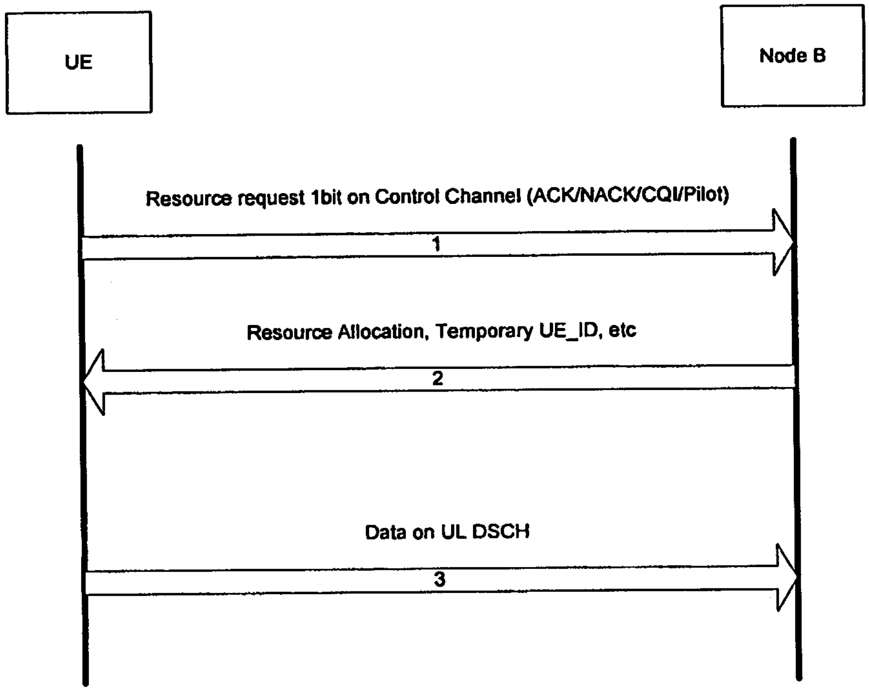
종래의 기술은 무선 단말이 Active 모드 상태에 있을 때 다운링크를 수신하면서 다운링크에 해당 되는 제어 신호를 상향 링크로 전송하기 때문에 상향링크 동기가 유지되고 있고 주파수도 할당된 특정 단일 주파수 대역만 사용하고 있어서 상향 링크 데이터가 전송하려 할 때 특별히 자원 요청을 할 필요가 없이 단말이 초기 접속을 시도 할 때 configuration으로 할당된 Uplink radio resource로 데이터를 바로 전송하면 되었다.

그러나 LTE에서는 다중 대역의 주파수의 자원을 이용한 OFDM 방식으로 데이터를 전송하는 방식이어서 Active 모드의 무선 단말이 데이터를 전송하려 할 때 보낼 데이터 양에 해당되는 자원을 할당 받기 위해 기지국으로 자원을 요청하게 되고 기지국은 무선 단말의 요청 자원에 알맞고 기지국이 할당 가능한 자원을 판단해서 무선 단말이 어느 주파수 대역을 사용하고 어느 시점에 얼마 동안 전송할 것인지에 대한 자원을 할당해 주어야 한다. 그리고 LTE 시스템에서는 Active 모드의 무선 단말이 상향 링크 동기가 유지되는 것뿐만

아니라 송수신이 오랫동안 하지 않더라도 즉 상향링크 동기가 유지되지 않더라도 Active 모드 상태를 유지하려고 한다. 따라서 이런 두 상태 (상향링크 동기유지, 상향링크 비동기 상태)에 있을 때 무선 단말이 보낼 데이터가 있을 경우 각각 상태에 따라 자원을 요청 방법을 규명 해야 한다.

4. 발명의 구성 및 작용

따라서, 본 발명은 무선 단말이 Active 모드에 있을 때 단말이 보낼 데이터가 있을 때 기지국으로 자원을 요청하는 것을 특징으로 한다. 상기 자원 요청에 대한 기지국의 자원 할당은 데이터가 보내게 될 주파수, 전송 시간, 그리고 얼마 동안 보내는 지에 대한 기간 등을 포함하는 것을 특징으로 한다. 상기 자원을 요청할 때 상향링크가 동기가 유지될 때 즉 상향링크로 제어 신호 혹은 파일롯 신호가 계속 혹은 주기적으로 보내지고 있을 때와 상향링크 동기가 유지 되지 않을 때 즉 상향링크로 어떤 데이터도 전송되지 않을 때에 따라 각각 자원 요청 방법을 다르게 하는 것을 특징으로 한다. 상기 자원 할당 방법은 상향링크 동기가 유지되었을 때 자원 할당 방법을 도 4에서 도시 하였고 상향링크 동기가 유지되지 않을 때 자원 할당 방법을 도 5에 도시 하였다 각각 도를 보면서 자원 할당 과정을 설명하도록 한다.



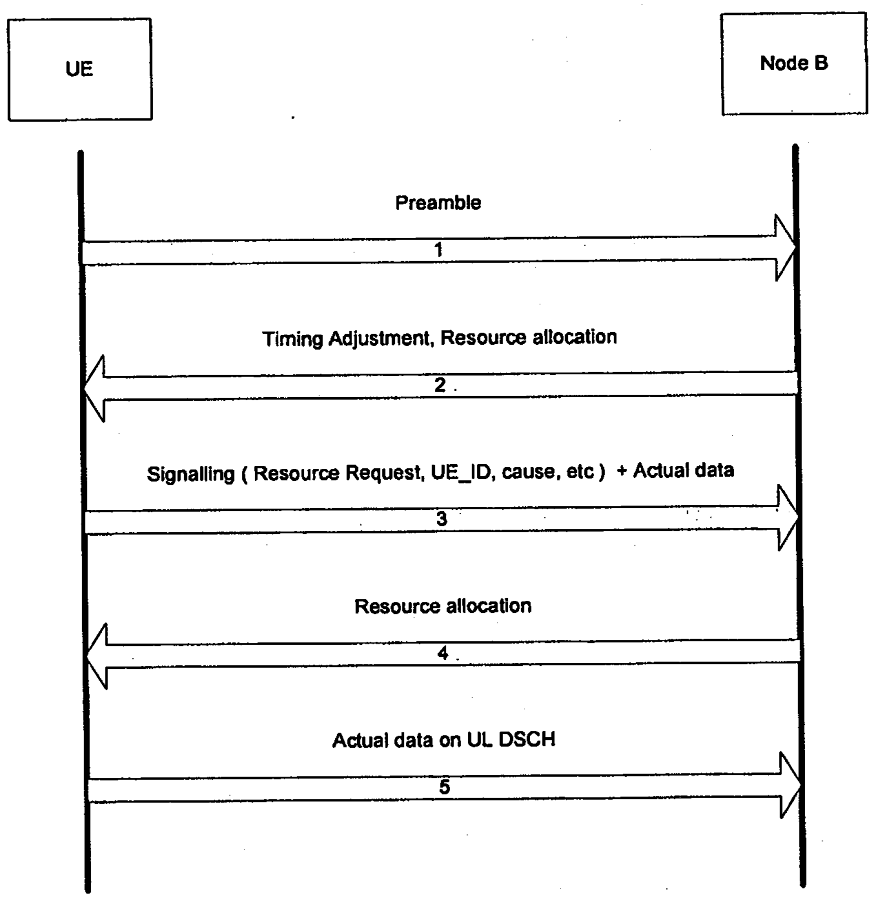
[도 4]. 상향 링크 동기가 유지되고 있을 때 자원 할당 방법

0. 무선 단말은 다운링크 데이터를 수신하고 있으면서 상향 링크로 제어 신호를 전송하고 있는 상태로 Active 모드 상태에서 상향 링크 동기가 유지되고 있는 상태이다. 이때 무선 단말이 기지국으로 보낼 데이터가 발생된 상태.

1. 상향 링크 물리 채널의 제어 채널을 이용해 자원 요청하는 것을 특징으로 한다. 자원 요청 정보는 1bit로 제어 신호(ACK/NACK or CQI or Pilot)에 포함하여 전송하는 것을 특징으로 한다.

2. 자원 요청 정보를 수신한 Node B는 제어 채널 정보가 dedicated된 신호이기 때문에 재어 채널을 전송한 단말 정보를 알게 됨으로 자원 할당 정보를 자원을 요청한 단말에게 dedicate하게 알려주기 위해 Temporary UE_ID정보를 포함해서 자원을 할당해 주는 것을 특징으로 한다. 상기 자원 할당 정보는 주파수 정보, 전송 시점 정보, 전송기간 정보 등등을 포함하는 것을 특징으로 한다.

3. 단말이 자원할당 정보를 수신하고 자원 할당 정보에 따라 상향 링크 전송 채널로 보낼 데이터를 전송하는 것을 특징으로 한다.



[도 5]. 상향 링크 동기가 유지하지 않을 때 자원 할당 방법

0. 무선 단말은 다운링크 데이터를 긴 주기를 갖는 DRX로 데이터를 수신하고 있고 이때 상향 링크는 어떤 데이터도 전송하지 않은 상태이다. 즉, 긴 시간 동안 상향링크 데이터를 전송하지 않았기 때문에 대부분 상

향링크 동기가 잃게 된 상태이다. 이 상태에서 무선 단말이 기지국으로 보낼 데이터가 있는 상태.

1. 무선 단말의 상향링크가 동기가 깨졌다고 보고 자원 요청 정보를 보내기 전에 상향 링크 동기를 유지할 필요가 있다. 그래서 단말이 자원 요청 정보를 보내기 전에 Preamble를 먼저 보내 기지국이 상향링크를 동기를 획득 하도록 하는 것을 특징으로 한다.

2. 기지국은 Preamble을 수신하고 상향링크 동기를 맞추기 위해 Time Adjustment정보를 단말로 보낸다. 그리고 단말이 자원 요청 정보 메시지를 보낼 수 있도록 자원을 할당해주는 정보를 보낸다. 이때 할당해 주는 자원은 단말이 자원 요청 정보를 포함한 signaling 메시지를 보낼 수 있을 정도의 최소 자원 (i.g. one resource block) 을 할당해 주는 것을 특징으로 한다.

3. 무선 단말은 기지국이 할당해준 자원을 통해 signaling 메시지 (자원 요청 정보, UE_ID정보, cause 정보, 등등) 및 실제 데이터를 보내는 것을 특징으로 한다. 기지국이 할당한 자원이 단말이 보내는 signaling 메시지를 보내고 남을 경우 실제 보내고자 하는 데이터를 같이 전송해서 자원의 낭비를 막는 것을 특징으로 한다. 상기 UE_ID정보는 단말이 기지국으로부터 Temporary UE_ID (i.g. C-RNTI)를 할당 받고 다른 Node B로 이동하지 않을 경우 기지국으로 할당 받은 Temporary UE_ID를 사용한다. 만약 단말이 다른 Node B로 이동하게 되면 UE_ID는 아직 이동한 Node B에서 새로운 Temporary UE_ID를 할당 받지 않았다면 단말의 Static UE_ID (i.g. IMSI)를 사용하는 것을 특징으로 한다.. 상기 cause 정보는 단말이 Initial access인지, Active mode 상태에서 자원 요청인지, 다른 Node B로의 Handover에 따른 자원 요청 등등을 알려주는 정보를 특징으로 한다.

4. 자원 요청 정보를 수신한 Node B는 단말로 수신한 signaling 메시지 내에 UE_ID 정보가 포함 되어 있어서 자원을 요구한 단말로 dedicate하게 자원 할당 정보를 보낼 수 있는 것을 특징으로 한다. 상기 자원 할당 정보는 주파수 정보, 전송 시점 정보, 전송 기간 정보 등등을 포함하는 것을 특징으로 한다.

5. 단말이 자원 할당 정보를 수신하고 자원 할당 정보에 따라 상향 링크 전송 채널로 보낼 데이터를 전송하는 것을 특징으로 한다.

5. 본 발명의 효과

이상 설명한 바와 같이 본 발명은, LTE 시스템에서 Active 모드 상태에 있는 무선 단말이 보낼 데이터가 있을 때 적절한 자원 할당 방법을 통해 효율적으로 상향링크 데이터를 전송 할 수 있다.

6. 특허 청구범위

[1]

3GPP TR 25.813 V0.6.0 (2006-03)

Technical Report

3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Radio interface protocol aspects (Release 7)

Keywords

Evolved UTRA and UTRAN

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Contents

Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

Introduction

With enhancements such as HSDPA and Enhanced Uplink, the 3GPP radio-access technology will remain highly competitive for several years to come. However, to ensure competitiveness in an even longer time frame, the long-term evolution of the 3GPP radio-access technology is under study. Important parts of such a long-term evolution include reduced latency, higher user data rates, optimised support for packet services, improved system capacity and coverage, and reduced cost for the operator, while also reducing system complexity. In order to achieve this, evolutions of the radio interface as well as the radio network architecture are considered in the study item "Evolved UTRA and UTRAN" [1]. This document covers the Radio Interface Protocol Aspects of the study item.

1 Scope

The purpose of this TR is to help TSG RAN WG2 to define and describe the radio interface protocol evolution under consideration for Evolved UTRA and UTRAN [1]. This activity involves the Radio Access Network work area of the 3GPP studies for evolution and has impacts both on the Mobile Equipment and Access Network of the 3GPP systems. This document is intended to gather the agreements rather than comparing different solutions.

NOTE: this document is a living document, i.e. it is permanently updated and presented to TSG-RAN meetings.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document.*

[1] TD RP-040461: "Proposed Study Item on Evolved UTRA and UTRAN".

[2] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[3] 3GPP TR 25.913: "Requirements for Evolved UTRA and UTRAN".

[4] 3GPP TR 25.912; "Feasibility Study for Evolved UTRA and UTRAN".

[5] 3GPP TR 25.814: "Physical Layer Aspects for Evolved UTRA".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply.

<defined term>: <definition>.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

<symbol> <Explanation>

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

aGW E-UTRAN Access Gateway
ARQ Automatic Repeat Request
AS Access Stratum
DL Downlink

eNB	E-UTRAN NodeB
E-UTRA	Evolved Universal Terrestrial Radio Access
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
HARQ	Hybrid Automatic Repeat Request
HO	Handover
L1	Layer 1 (physical layer)
L2	Layer 2 (data link layer)
L3	Layer 3 (network layer)
MAC	Medium Access Control
NAS	Non-Access Stratum
PDCP	Packet Data Convergence Protocol
PDU	Protocol Data Unit
RLC	Radio Link Control
RRC	Radio Resource Control
SAE	System Architecture Evolution
SDU	Service Data Unit
TCH	Traffic Channel
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunications System
UTRA	UMTS Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network

Other abbreviations used in the present document are listed in 3GPP TR 21.905 [2].

4 Objectives and requirements

Simplification of the UTRAN protocol architecture and actual protocols is expected.

4.1 Complexity

A key requirement of E-UTRAN is to maintain the complexity at a reasonable level. In this respect the following assumptions apply:

- The number of transport channels will be reduced, by making use of shared channels.
- Dedicated transport channels are not supported by E-UTRAN.
- The number of different MAC-entities will be reduced (MAC-d not needed in the absence of dedicated transport channels).
- Segmentation/Re-assembly function is agreed to be no longer needed on RLC.
- The BMC layer and the CTCH are not needed i.e. All data broadcast will be on MBMS and on e.g. MTCH.
- There is no SHO in the downlink (as currently supported for Rel-6 dedicated channels) for the shared channel, in case of unicast transmissions. Note: This does not preclude the potential support of other schemes such as fast cell selection, bi-casting, "softer HO" (L1 combining) for intra-site cases, etc.
- Compressed mode should not be supported. If some transmission/reception gaps for measurement purpose have to be provided to the UE (exact need/case to be defined), this will be based on scheduling gaps.
- Only one receiver structure will be assumed for defining the measurements and their requirements.
- RRC should be simplified by e.g. reducing the number of RRC states compared to UTRAN (e.g. removal of CELL_FACH is agreed).

4.2 Performance

Note: From R2-051759: U-Plane Latency < 5msec; C-Plane Latency < 100msec (from Inactive to Active): optimisation of User Plane for high bit rates: hide breaks from application; shorter transitions (state transitions. handover within UTRA?); support "always-on" efficiently.

5 Protocol architecture

5.1 Overall protocol architecture

The E-UTRAN consists of eNBs, providing the E-UTRA user plane (PHY/MAC) and control plane (RRC) protocol terminations towards the UE. The eNBs are interconnected with each other in a meshed way and interface to the aGW via the S1 interface in a flexible manner.

Figure 5.1 below gives an overview of the E-UTRAN architecture where:

- Logical Nodes depicted as yellow-shaded boxes with solid frame are agreed.
- Logical Nodes depicted as yellow-shaded boxes with dashed frame are not yet agreed.
- White boxes depict the functional entities of the control plane and blue boxes depict the functional entities of the user plane:
    - Those, where an agreement on their association with logical nodes has been achieved are depicted inside this logical node;
    - Those, where an agreement on their association with logical nodes has not yet been achieved, are depicted outside logical nodes and their possible locations are indicated by arrows;
    - Those, where an agreement on their existence has been achieved are depicted with solid frames;
    - Those, where an agreement on their existence has not been achieved are depicted with dashed frames;

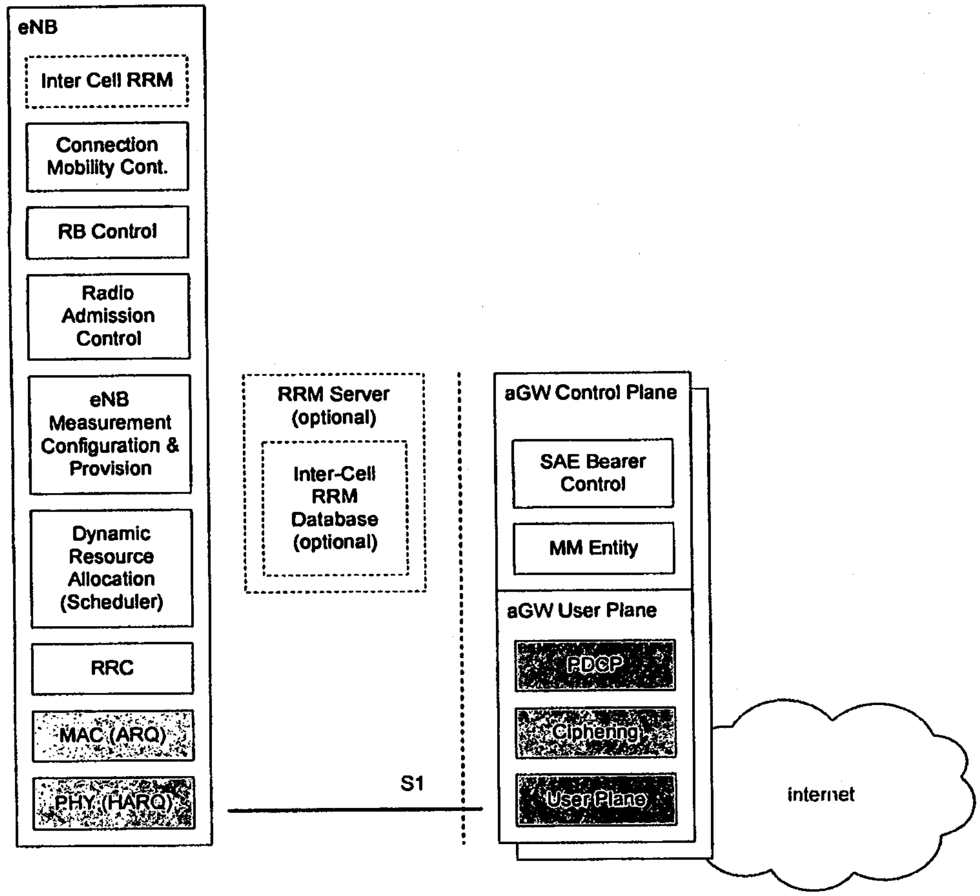


Figure 5.1: E-UTRAN Architecture

The functions agreed to be hosted by the eNB are:

- Selection of aGW at attachment;
- Routing towards aGW at RRC activation;
- Scheduling and transmission of paging messages;
- Scheduling and transmission of BCCH information;
- Dynamic allocation of resources to UEs in both uplink and downlink;
- The configuration and provision of eNB measurements;
- Radio Bearer Control;
- Radio Admission Control;
- Connection Mobility Control in LTE_ACTIVE mode.

It remains FFS whether the aGW is split into U- and C-plane. The functions agreed to be hosted by the aGW are:

- Paging origination;
- LTE_IDLE mode management;
- Ciphering of the user plane;
- PDCP;

- SAE Bearer Control.

5.1.1 User plane

Figure 5.1.2 below shows the user-plane protocol stack for E-UTRAN, where:

- A MAC-layer above the physical layer exists in both the UE and the eNB;
- No separate RLC entity is introduced;
- PDCP is located in the aGW on the network side but the exact functionalities that it supports need to be revisited compared to UTRAN.

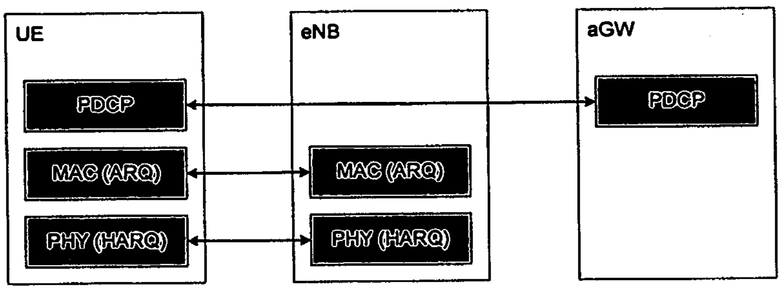


Figure 5.1.1: User-plane protocol stack

5.1.2 Control plane

Figure 5.1.2 below shows the control-plane protocol stack for E-UTRAN. The following working assumptions apply:

- Same MAC layer as in the user plane;
- No separate RLC entity is introduced;
- RRC terminates in the eNB on the network side.

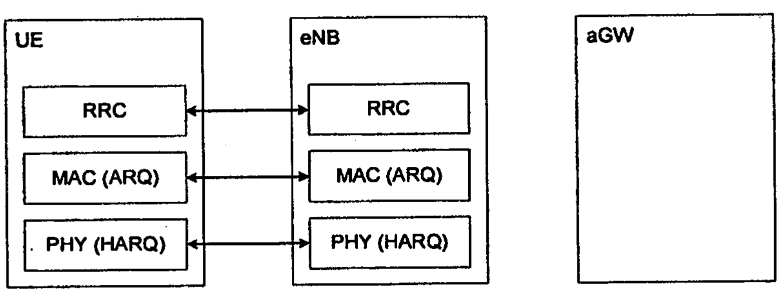


Figure 5.1.2: Control-plane protocol stack

5.2 Layer 1

Note: This section will summarize the Layer 1 in terms of services, functions and transport channels offered to Layer 2 (input from WG1 and 25.814).

5.2.1 Services and functions

The physical layer offers information transfer services to MAC and higher layers. The physical layer transport services are described by *how* and with what characteristics data are transferred over the radio interface. An adequate term for this is "Transport Channel".

NOTE: This should be clearly separated from the classification of *what* is transported, which relates to the concept of logical channels at MAC layer.

5.2.2 Transport channels

Downlink transport channel types are:

1. **Broadcast Channel (BCH)** characterised by:
   - low fixed bit rate;
   - requirement to be broadcast in the entire coverage area of the cell.
2. **Downlink Shared Channel (DL-SCH)** characterised by:
   - possibility to use HARQ;
   - possibility of applying link adaptation by varying the modulation, coding and transmit power;
   - possibility to be broadcast in the entire cell;
   - possibility to use beamforming;
   - dynamic or semi-static resource allocation;
   - possibility of CQI reporting;
   - different levels of UE activity so as to achieve UE power saving.

   NOTE: the possibility to use slow power control depends on the physical layer.
3. **Paging Channel (PCH)** characterised by:
   - support of UE power saving (DRX cycle is indicated by the network to the UE);
   - requirement to be broadcast in the entire coverage area of the cell;
   - mapped to physical resources which can be used dynamically also for traffic/other control channels.
4. **Notification Channel (NCH) FFS** characterised by:
   - support of UE power saving;
   - requirement to be broadcast in the entire coverage area of the cell.

It is FFS whether a separate **Multicast Channel (MCH)** would exist or if additional attributes will be added to the SCH.

Uplink transport channel types are:

1. **Uplink Shared channel (UL-SCH)** characterised by:
   - possibility to use beamforming; (likely no impact on specifications)
   - possibility of applying link adaptation by varying the transmit power and potentially modulation and coding;
   - possibility to use HARQ;
   - dynamic or semi-static resource allocation; (Note: new attribute, FFS on whether there would be two types of UL-SCH)

- possibility of CQI reporting. (Note: new attribute, FFS on whether there would be two types of UL-SCH)

NOTE: the possibility to use uplink synchronisation and timing advance depend on the physical layer.

It is FFS, whether a Random Access Channel is included. If yes, it would be characterised by the following attributes:

2. **Random Access Channel(s) (RACH)** characterised by:
   - limited data field;
   - collision risk;
   - possibility to use HARQ.

NOTE: the possibility to use open loop power control depends on the physical layer solution.

5.3 Layer 2

This section gives a high level description of the Layer 2 sub-layers in terms of services and functions.

5.3.1 MAC

The MAC layer performs multiplexing of logical channels on the same HARQ process. Whether logical channels with the same QoS shall be multiplexed onto the same priority queue (e.g. by means of "MAC-d flows") is FFS. If there is no multiplexing of logical channels onto priority queues, there is only one level of multiplexing in the MAC layer, similarly as in HSUPA in Release 6.

NOTE: How the multiplexing relates to the QoS of the multiplexed logical channels is FFS.

Figure 5.3.1a and Figure 5.3.1.b below depicts the MAC architecture for downlink and uplink respectively, where the multiplexing of several logical channels on the same transport channel is possible, the multiplexing of several logical channel on several transport channel is FFS.

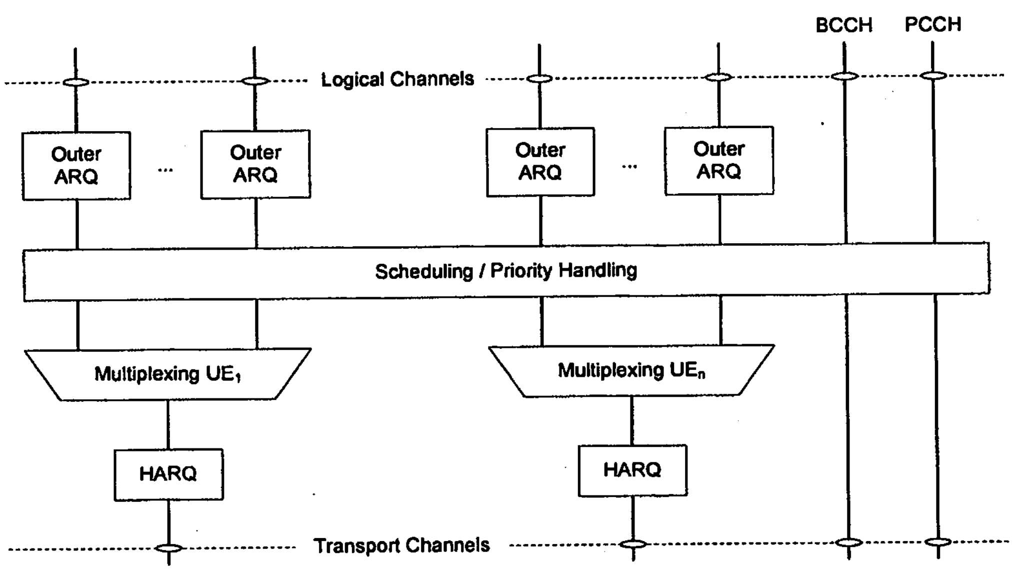


Figure 5.3.1a: MAC structure for DL in eNB

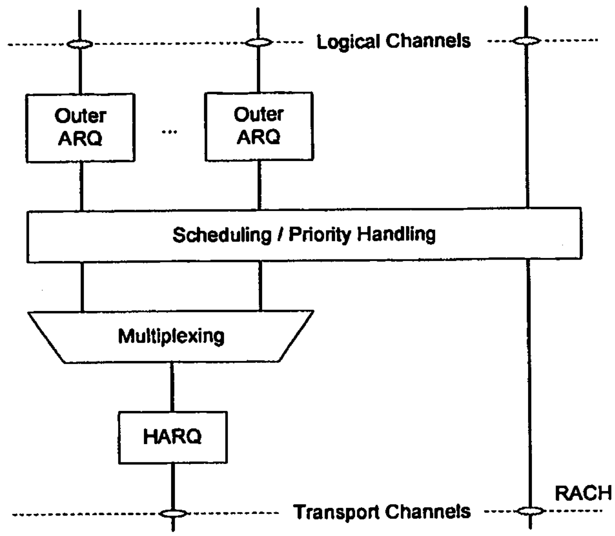


Figure 5.3.1b: MAC structure for UL in UE

5.3.1.1 Logical Channels

The MAC layer provides data transfer services on logical channels. A set of logical channel types is defined for different kinds of data transfer services as offered by MAC. Each logical channel type is defined by what type of information is transferred.

A general classification of logical channels is into two groups:

- Control Channels (for the transfer of control plane information);
- Traffic Channels (for the transfer of user plane information).

There is one MAC entity per cell. MAC generally consists of several function blocks (transmission scheduling functions, per UE functions, MBMS functions, MAC control functions, transport block generation…). Transparent Mode is only applied to BCCH (FFS) and PCCH.

5.3.1.1.1 Control Channels

Control channels are used for transfer of control plane information only. The control channels offered by MAC are:

- **Broadcast Control Channel (BCCH)**

  A downlink channel for broadcasting system control information.

- **Paging (and Notification) Control Channel (P(N)CCH)**

  A downlink channel that transfers paging information (and also notifications for MBMS FFS). This channel is used when the network does not know the location cell of the UE.

- **Common Control Channel (CCCH)**

  FFS: This channel is used by the UEs having no RRC connection with the network (need is FFS depending on whether the access mechanism is contained in L1. If RACH is visible as a transport channel, CCCH would be used by the UEs when accessing a new cell or after cell reselection).

- **Multicast Control Channel (MCCH)**

FFS whether it is distinct from CCCH: a point-to-multipoint downlink channel used for transmitting MBMS scheduling and control information from the network to the UE, for one or several MTCHs. After establishing RRC connection this channel is only used by UEs that receive MBMS. (Note: old MCCH+MSCH).

- **Dedicated Control Channel (DCCH)**

  A point-to-point bi-directional channel that transmits dedicated control information between a UE and the network. Used by UEs having an RRC connection.

5.3.1.1.2 Traffic Channels

Traffic channels are used for the transfer of user plane information only. The traffic channels offered by MAC are:

- **Dedicated Traffic Channel (DTCH)**

  A Dedicated Traffic Channel (DTCH) is a point-to-point channel, dedicated to one UE, for the transfer of user information. A DTCH can exist in both uplink and downlink.

- **Multicast Traffic Channel (MTCH)**

  A point-to-multipoint downlink channel for transmitting traffic data from the network to the UE. (Note: Includes Rel 6/7 MTCH)

5.3.1.2 Mapping between logical channels and transport channels

The figure below depicts the mapping between logical and transport channels (in grey the items for FFS):

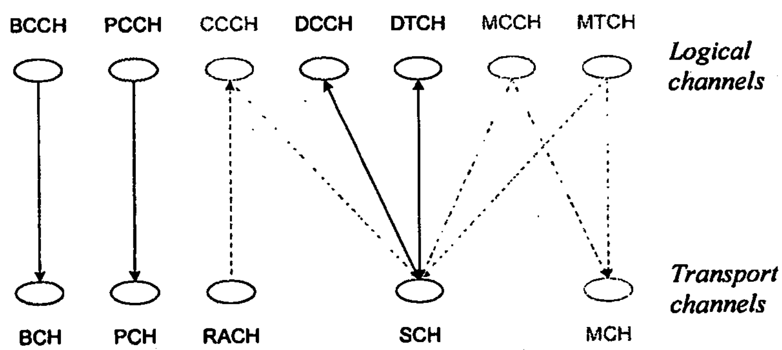


Figure 5.3.1.2: Mapping between logical channels and transport channels

5.3.1.2.1 Mapping in Uplink

In Uplink, the following connections between logical channels and transport channels exist:

- CCCH can be mapped to RACH; (FFS if access procedure is not contained within L1);
- CCCH can be mapped to Uplink SCH; (FFS: if just a transient (random) ID is assigned for the resource request, the actual e.g. RRC Connection Request message has still to contain a UE identifier and therefore such message is considered to be a CCCH message, even if it's transported on the UL_SCH. Also the UE is not in connected mode so far);
- DCCH can be mapped to Uplink SCH;
- DTCH can be mapped to Uplink SCH.

5.3.1.2.2 Mapping in Downlink

In Downlink, the following connections between logical channels and transport channels exist:

- BCCH can be mapped to BCH;
- PCCH can be mapped to PCH;
- CCCH can be mapped to Downlink SCH (FFS if CCCH exists);
- DCCH can be mapped to Downlink SCH;
- DTCH can be mapped to Downlink SCH;
- MTCH can be mapped to Downlink SCH; (FFS if a separate MCH does not exist)
- MTCH can be mapped to MCH; (FFS if a separate MCH exists)
- MCCH can be mapped to Downlink SCH; (FFS if a separate MCCH exist)
- MCCH can be mapped to MCH. (FFS if a separate MCCH and MCH exist)

5.3.1.3 Services and Functions

The main functions of MAC include:

- Mapping between logical channels and transport channels;
- Multiplexing/demultiplexing of upper layer PDUs belonging to one or different radio bearers into/from transport blocks (TB) delivered to/from the physical layer on transport channels;
- Traffic volume measurement reporting;
- Error Correction through HARQ;
- Priority handling between data flows of one UE;
- Priority handling between UEs by means of dynamic scheduling;
- Transport format selection;
- Mapping of Access Classes to Access Service Classes (FFS for RACH).
- Segmentation (FFS);
- Padding (FFS);
- Flow Control (FFS between aGW and eNB);
- Transfer of upper layer PDUs supporting AM, UM or TM data transfer;
- Error Correction through ARQ;
- In-sequence delivery of upper layer PDUs;
- Duplicate Detection;
- Protocol error detection and recovery;
- SDU discard.

5.3.2 PDCP

Note: From R2-051759: Compression kept. Should PDCP include a lossless relocation function? Proposal to add mapping of IP flows on Radio Bearer.

5.3.3 Data flows through Layer 2

Note: Different flows for different transport channels, logical channels and transfer mode.

5.4 Layer 3 - RRC

5.4.1 RRC protocol states & state transitions

RRC will use the following states in E-UTRAN:

- **LTE_DETACHED**:
  - No RRC entity.
- **LTE_IDLE**:
  - DRX;
  - Cell re-selection mobility;
  - The UE shall have been allocated an id which uniquely identifies the UE in a tracking area;
  - Some information is stored in UE and network:
    - IP address, etc;
    - Security association (keys, etc);
    - UE capability information (FFS);
    - Radio Bearers (FFS);
  - no RRC context.
- **LTE_ACTIVE**:
  - UE has an E-UTRAN-RRC connection;
  - UE has context in E-UTRAN;
  - E-UTRAN knows the cell which the UE belongs to;
  - Network can transmit and/or receive data to/from UE;
  - Network controlled mobility (handover);
  - Neighbour cell measurements;
  - State transition decided in eNB;
  - LTE-MAC level:
    - UE can transmit and/or receive data to/from network;
    - UE monitors control signalling channel for shared data channel to see if any transmission over the shared data channel has been allocated to the UE;
    - UE also reports channel quality information and feedback information to eNB;
    - Activity control (signalling or timer based, TBD…): continuous operation or discontinuous with DRX/DTX factor.
- **RRC C-plane connected** (need is FFS):
  - Connected but without User-plane (Radio Bearers…);
  - Cell-reselection;
  - Tracking area;
  - Managed in intermediate RRC server.

The agreed parts are reflected in the following figure:

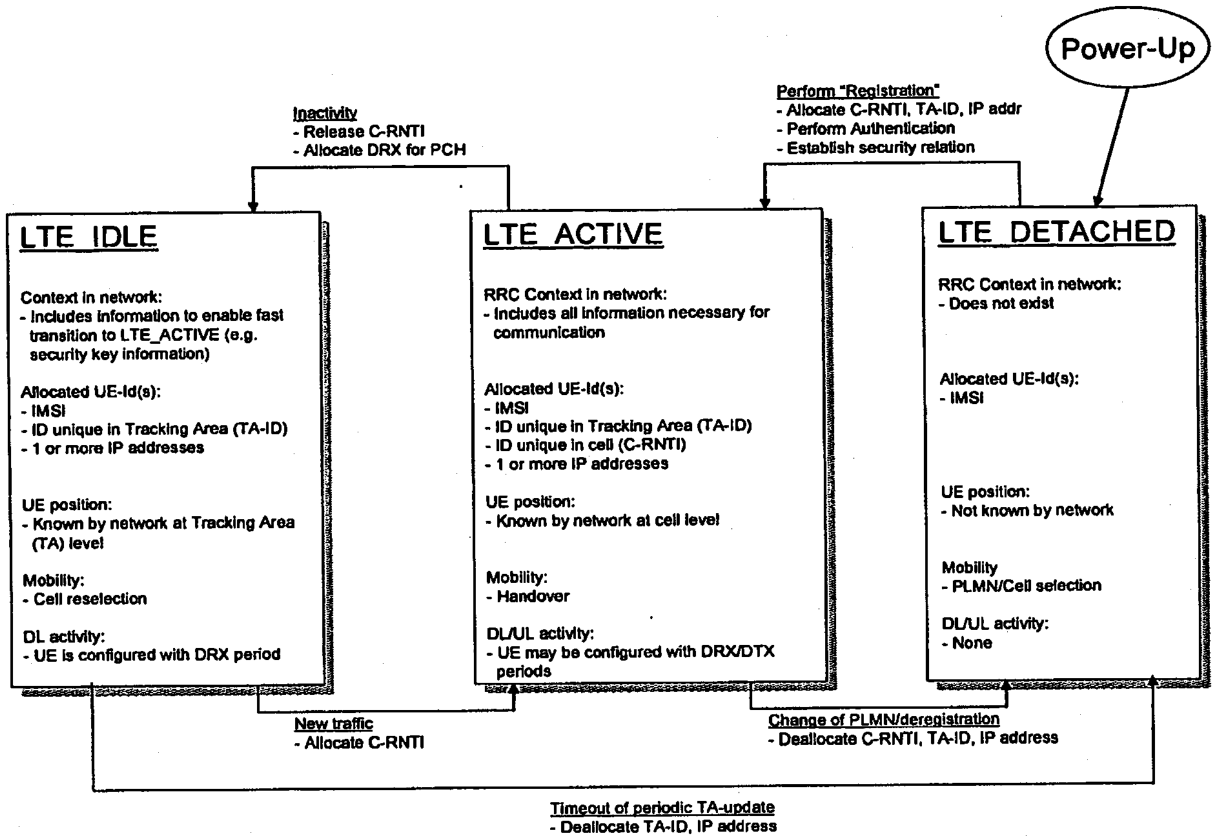


Figure 5.4.1: E-UTRAN RRC protocol states

NOTE: The applicability of the ID unique in Tracking Area (TAID) in LTE_DETACHED is FFS.

The UE context in the aGW will discriminate the 3 states. The UE context in the eNB will only exist in the LTE_ACTIVE state.

5.4.2 Functions

RRC in eNB performs the following main functions:

- Broadcast of System Information related to the non-access stratum;
- Broadcast of System Information related to the access stratum;
- Paging;
- Establishment, maintenance and release of an RRC connection between the UE and E-UTRAN including:
  - Allocation of temporary identifiers between UE and E-UTRAN;
  - Configuration of radio resources for RRC connection.
- Security functions including integrity protection for RRC messages;
- Establishment, maintenance and release of point to point Radio Bearers including configuration of radio resources for the Radio Bearers
- Mobility functions including:

- UE measurement reporting and control of the reporting for inter-cell and inter-RAT mobility;
- Inter-cell handover;
- UE cell selection and reselection and control of cell selection and reselection;
- Context transfer between eNBs.

- Notification for multicast/broadcast services (FFS);
- Establishment, maintenance and release of Radio Bearers for multicast/broadcast services, including configuration of radio resources for the Radio Bearer (FFS);
- QoS management functions (FFS is spread across multiple layers);
- UE measurement reporting and control of the reporting;
- NAS direct message transfer to/from NAS from/to UE (FFS).

5.5 Protocol termination

Note: This section will specify in which node of the evolved UTRAN the radio interface protocols are terminated, i.e. where within the evolved UTRAN the respective protocol services are accessible.

6 ARQ and HARQ

E-UTRAN provides ARQ and HARQ functionalities. The ARQ functionality provides error correction by retransmissions in acknowledged mode at Layer 2. The HARQ functionality ensures delivery between peer entities at Layer 1.

Note: This section will describe the characteristics of HARQ (e.g. interaction between layer 1 and 2) and ARQ (e.g. whether it operates on SDUs or segmented SDUs).

7 Scheduling

Note: This section will explain how scheduling is implemented and what kind of rules and signalling are used (in a way that is similar to what was done for HSUPA and HSDPA). DTX concept could be included in this section or be the subject of a separate one.

8 QoS Control

Note: This section will describe how QoS is managed.

9 Mobility

In LTE_ACTIVE state, network controlled UE assisted handovers are performed and various DRX/DTX cycles are supported:

- UE performs neighbour cell measurements based on measurement control and neighbour cell information from the network;
- Network signals reporting criteria for event-triggered and possibly periodical (FFS) reporting.

In LTE_IDLE state, cell reselections are performed and DRX is supported.

9.1 Intra E-UTRAN

9.1.1 UE identification on the radio interface

9.1.2 Cell selection

9.1.3 Cell reselection

9.1.4 Paging

Note: From R2-051759: Several proposals 1) paging channel; 2) DRX on shared channel instead of paging channel. URA concept retained. Common with UTRA or specific to E-UTRA always? No need for NAS paging if some NAS/AS functionality merge (PMM with RRC) take place (e.g. if Idle mode is removed).

9.1.5 Handover

Note: From R2-051759: should depend on the RRC state and can be of intra-frequency or inter-frequency. Network controlled proposed to be primary method, and UE controlled only for RL failure case. UE controlled (like cell re-selection) for active state also proposed to be studied.

9.1.6 Measurements

Measurements to be performed by a UE for intra/inter-frequency mobility can be controlled by E-UTRAN, using broadcast or dedicated control. In LTE_IDLE state, a UE shall follow the measurement parameters defined for cell reselection specified by the E-UTRAN broadcast (as in UTRAN SIB). The use of dedicated measurement control in cell reselection is FFS. In LTE_ACTIVE state, a UE shall follow the measurement parameters specified by RRC or MAC commands (FFS) directed from the E-UTRAN (e.g. as in UTRAN MEASUREMENT_CONTROL).

Usage of dedicated control for LTE_IDLE state is FFS.

9.1.6.1 Intra-frequency

In a system with frequency reuse = 1, intra-frequency handovers are the most important and common handovers. Good intra-frequency measurements are needed in order to ensure good mobility support and easy network deployment. Search of intra-frequency neighbour cells from the neighbour list, and measurements of the relevant quantities for identified cells is needed.

NOTE: To avoid UE activity outside the DRX/DTX cycle, the reporting criteria for intra frequency measurements should match the used DRX/DTX cycle.

9.1.6.2 Inter-frequency

Regarding inter-frequency handovers, UE performs neighbour cell measurements during DL/UL idle periods that are provided by DRX/DTX or packet scheduling, if necessary.

NOTE: How the gaps are controlled, as well as how the scheduler knows the gaps required by the UE, is FFS.

9.1.7 Network aspects

Note: eNBs interconnection for call context transfer (security, header compression, data forwarding). Bi-casting? The use of fast cell selection should be evaluated: what are the gains versus the increase in complexity, can we limit the complexity? Do we need handover preparation including admission and resource reservation to guarantee a level of QoS (alternative is to maintain some resources for mobility and to apply load control)?

9.2 Inter RAT

Note: From R2-051759: simultaneous operation in two RATs should not be considered because of RF issues.

9.2.1 Cell reselection

9.2.2 Handover

9.2.3 Measurements

9.2.3.1 Inter-RAT handovers from E-UTRAN

Measurements to be performed by a UE for inter-RAT mobility can be controlled by E-UTRAN, using broadcast or dedicated control. In LTE_ACTIVE state, a UE shall follow the measurement parameters specified by RRC or MAC commands (FFS) directed from the E-UTRAN (e.g. as in UTRAN MEASUREMENT_CONTROL).

UE performs inter-RAT neighbour cell measurements during DL/UL idle periods that are provided by the network through suitable DRX/DTX period or packet scheduling if necessary.

NOTE: How the gaps are controlled, as well as how the scheduler knows the gaps required by the UE, is FFS.

9.2.3.2 Inter-RAT Handovers to E-UTRAN

From UTRAN, UE performs E-UTRAN measurements by using idle periods created by compressed mode (CELL_DCH), FACH measurement occasions (CELL_FACH - FFS), or DRX (other states).

From GERAN, E-UTRAN measurements are performed in the same way as WCDMA measurements for handover to UTRAN: E-UTRAN measurements are performed in GSM idle frames in a time multiplexed manner. However, it should be discussed with GERAN how to ensure that inter-RAT measurements do not take too much measurement time, while the requested 3GPP inter-RAT measurements can be performed well enough.

Design constraints of 3GPP inter-RAT measurements should be considered when L1 details of E-UTRAN concept are defined.

9.2.3.3 Inter-RAT cell reselection from E-UTRAN

In LTE_IDLE state, a UE shall follow the measurement parameters specified by the E-UTRAN broadcast (as in UTRAN SIB). The use of dedicated measurement control is FFS.

9.2.3.4 Limiting measurement load at UE

Introduction of E-UTRA implies co-existence of various UE capabilities. Each UE may support different combinations of RATs, e.g., E-UTRA, UTRA, GSM, and non-3GPP RATs, and different combinations of frequency bands, e.g., 800 MHz, 1.7 GHz, 2 GHZ, etc. Moreover, some UEs may support the full E-UTRA spectrum bandwidth of 20 MHz, whereas some UEs may support only a part of 20 MHz. Despite such heterogeneous environment, the measurement load at UE should be minimised. To limit the measurement load and the associated control load:

- E-UTRAN can configure the RATs to be measured by UE;
- The number of measurement criteria (event and periodic reporting criteria) should be limited (as in TS 25.133 section 8.3.2);
- E-UTRAN should be aware of the UE capabilities for efficient measurement control, to prevent unnecessary waking up of the measurement entity;
- The UE capabilities should be categorised to prevent diversion of capabilities and conformance test scenarios, FFS;
- Support for blind HO (i.e., HO without measurement reports from UE) is FFS.

Note: From R2-051759: which Inter System measurements should be made mandatory (GERAN, UTRAN)? Measurement of other technologies – e.g. WLAN, will depend on architectural integration. SYSINFO or dedicated list of info for measurement purpose.

9.2.4 Network Aspects

10 Security

Note: This section will describe how Security is ensured.

10.1 Security Termination Points

The table below describes the security termination points.

Table 10.1 Security Termination Points

	Ciphering	Integrity Protection
NAS Signalling	Required and terminated above eNB (NOTE 1)	Required and terminated above eNB (NOTE 1)
U-Plane Data	Required and terminated in aGW (NOTE 2)	Need is FFS
RRC Signalling (AS)	Need is FFS	Required an terminated in eNB (NOTE 3)
MAC Signalling (AS)	Need is FFS	Need is FFS
NOTE 1: "Above eNB" means that the termination point is in either the aGW or above (FFS) and that the activation/deactivation is not controlled by the eNB. NOTE 2: The protocol stack layer in which the ciphering takes place is FFS. The activation/deactivation of ciphering of the U-Plane is not controlled by the eNB NOTE 3: Key set for RRC protection cannot be used to derive NAS and user-plane keys.		

11 MBMS

Note: A separate chapter might be needed to deal with MBMS specific issues.

Note: From R2-051759: The following issues have to be discussed: need for selective combining within E-UTRA, possibility to perform selective combining between E-UTRA and UTRA: need for L1 combining (simpler with OFDM); FLC across UTRA and E-UTRA, all new requirements of MBMS for LTE...

12 Migration and compatibility

Note: This section will have a closer look at the evolution in terms of migration scenario and interaction with previous releases. It will summarize what will be described in 25.912 and 25.913 from a protocol architecture viewpoint. SA1 and SA2 should lead the way.

Note: From R2-051759: concept of having two stacks in the UE with a legacy stack connecting to legacy CN via Iu, and a new stack, where E-RRC replaces NAS+RRC. Dual IP addresses.

12.1 Migration scenario

12.2 Interaction with previous releases

12.3 Interoperability

13 UE capabilities

Note: This section will deal with the UE capabilities from a RAN2 viewpoint (e.g. signalling support).

Note: From R2-051759: Mandating dual Receiver should be discussed early (different views. UE manufacturers prefer single receiver; dual-receiver likely to be an optimisation (UE cap?). Possibility to have separate capability for 20MHz. Will need signalling support of capabilities.

14 Impact on specifications

14.1 Specification methodology

14.2 Affected specifications

Note: This section will list the specifications that affected – if any.

14.3 New specifications

Note: This section will list the specifications that affected – if any.

Annex A: Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2005-08	RAN2#48	R2-051787			Proposed Skeleton for RAN2#48		0.0.0
2005-08	RAN2#48	R2-052241			Proposed Skeleton for RAN2#48	0.0.0	0.0.1
2005-10	RAN2#49	R2-052730			Transport channels and Logical Channels added in Section 5	0.0.1	0.0.2
2005-11	RAN2#49	R2-053071			Presence of both HARQ and ARQ Overview of the E-UTRAN Architecture added	0.0.2	0.1.0
2006-01	RAN2#50	R2-060128			Editorship updated for MBMS section	0.1.0	0.1.1
2006-01	RAN2#50	R2-060133			Descriptive text for Handovers added in Section 9; Update of the transport channels in Section 5; Annex added to reflect agreements on RACH; Function for MAC, RRC and RLC listed in section 5; Termination points for security captured in section 10.1; Figure of logical channels to transport channels added in section 5. RRC States described in section 5.	0.1.1	0.2.0
2006-01	RAN2#50	R2-060146			Various editorial changes and clarifications	0.2.0	0.3.0
2006-02	RAN2#51	R2-060309			Update of the Nomenclature and removal of some editor's notes	0.3.0	0.3.1
2006-02	RAN2#51	R2-060760			Inclusion of the agreed MAC archtecture	0.3.1	0.4.0
2006-02	RAN2#51	R2-060798			Editorial Corrections	0.4.0	0.4.1
2006-02	RAN2#51	R2-060803			Addition of the Chairman Notes of RAN2#51 in Annex C.	0.4.1	0.5.0
2006-03	RAN#31	RP-060176			Agreement on the state names reflected throughout the document	0.5.0	0.5.1
2006-03	RAN2#52	RP-060xxx			Agreements of RAN#31 and from RP-060122 + SRJ-060059 included: ARQ and RRC in eNB, SAE Bearer + Radio Bearer.	0.5.1	0.6.0

Annex B: RACH and Contention Resolution

The contention channel i.e. RACH, allows achieving the following:

- Synchronising the L1 timing (timing advance);
- Transmission of a X bits message towards the network MAC e.g. 16 bits;
- RAN1 should combine both if possible to gain time.

The X bits may have a different content depending on the case where the RACH is used. This is TBD:

- Some information on UL resources needed, priority, establishment cause, and random ID to assist in contention resolution;
- UE ID already allocated by the network to the UE.

In the case of the initial access, means for the network to prioritise the various requests should be possible.

After the X bits have been received by the network, the network is responsible to send to the UE:

- If necessary, timing advance information to be used on the UL SCH;
- If necessary, C-RNTI;
- Allocation of UL resources on UL SCH.

Contention resolution takes place using the UL/DL-SCH.

The RACH L1 channel may have multiple signatures in UL (to help resolving collisions). To be checked with RAN1.

Transmission of L3 messages, MAC data or control PDU, only takes place on the UL-SCH, possibly after the RACH procedure used to get an uplink allocation.

Resources for RACH are indicated by the network.

The RACH procedure can be used for (exact list TBD, details of its use/content of X bits TBD):

- Initial access to get UL SCH resources to send RRC connection request;
- To obtain L1 synchronisation;
- To request resources when no UL resources are available;
- In case of mobility.

Annex C: Architecture Progress

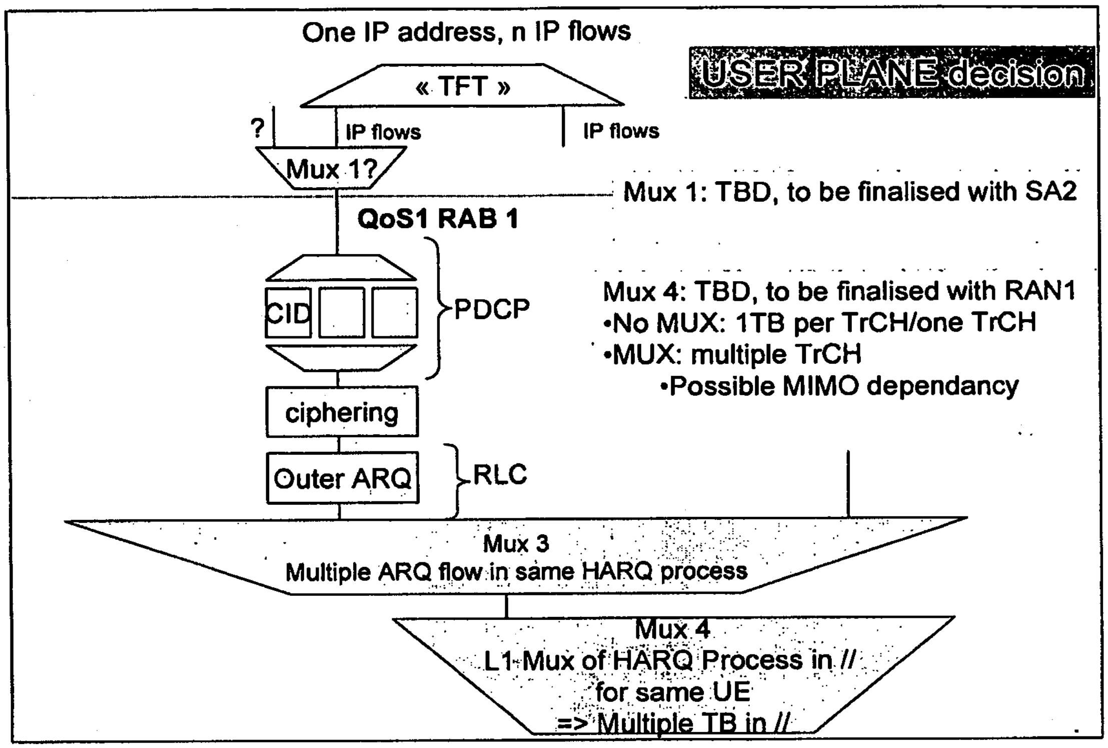


Figure C1: User Plane

Table C1: Location of Control Plane Functions

Function	eNB	aGW	Comment
Broadcast	+		Originated from aGW or O&M
Paging	+		Originated from aGW
aGW connection handling		+	NAS
Security control		+	
Mobility handling for LTE_ACTIVE state	+		
Measurement configuration and reporting for mobility	+		
Mobility handling for LTE_IDLE state		+	NAS
RAB/QoS control		+	NAS
Node-B level configuration	+		
Assignment of radio resources	+		
Identification and mapping of logical channels	+		
Scheduling for all channels incl BCH and PCH	+		
Measurements for scheduling	+		

Annex D: Editorship

In addition to the rapporteur (Benoist Sébire - Nokia), an editor was nominated for each section of the TR as described in Table B below.

Table B. Editorship

Section	Company	Name	email
1. Scope	Nokia	Benoist Sébire	benoist.sebire@nokia.com
2. References	Nokia	Benoist Sébire	benoist.sebire@nokia.com
3. Definitions, symbols and abbreviations	Nokia	Benoist Sébire	benoist.sebire@nokia.com
4. Objectives and requirements	Nokia	Benoist Sébire	benoist.sebire@nokia.com
5. Protocol architecture	Nokia	Benoist Sébire	benoist.sebire@nokia.com
6. ARQ and HARQ	NEC	Michael Roberts	michael.roberts@nectech.fr
7. Scheduling	Nokia	Benoist Sébire	benoist.sebire@nokia.com
8. QoS Control	Samsung	Mr. Gert-Jan van Lieshout	gert.vanlieshout@samsung.com
9. Mobility	Samsung	Mr. Gert-Jan van Lieshout	gert.vanlieshout@samsung.com
10. Security	NEC	Michael Roberts	michael.roberts@nectech.fr
11. MBMS	LGE	YoungDae Lee	leego@lge.com
12. Migration and compatibility	LGE	Patrick Fischer	pfischer@lge.com
13. UE capabilities	Motorola	Agnes Revel	agnes.revel@motorola.com
14. Impact on specifications	Motorola	Agnes Revel	agnes.revel@motorola.com
Annex A – Change History	Nokia	Benoist Sébire	benoist.sebire@nokia.com

DRX of Active UE Procedures (1/2)

NB configures UE DRX activity

UE Synchronization Procedure Type 1 (Normal UE operation)

- In case of fast moving UE or short DRX active UE
  - Synchronized in Uplink
  - CQI needed
- UE transmits periodic UL Pilot Channel
  - NB controls a period of UL pilot channel for a UE
  - NB (regularly) transmits adjustment of UL synch for a specific UE
    - Need for regular confirmation ? (Cost?)
- UE monitors DL-SCCH every monitoring period
  - NB controls how often UE should monitor DL-SCCH
- If dormancy changes,
  - DL-SCCH updates the monitoring period and the UL pilot period
  - DL-SCCH can direct the UE to Type 2

UE Synchronization Procedure Type 2 (Not Error Case)

- In case of stationary UE or long DRX active UE
  - Unsynchronized in Uplink
  - CQI needed ?

DRX of Active UE Procedures (2/2)

UE Synchronization Procedure Type 2 (cont.)

- UE applies Random Access procedure (whenever traffic comes)
  - in case NB wake up the UE e.g. due to active DL traffic or confirmation
    - UE uses reserved preamble (reserved signature/time) for UL synch
    - Reserved preamble signaled by NB
      - Only preamble if no collision
    - If not reserved, normal random access procedure
  - in case UE needs to transmit UL traffic
    - Normal Random Access Procedure
      - Preamble + Message
  - [FFS] Need for periodic Random Access for UL synch or confirmation ?
    - Alt.) NB triggers the UE to do RACH access regularly or when NB wishes to check.
- UE monitors DL-SCCH e.g. every monitoring period
  - The monitoring period could be long like paging DRX
  - NB controls how often UE should monitor DL-SCCH
- If dormancy changes,
  - DL-SCCH updates the monitoring period (and a period of RACH access)

Recovery of Out-of Synch (Error Case)

- How UE find if UE is out-of-synch or not
- UE applies Random Access procedure

Random Access Procedure

- Random Access Procedure
  - Usage
    - Unsynchronized in Uplink
      - Initial Access
      - Handover in Active Mode
      - Long DRX Active UE (directed by NB) ?
    - Synchronized in Uplink, but no UL resource (if no problem of load)
      - All processes are INACTIVE
  - Two-step approach
    - RACH Preamble
      - only signature
      - used for UL synchronization & collision detection
      - NB indicates ACK/NACK of Preamble like AICH (Design Issue)
    - RACH Message (Check)
      - UE ID (16 bits or less)
        - Random ID or
        - C-RNTI (Target Cell or Source Cell C-RNTI)
      - UE ID Type (1 or 2 bits) ?
      - Request Cause
        - Call Setup (Originating / Terminating Call)
        - Resource Request

Other LTE Channels (1/2)

Synch Channel (SCH)

- Equal to or less than 1.25 Mhz (due to minimum Cell BW)
- Fixed configuration on minimum Cell/UE capability
- Support for Multiple SCH channels for less inter-frequency measurement ???

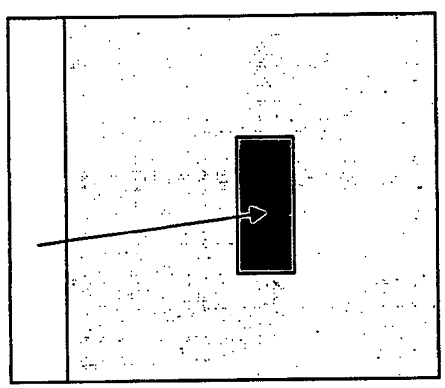
Broadcast Channel

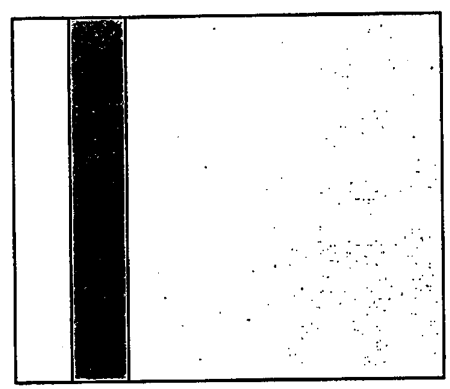
- Two types of BCH
    - Primary BCH
        - Fixed rate on minimum Cell/UE capability
        - Equal to or less than 1.25 Mhz (Collocation with SCH)
        - Multiple P-BCH for each SCH ?
        - Carrying MIB (including Configuration of S-BCH, SIB Scheduling)
    - Secondary BCH (Fixed AMC)
        - Flexible rate based on minimum UE capability (10 Mhz)
        - Flexible BW allocation (for frequency diversity)
        - Possibly, wider than 1.25 Mhz depending on Cell BW up to 10 Mhz
        - Carrying SIBs
- Subband Hopping for BCH ?
    - mostly for Active UE ?
    - Only specific SIB types may support the Subband Hopping for active UE

Other LTE Channels (2/2)

Paging Channel

- PCH: Only short info (e.g. TA UE ID) and Cause ?
- No PICH ?
  - Depending on L1 control channel structure
- Collocation of PCH and SCCH on the same symbol ?
- Selection of 10 Mhz subband based on TA UE ID for IDLE UE
- Selection of Paging Occasion based on TA UE ID for IDLE UE
- If PCH and DL-SCCH are different channels (if PCH is not mapped to DL-SCCH) and PCH is read only by IDLE UE,
  - Active UE may use DL-SCCH for DRX in Active mode, so that it does not need to read PCH





Shared Channel

DL/UL Shared Control Channel (Mostly, Scheduling Info)

- Control Information needs to be defined
  - Review of R2-060109 from LG RAN2 (See another slide)
- Occupy one symbol per one sub-frame ?
- Allocation of periodic resources for VoIP ?

CQI reporting

- Full CQI Info carried on MAC / RRC Signaling / L1 ?
  - Retransmission of full CQI may be needed
    - L2/3 : overhead, delay due to HARQ, MAC header
- Partial CQI Info carried on L1 CQI channel (only variation of full CQI info)
- NB could dynamically control CQI (e.g. period, resource) as piggybacking
  - When DL scheduling info is given
  - When UL scheduling info is granted ?

Hybrid ARQ

- Synchronous or Asynchronous Retransmission ?
- Synchronous or Asynchronous ACK/NACK ?

Scheduling Information for DL SCH

Information transmitted on DL for DL SCH transmission

1. List of Scheduled UE/Service
   - UE identity (cell level identity or TA level identity [FFS])
   - Service identity (for MBMS)
2. HARQ/ARQ information for each UE identity [Details are FFS]
3. DL TFRI information for each UE/Service identity
   - Modulation and coding info
   - Transport block size (= Transport block set size)
   - Time and frequency for scheduled DL transmission
4. Feedback information for each UE identity
   - Time and frequency for UL feedback of scheduled DL transmission (i.e. UL resource allocation of ACK/NACK/CQI transmissions for scheduling period)

Scheduling Information for UL SCH

Information transmitted on DL for UL SCH transmission

1. List of scheduled UE
   - UE identity (cell level identity or TA level identity [FFS])
   - UE Group identity [FFS] (like R6 secondary E-RNTI)
2. Scheduling grant for each identity [Contents of scheduling grant are FFS]

Information transmitted on UL for UL SCH transmission

1. Scheduling Information
   - Logical channel Identity [Details are FFS]
   - UE buffer occupancy [Details are FFS]
   - Further information is FFS
2. UL TFCI information
   - Modulation and coding info
   - Transport block size (= Transport block set size)
3. HARQ/ARQ information [Details are FFS]
4. Happy bit [FFS]

Multicast/Broadcast

Multicast/Broadcast on DL SCH

- TDM or FDM of MBMS and Dedicated Service ?
  - TDM is better for soft combining
  - But, fixed BW division possible (e.g. MBMS for 2.5 Mhz, 5 Mhz ....)

  -> TDM with restricted FDM
- Same TTI as Dedicated Service
  - Better coordination with dedicated service
- No counting or Simple detection of one user
  - That means no PTP bearer for MBMS
  - RACH message could include 'MBMS service ID' for this purpose
- No AMC
- HARQ possible, but fixed retransmission
  - Synchronous or Asynchronous retransmission ?
  - No NACK (Need for ACK is for early termination: FFS)
- Soft combining possible
  - RRC in aGW supports it
- MCCH needed
- Use DL-SCCH instead of MSCH
- FLC & CBS
  - Wait for LS about 'Aggregation'

Others ?

Periodic Resource Allocation

- Can NB give periodic radio block to a specific UE ?
  - NB control ACTIVE/INACTIVE of the radio block if necessary

UL Synchronization Procedure for Active UE (1/2)

NB directs Active Mode UE to Type 1 or 2

UL Synchronization Procedure Type 1 (Normal Active UE operation)

- Frequent Data Transfer
  - Synchronized in Uplink
  - CQI needed
- UE transmits periodic UL Pilot Channel (allocated by NB)
  - NB controls a period of UL pilot channel for a UE
  - NB (regularly or irregularly) transmits adjustment of UL synch for a specific UE
- In case of out-of-synch, ?
- UE monitors DL-SCCH every monitoring period
  - NB controls how often UE should monitor DL-SCCH
- If dormancy changes,
  - DL-SCCH updates the monitoring period and the UL pilot period
  - DL-SCCH can direct the UE to Type 2

UL Synchronization Procedure Type 2 (Active UE with rare traffic)

- Rare traffic
  - Unsynchronized in Uplink
  - No CQI (Alt. CQI on RACH)

UL Synchronization Procedure for Active UE (2/2)

UE Synchronization Procedure Type 2 (cont.)

- UE applies Random Access procedure (whenever traffic comes)
  - in case NB wake up the UE e.g. due to active DL traffic or confirmation
    - UE uses reserved preamble (reserved signature/time) for UL synch
    - Reserved preamble signaled by NB
      - Only preamble if no collision
      - Maybe, no RACH message because this is only for UL synch
    - If not reserved, normal random access procedure
  - in case UE needs to transmit UL traffic / UL Signalling
    - Normal Random Access Procedure
      - Preamble (for UL synch) + Message (UE ID ?)
  - UE monitors DL-SCCH e.g. every monitoring period
    - The monitoring period could be long like paging DRX
  - NB controls how often UE should monitor DL-SCCH
- If DRX cycle changes,
  - DL-SCCH updates the monitoring period

Random Access Procedure

- Random Access Procedure
  - Usage
    - Unsynchronized in Uplink
      - Initial Access
      - Handover in Active Mode
      - UL synch Type 2
    - Synchronized in Uplink, but no UL resource (if no problem of load)
      - All processes are INACTIVE
  - Two-step approach
    - RACH Preamble
      - only signature
      - used for UL synchronization & collision detection
      - NB indicates ACK/NACK of Preamble like AICH (Design Issue)
    - RACH Message (Check)
      - UE ID (16 bits or less)
        - Random ID or
        - C-RNTI (Target Cell or Source Cell C-RNTI)
      - UE ID Type (1 or 2 bits) ?
      - Request Cause
        - Call Setup (Originating / Terminating Call)
        - Resource Request

Synch Channel & BCH

DL Synch Channel (SCH)

- minimum 1.25 Mhz (due to minimum Cell BW)
- Fixed configuration on minimum Cell/UE capability
- Support for Multiple SCH channels for less inter-frequency measurement ???
  (To measure, UE should receive SCH at least.)

Broadcast Channel

- Two types of BCH
  - Primary BCH
    - Fixed rate on minimum Cell/UE capability
    - Minimum 1.25 Mhz (Collocation with SCH)
    - Multiple P-BCH for each SCH ?
    - Carrying MIB (including Configuration of S-BCH, SIB Scheduling)
  - Secondary BCH
    - Flexible rate based on minimum UE capability (10 Mhz)
    - Flexible BW allocation (for frequency diversity)
    - Possibly, wider than 1.25 Mhz depending on Cell BW up to 10 Mhz
    - Carrying SIBs

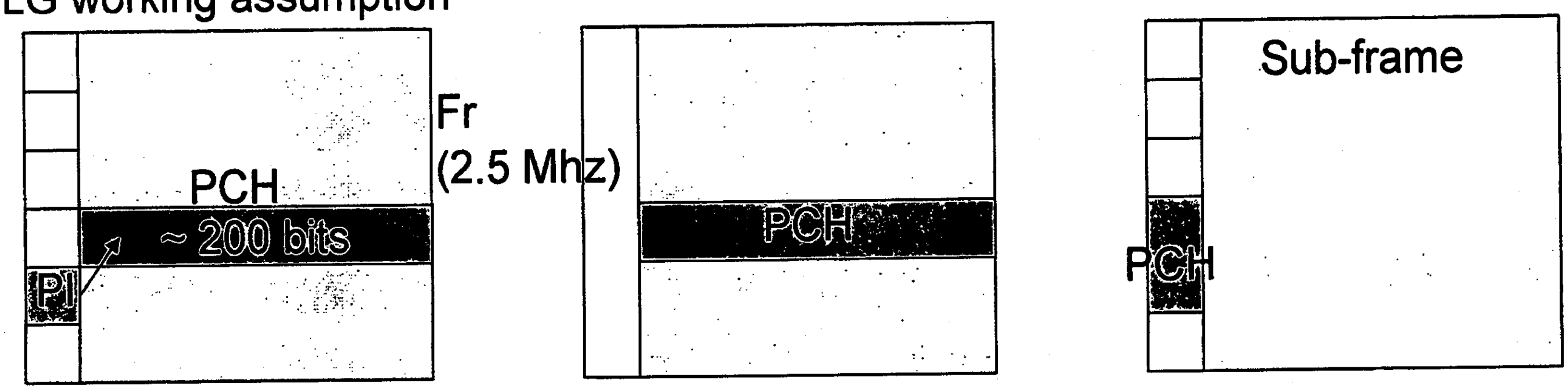
Paging Channel

Paging Channel

- PCH: Only short info (e.g. TA UE ID, IMSI, TMSI 32 bits) and Cause?
- PICH is needed because PICH can be simply decoded.
  - Depending on L1 control channel structure
- Collocation of PCH and SCCH on the same symbol ? (Not so good)
- Selection of 10 Mhz subband based on TA UE ID for IDLE UE
- Selection of Paging Occasion based on TA UE ID for IDLE UE

NOTE: Active Mode UE reads DL-SCCH with 16 bit UE ID (not 32 bits) for DRX in Active mode (Active Mode UE does not need to read PCH)

"LG working assumption"



PI: PCH existence,
UE group ID, PCH scheduling

No PI

No PI

Shared Channel

DL/UL Shared Control Channel (Mostly, Scheduling Info)

- Occupy one or more front symbol per one sub-frame
- Allocation of periodic resources for VoIP is possible in RAN1 TR (Persistence Schedule)

CQI reporting (LG RAN1 proposal)

- Full CQI Info carried on MAC/L1 Signaling
- Partial CQI Info carried on L1 CQI channel (only variation of full CQI info)
- NB could dynamically control CQI (e.g. period, resource) as piggybacking
  - When DL scheduling info is given
  - When UL scheduling info is granted ?

Hybrid ARQ

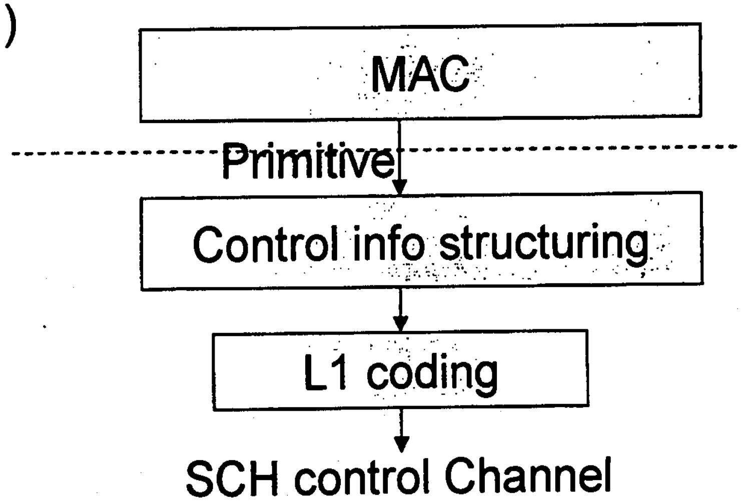
- Synchronous or Asynchronous Retransmission ?
- Synchronous or Asynchronous ACK/NACK ?

- HARQ process was defined in RAN1

Scheduling Information for DL SCH (R2-060109)

Information transmitted on DL for DL SCH transmission

1. List of Scheduled UE/Service
   - UE identity (cell level identity or TA level identity [FFS])
   - Service identity (for MBMS) [FFS]
2. HARQ/ARQ information for each UE identity [Details are FFS]
3. DL TFRI information for each UE/Service identity
   - Modulation and coding info
   - Transport block size (= Transport block set size)
   - Time and frequency for scheduled DL transmission
4. Feedback information for each UE identity (Optional)
   - Time and frequency for UL feedback of scheduled DL transmission (i.e. UL resource allocation of ACK/NACK/CQI transmissions for scheduling period)



Scheduling Information for UL SCH (R2-060109)

Information transmitted on DL for UL SCH transmission

1. List of scheduled UE
    - UE identity (cell level identity or TA level identity [FFS])
    - UE Group identity [FFS] (like R6 secondary E-RNTI)
2. Scheduling grant for each identity [Contents of scheduling grant are FFS]

Information transmitted on UL for UL SCH transmission

1. Scheduling Information (MAC)
    - Logical channel Identity [Details are FFS]
    - UE buffer occupancy [Details are FFS]
    - Further information is FFS
2. UL TFCI information (maybe not needed if UE just follows Node B scheduling)
    - Modulation and coding info
    - Transport block size (= Transport block set size)
3. HARQ/ARQ information [Details are FFS]

Multicast/Broadcast (To be further discussed)

Multicast/Broadcast on DL SCH

- TDM or FDM of MBMS and Dedicated Service ?
  - TDM is better for soft combining
  - But, fixed BW division possible (e.g. MBMS for 2.5 Mhz, 5 Mhz ....)

  -> <u>TDM with restricted FDM</u>
- Same TTI as Dedicated Service
  - Better coordination with dedicated service
- No counting or Simple detection of one user
  - That means no PTP bearer for MBMS
  - RACH message could include 'MBMS service ID' for this purpose
- No AMC
- <u>HARQ possible, but fixed retransmission</u>
  - Synchronous or Asynchronous retransmission ?
  - No NACK/ACK
- Soft combining possible
  - RRC in aGW supports it
- MCCH needed
- <u>Use DL-SCCH instead of MSCH for MBMS scheduling</u>
- FLC & CBS
  - Wait for LS about 'Aggregation'

ANNEX: Periodic Resource Allocation

Periodic Resource Allocation

- NB can give periodic radio block to a specific UE. (Already in RAN1 TR)
  - NB control ACTIVE/INACTIVE of the radio block if necessary

TSG-RAN Working Group 2 #52 **R2-06xxxx**
Athens, Greece, 27th – 31th March 2006

Agenda Item : ???

Source : MyungCheul Jung / LG Electronics (March 2006)

Title : RB, RAB, AS, NAS, AS/NAS function distributions

Document for LG Internal Discussion

Introduction

In the last Denvor meeting, there were discussions on the Bearer service concept for the SAE/LTE network. The concept of RB and RAB is not fully adaptable in the SAE/LTE network. It is because the SAE/LTE network architecture and protocol distribution is changed and different from UTRAN aspect . In the last RAN plenary meeting, the Bearer service concept in the SAE/LTE network was newly defined[23.882, tdoc#??]. However, we still have some point for further discussion. For example, the scope of AS and NAS signalling is not clear. This paper summarize the concept of the bearer service in the LTE network and propose the further discussion points.

The SAE Bearer Service Architecture

The following figure show the SAE Bearr service concept in the LTE network.

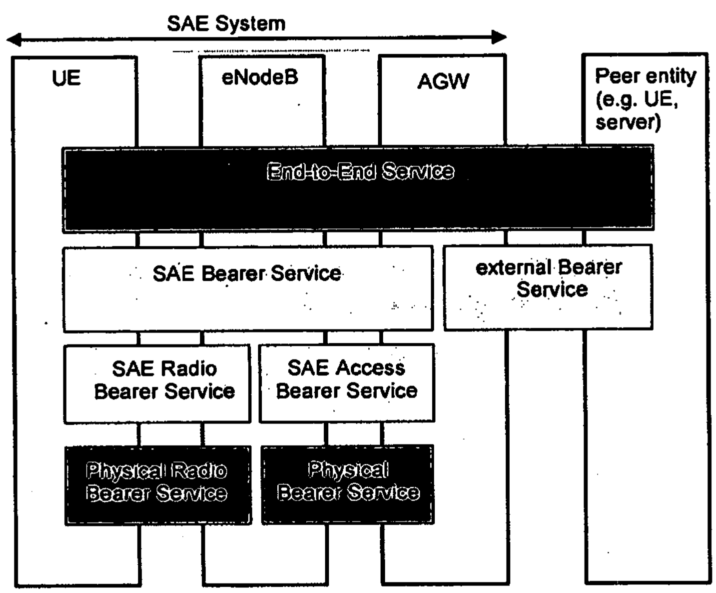


Figure 1 SAE Bearer Service Architecture.

It is FFS whether one or multiple AGWs serve a UE.

The SAE bearer service layered architecture is depicted in Figure 7.12-1. The definition of a bearer service as given in TS 23.107 is still applicable:

A bearer service includes all aspects to enable the provision of a contracted QoS. These aspects are among others the control signalling, user plane transport and QoS management functionality.

The SAE Bearer Service provides

-QoS wise aggregation of IP end-to-end-service flows

-IP header compression (and provision of related information to UE)

-UP encryption (and provision of related information to UE)

-if prioritised treatment of end-to-end-service signalling packets is required an additional SAE bearer service can be added to the default IP service

-provision of mapping/multiplexing information to the UE

-provision of accepted QoS information to the UE

The SAE Radio Bearer Service provides

-transport of the SAE Bearer Service data units between eNodeB and UE according to the required QoS

-linking of the SAE Bearer Service to the respective SAE Bearer Service

The SAE Access Bearer Service provides

-transport of the SAE Bearer Service data units between aGW and eNodeB according to the required QoS

-provision of aggregate QoS description of the SAE Bearer Service towards the eNodeB

-linking of the SAE Access Bearer Service to the respective SAE Bearer Service

Question?

- Does SAE mean LTE? SAE consider several networks except LTE? Actually, in current discussion, SAE means LTE. So, we assume the SAE is LTE in this paper.

- SAE Bearer seems to be mapped to RAB and SAE Radio Bearer to RB?

The LTE Data Bearer and LTE Radio Bearer concept

Basically, the concept of the RB and RAB in UTRAN comes from the network and protocol architecture. However, in the LTE architecture, EUTRAN is different from the UTRAN. For clarification and further discussion, we need to newly define the RB and RAB concepts in LTE.

The definition of RB and RAB in UTRAN is in the followings.

***Radio access bearer**: The service that the access stratum provides to the non-access stratum for transfer of user data between User Equipment and CN.*

***Radio Bearer**: The service provided by the Layer 2 for transfer of user data between User Equipment and UTRAN.*

Based on the last meeting agreement (figure 1), we propose the new definition for the LTE Data Bearer and LTE Radio Bearer in the following.

***LTE Data Bearer, LDB (SAE Bearer)**: The service that the access stratum provides to the non-access stratum for transfer of user data between User Equipment and accessGW. [It can be mapped into UPE. FFS. It was written from the current RAB definition.].*

The service that provide logical data flow to non-access stratum for transfer of the user data between User Equipment and access GW.

***LTE Radio Bearer, LRB (SAE Radio Bearer)**: the service provided by the Layer2 for transfer of user data between User Equipment and eNB.*

The service that transport LTE Data Bearer Service data unit between User Equipment and eNodeB according to the required QoS

The AS and NAS signalling in LTE

In the following, we show the two control signalling alternatives in LTE system.

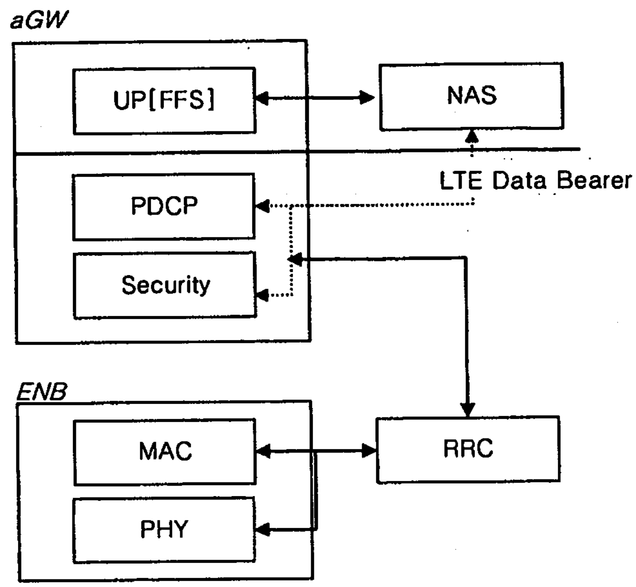


Figure 2. The control signalling in LTE/SAE

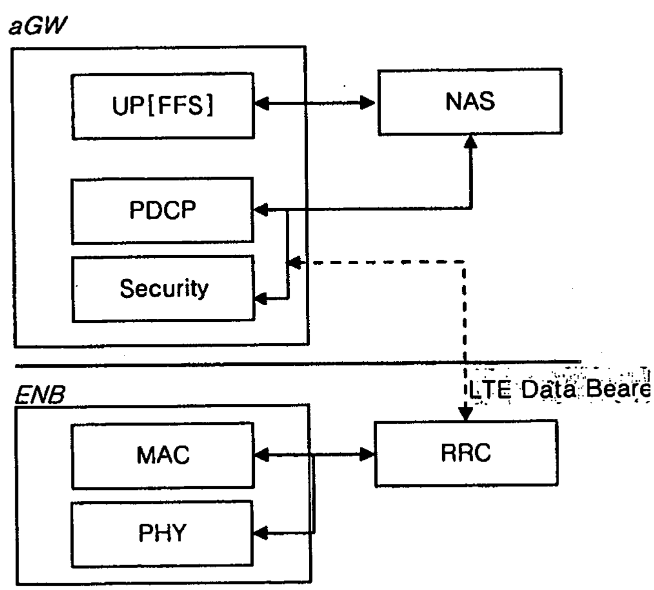


Figure 3. The control signalling in LTE/SAE

In the above figures, we assume that there is no Upper layer RRC(Because it was decided that the RRC termination point would be in the ENB, not aGW).

Figure 2 show that the control signalling for AS and NAS in case of no upper RRC in aGW and PDCP/Security handled in the RRC of ENB. In this case, the control of the PDCP and Security for the user plane is handled in the RRC of ENB.

My understanding is that t is feasible solution. However, it is strange to me that the RRC control the aGW also. How much signalling overhead increase from this? Is it agreeable?

Figure 3 show that the control signalling for AS and NAS in case of no upper RRC in aGW and PDCP/Security handled in the NAS of aGW. In this case, the control of the PDCP and security for the user plane is handled in the NAS part. In the network perspect, it is ease to handle and reduce signalling overhead. However, we should seriously consider the feasibility for the interRAT handover to UTRAN.

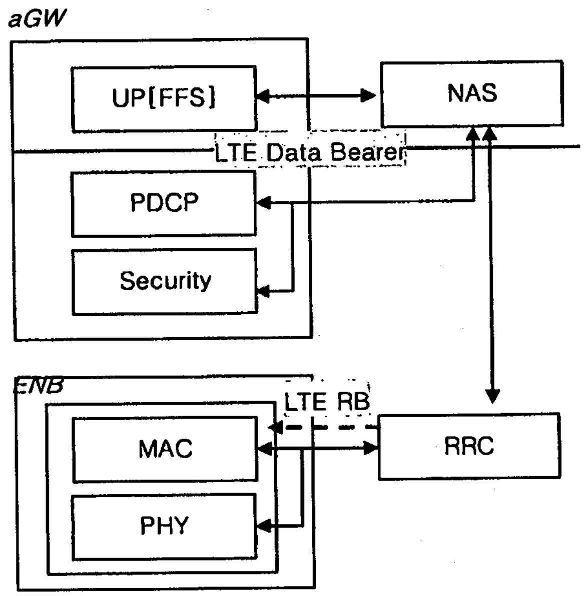


Figure 4. The control signalling in LTE/SAE [Is it feasible or not?]

The figure3 show the proposal control signalling for LTE/SAE. There is no Upper RRC in aGW. The PDCP and security is controlled by NAS part. The NAS signalling is mapped to RRC(Lower RRC) in ENB. [neet to discuss further]

One LTE Data Bearer should be mapped to one QoS flow (This is decided in the last RAN2 meeting). One PDP context should be mapped to one LTE Data Bearer?

Thus, One LTE Data Bearer should support one and same QoS flow. It is not allowed for mapping several different QoS into one LTE Data Bearer.

LTE Data Bearer reference point should be in the above the PDCP and security blocks.

LTE Radio Bearer configuration don't include the PDCP and security blocks. MAC(Outer ARQ, HARQ, etc) and Physical layer element should be configured in the LTE Radio Bearer.

Question: LTE Radio Bearer should be mapped to LTE Bearer? (from NttDocomo Question)

- Should RB be defined for each RAB flow?
- Should RB be defined when each RAB flow is established (except for the default RB)?
- Should a set of default RBs be defined for each RAB flow?
- Should one default RB be defined for all RAB flow (independent to the RAB flow)?

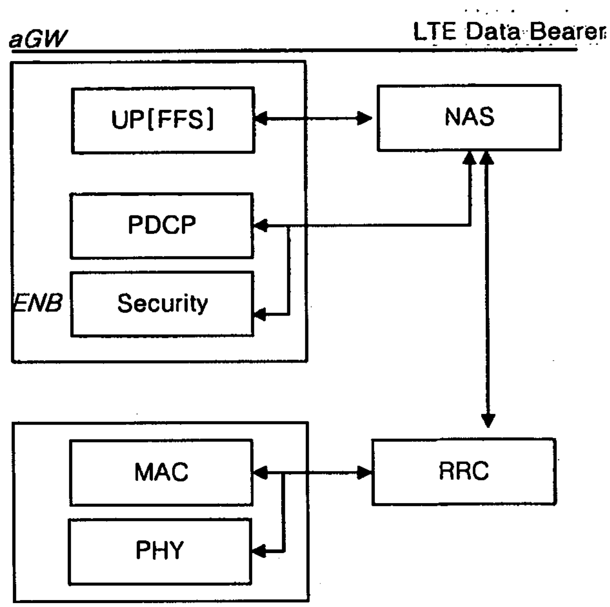


Figure 5. The control signalling in LTE/SAE [Is it feasible or not?]

[???]

The mapping of LTE Data Beaer and LTE Radio Bearer

Currently, it is not clear that we should maintain the one to one mapping concept between RB and RAB in the UTRAN.

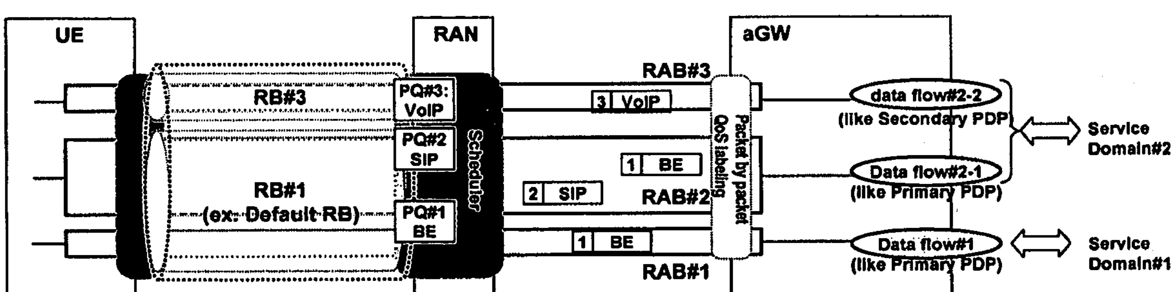


Figure5: RAB and RB correspondence in multi IP connectivity(Figure from NttDocomo)

In the UTRAN network, the concept of RB and RAB is based on the dedicated channe concept. However, in the LTE network, we don't consider the concept of the dedicated chanel but just consider the shared channel concept. Thus, it doesn't need to adhere to one to one mapping between RB and RAB in LTE.

In LTE network, the LTE Data Bearer don't need to be mapped to dedicated LTE Radio Bearer. Thus, when LTE Data Bearer establish, it is possible to be mapped to exist LTE Radio Bearer without new establishment of the new LTE Radio Bearer for that LTE Data Bearer. Existing LTE Radio Bearer can be Default LTE Radio Bearer or any other LTE Radio Bearer can support negotiated QoS for that LTE Data Bearer. It is FFS how to support default Radio Bearer and the level of default LTE Radio Bearer is FFS.

LTE Data Beaer and LTE Radio Bearer Assignment procedure

The purpose of the LTE Data bearer assignment procedure is to enable establishment of new LTE Data Bearer for a given UE and/or modification and/or establishment RABs and/or mapping into the RB can support and fulfil the QoS.

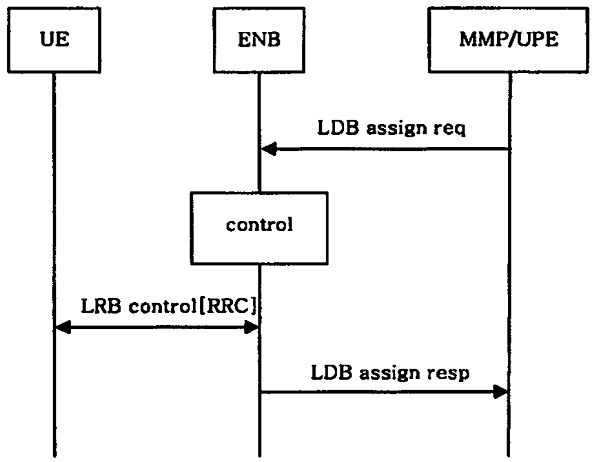


Figure x. LTE Data Bearer(LDB) assignment procedure.

LTE Data Bearer have the following configuration parameters:

- FFS (including PDCP and ciphering info?)

LTE Radio Bearer have the follwoig configuration parameters:

- FFS

LRB control in RRC have the function to estabilish or release or modify LRB. Based on the decision in control block, it is possible to mapping the current existing LRB.

PDP context and LTE Data Bearer

Question?

Where is the location of the PDP context for LTE services?

In case of aGW [MME/UPE],

What is the different between PDP context and the LTE Data bearer? Do we need to maintain PDP context and LTE Data bearer concept individually?

In case of the out of aGW[MME/UPE],

We should maintain the PDP context concept.

One to one mapping of the RAB and RB should be kept or changed?

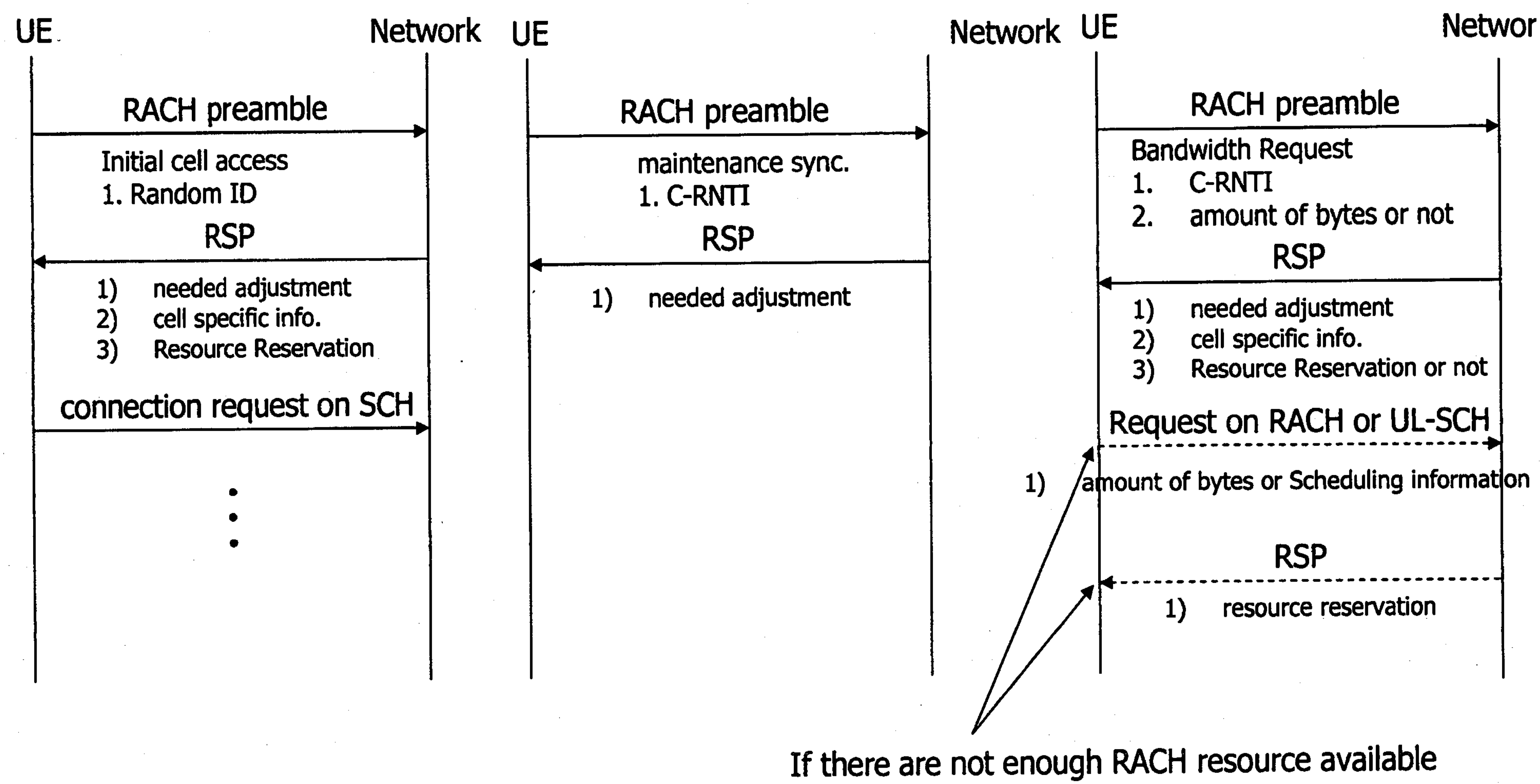
Other business

One IP connectivity : Multi IP flows

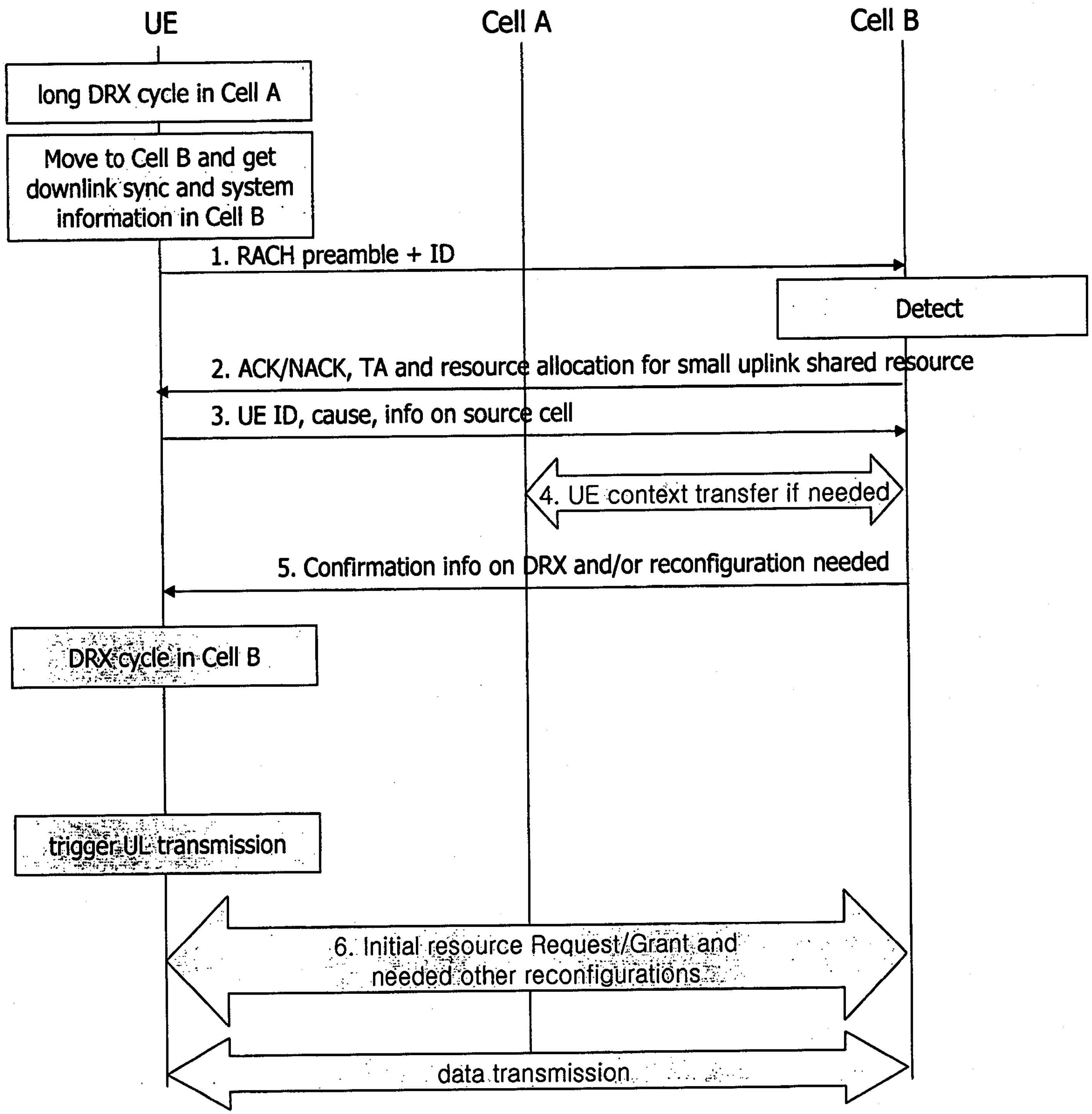
IP flows can be mapped in the same QoS flow.

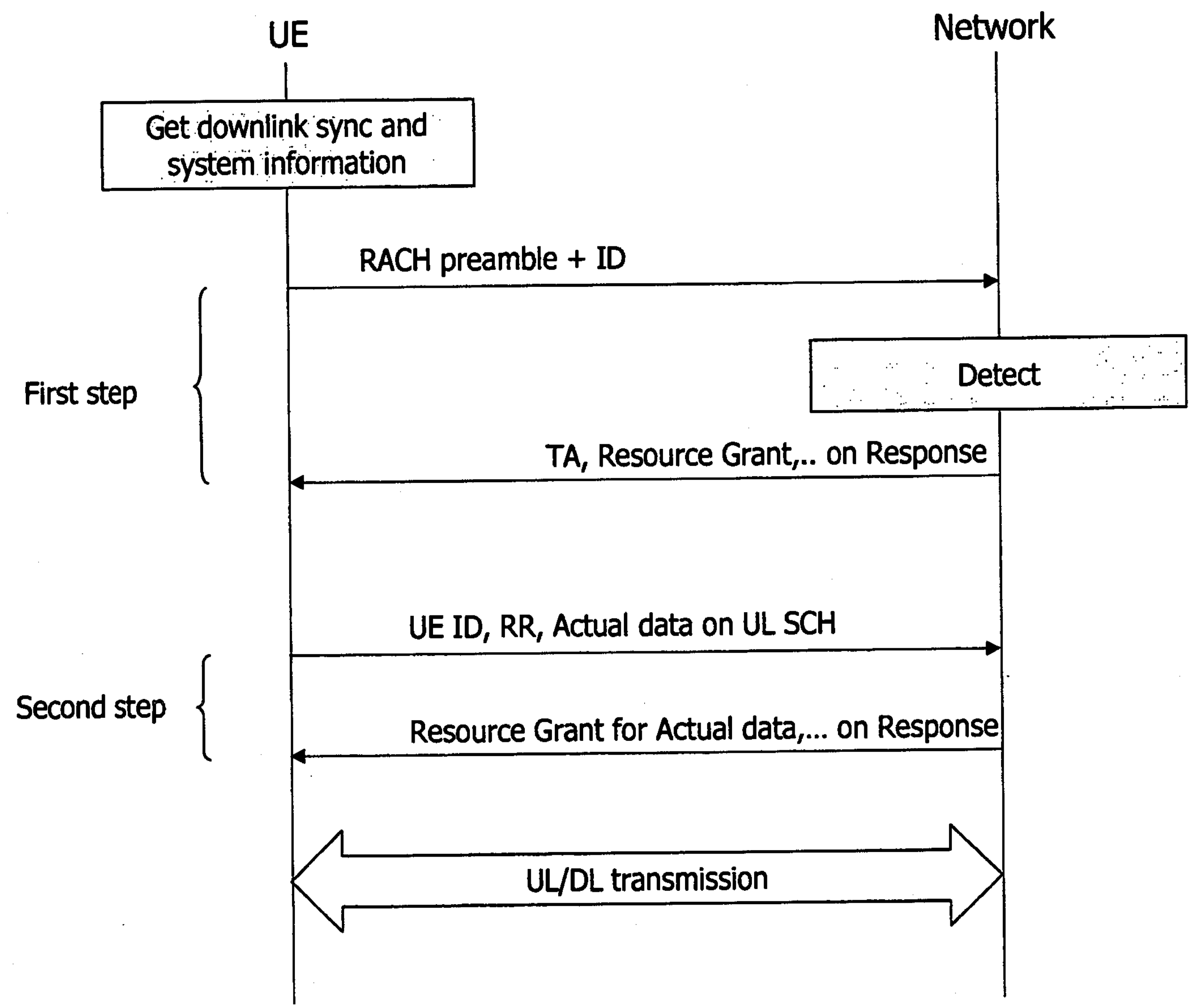
One QoS flow can be mapped in the one LTE Data Bearer

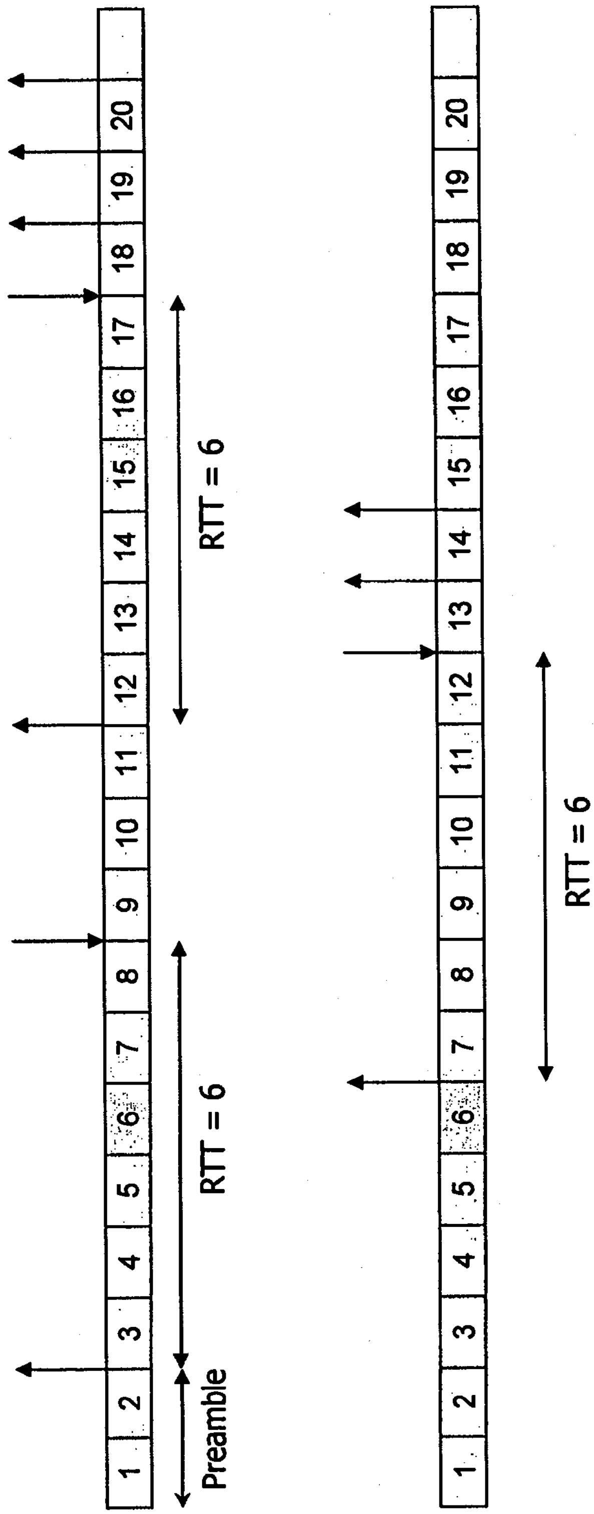
Regarding RAB and RB, it was defined as AS function. RB is linked with RRC

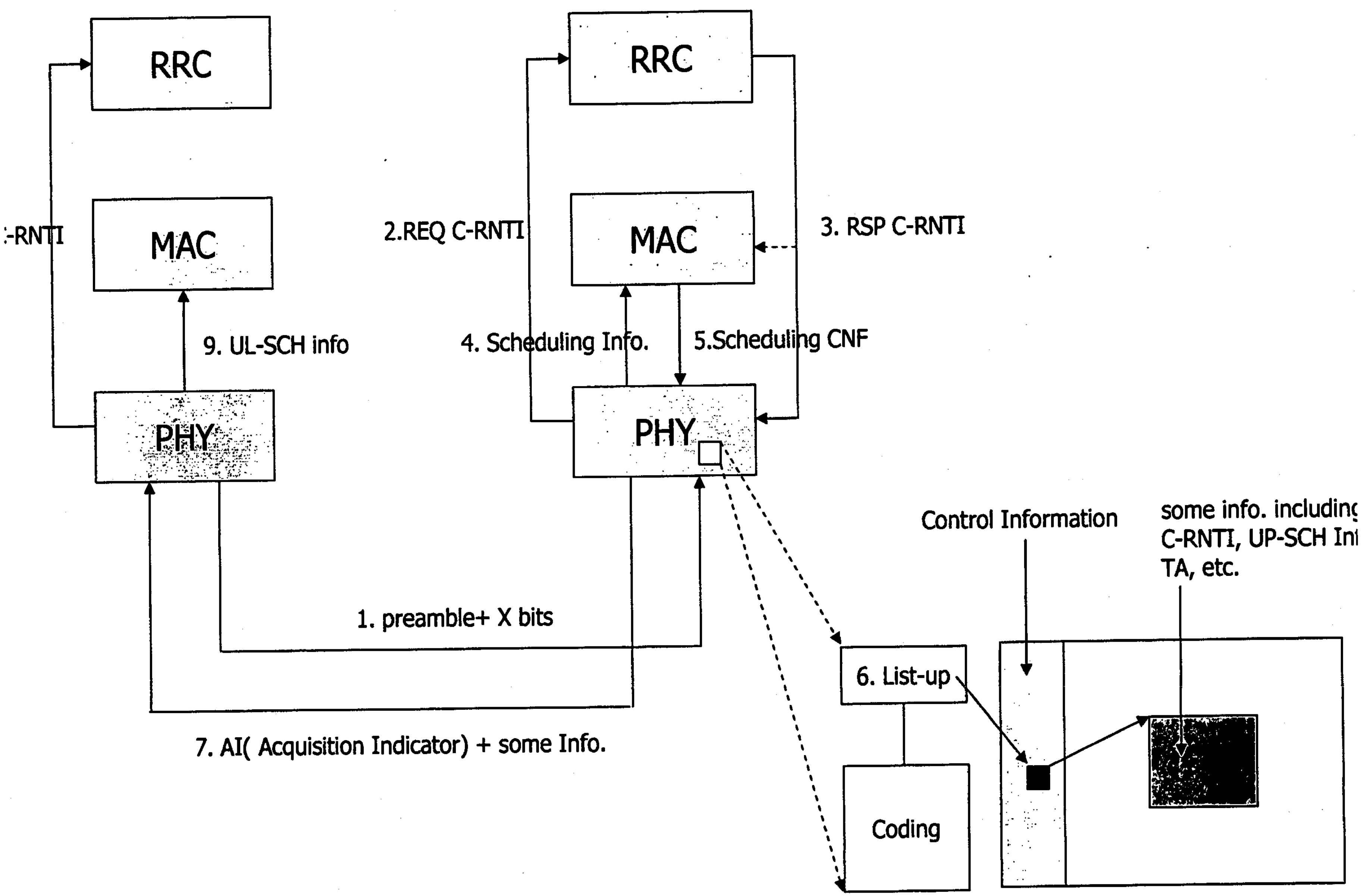


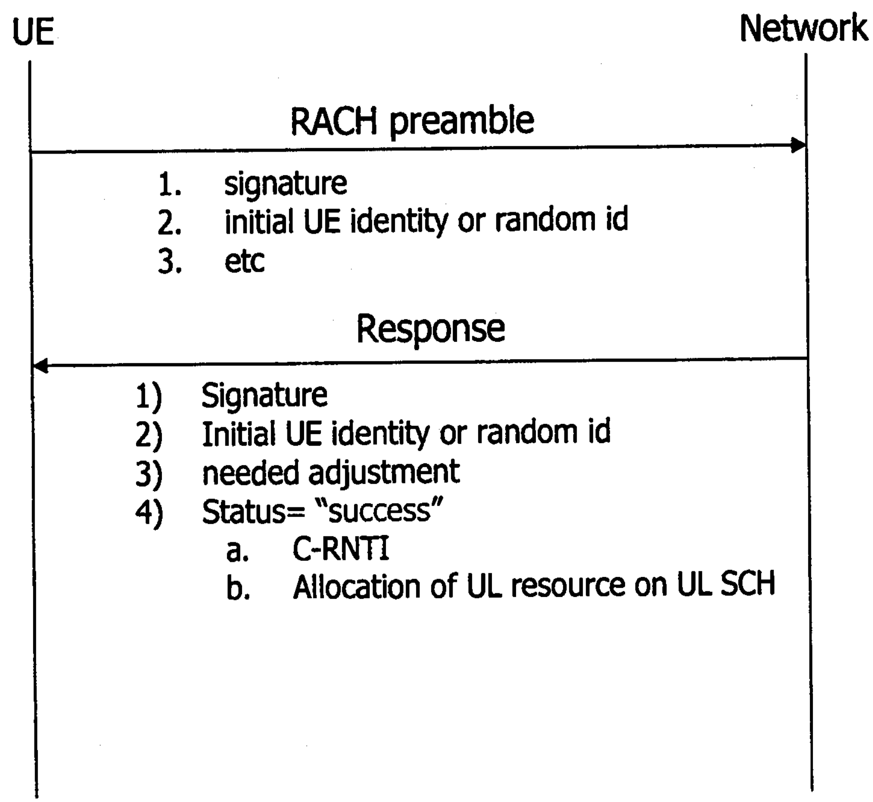
UE
Network
RACH preamble
Initial cell access
1. Random ID
RSP
1) needed adjustment
2) cell specific info.
3) Resource Reservation
connection request on SCH
UE
Network
RACH preamble
maintenance sync.
1. C-RNTI
RSP
1) needed adjustment
UE
Networ
RACH preamble
Bandwidth Request
1. C-RNTI
2. amount of bytes or not
RSP
1) needed adjustment
2) cell specific info.
3) Resource Reservation or not
Request on RACH or UL-SCH
1) amount of bytes or Scheduling information
RSP
1) resource reservation
If there are not enough RACH resource available

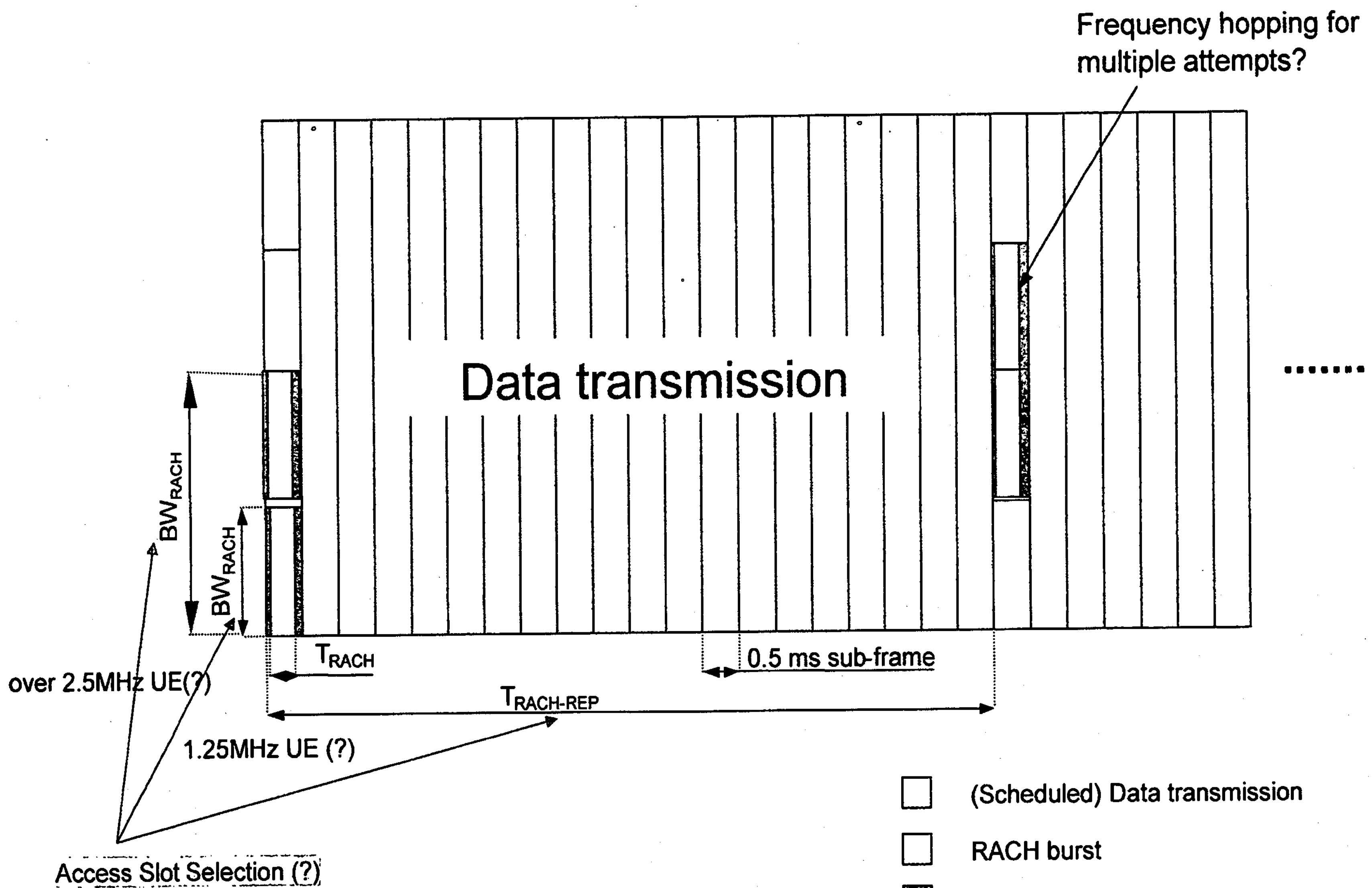

UE
Cell A
Cell B
long DRX cycle in Cell A
Move to Cell B and get downlink sync and system information in Cell B
1. RACH preamble + ID
Detect
2. ACK/NACK, TA and resource allocation for small uplink shared resource
3. UE ID, cause, info on source cell
4. UE context transfer if needed
5. Confirmation info on DRX and/or reconfiguration needed
DRX cycle in Cell B
trigger UL transmission
6. Initial resource Request/Grant and needed other reconfigurations
data transmission


UE
Network
Get downlink sync and system information
RACH preamble + ID
Detect
TA, Resource Grant,.. on Response
First step
UE ID, RR, Actual data on UL SCH
Resource Grant for Actual data,... on Response
Second step
UL/DL transmission

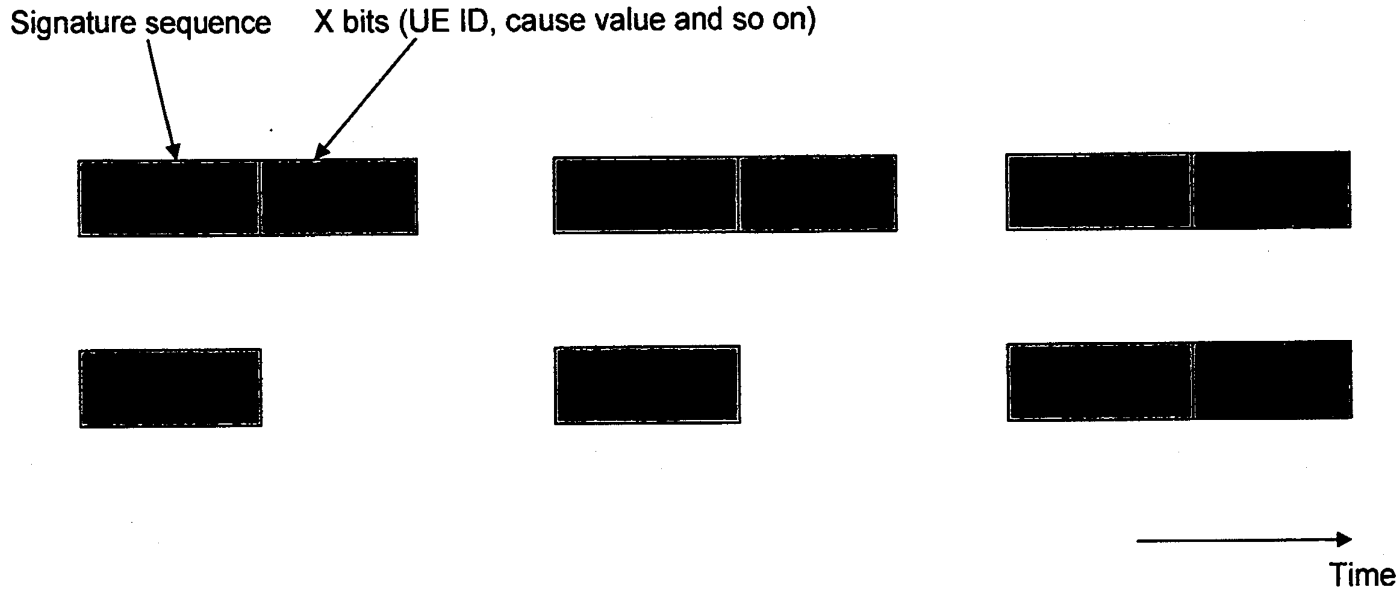

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Preamble
RTT = 6
RTT = 6
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
RTT = 6

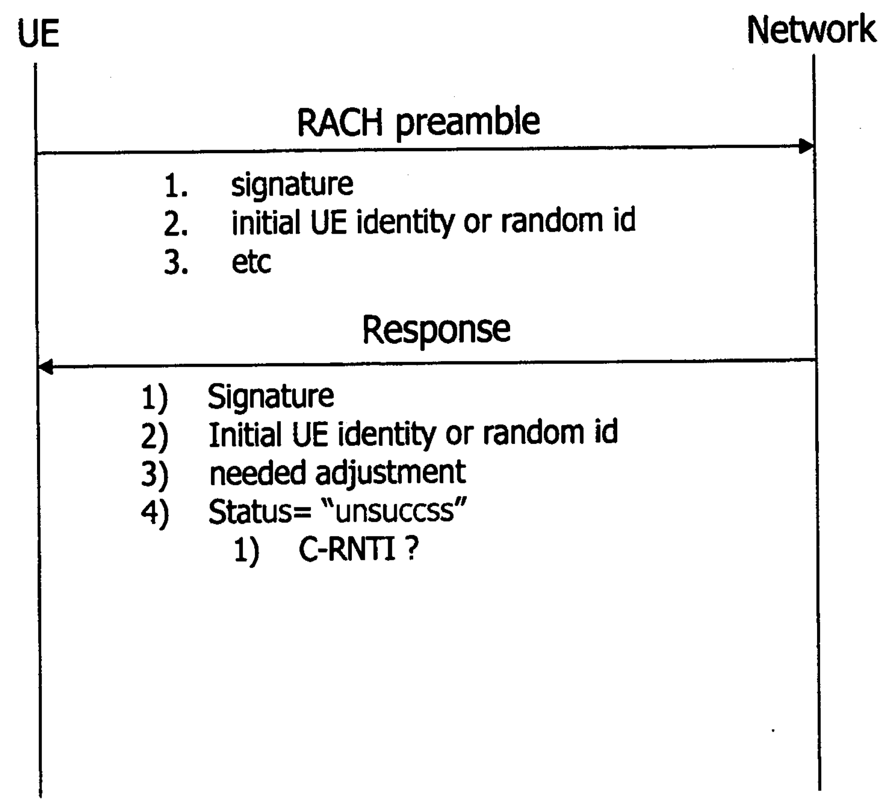

RRC
MAC
PHY
:-RNTI
9. UL-SCH info
RRC
MAC
PHY
2.REQ C-RNTI
3. RSP C-RNTI
4. Scheduling Info.
5.Scheduling CNF
1. preamble+ X bits
7. AI(Acquisition Indicator) + some Info.
6. List-up
Coding
Control Information
some info. includinç
C-RNTI, UP-SCH In
TA, etc.

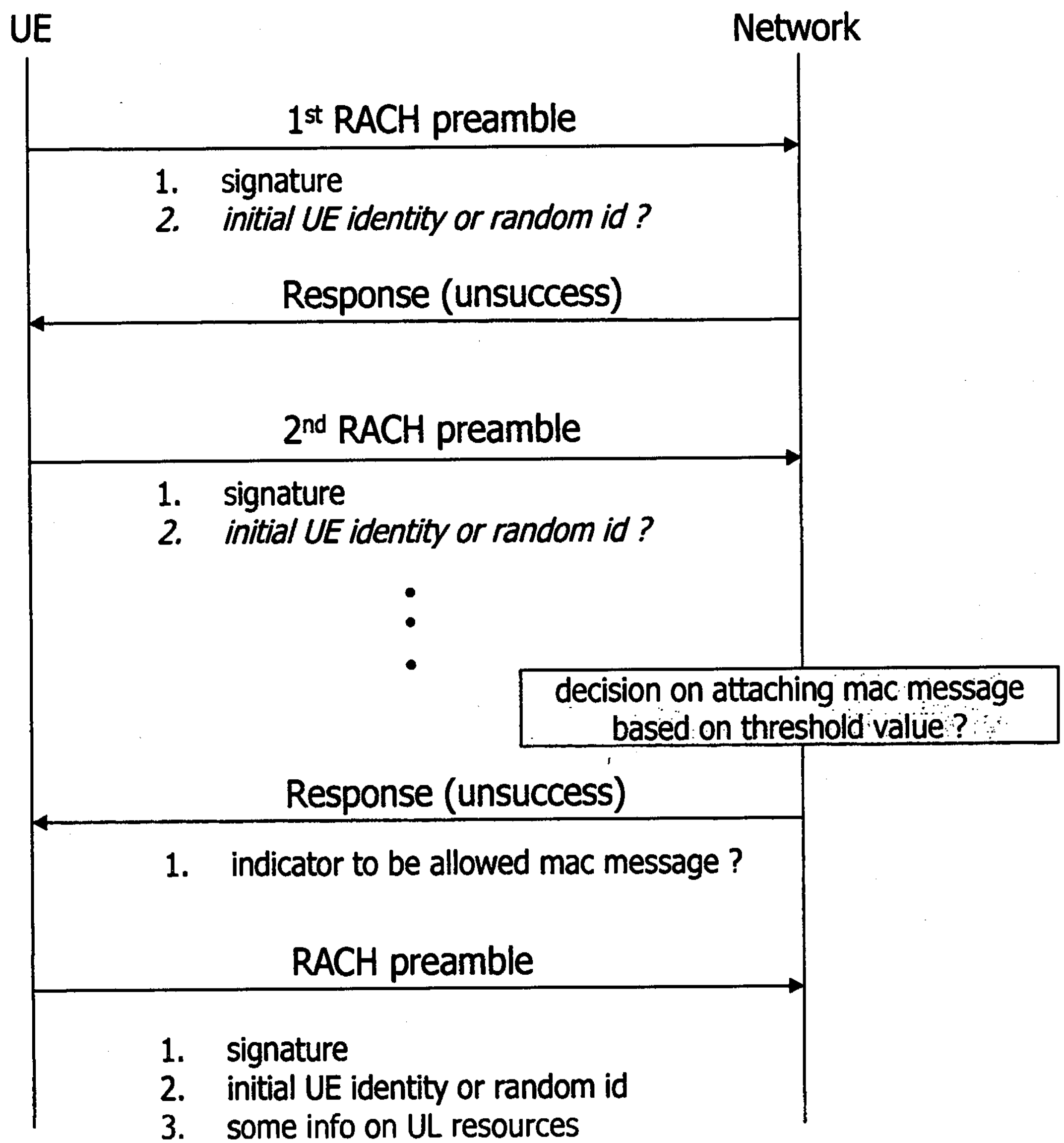

UE
Network
RACH preamble
1. signature
2. initial UE identity or random id
3. etc
Response
1) Signature
2) Initial UE identity or random id
3) needed adjustment
4) Status= "success"
a. C-RNTI
b. Allocation of UL resource on UL SCH

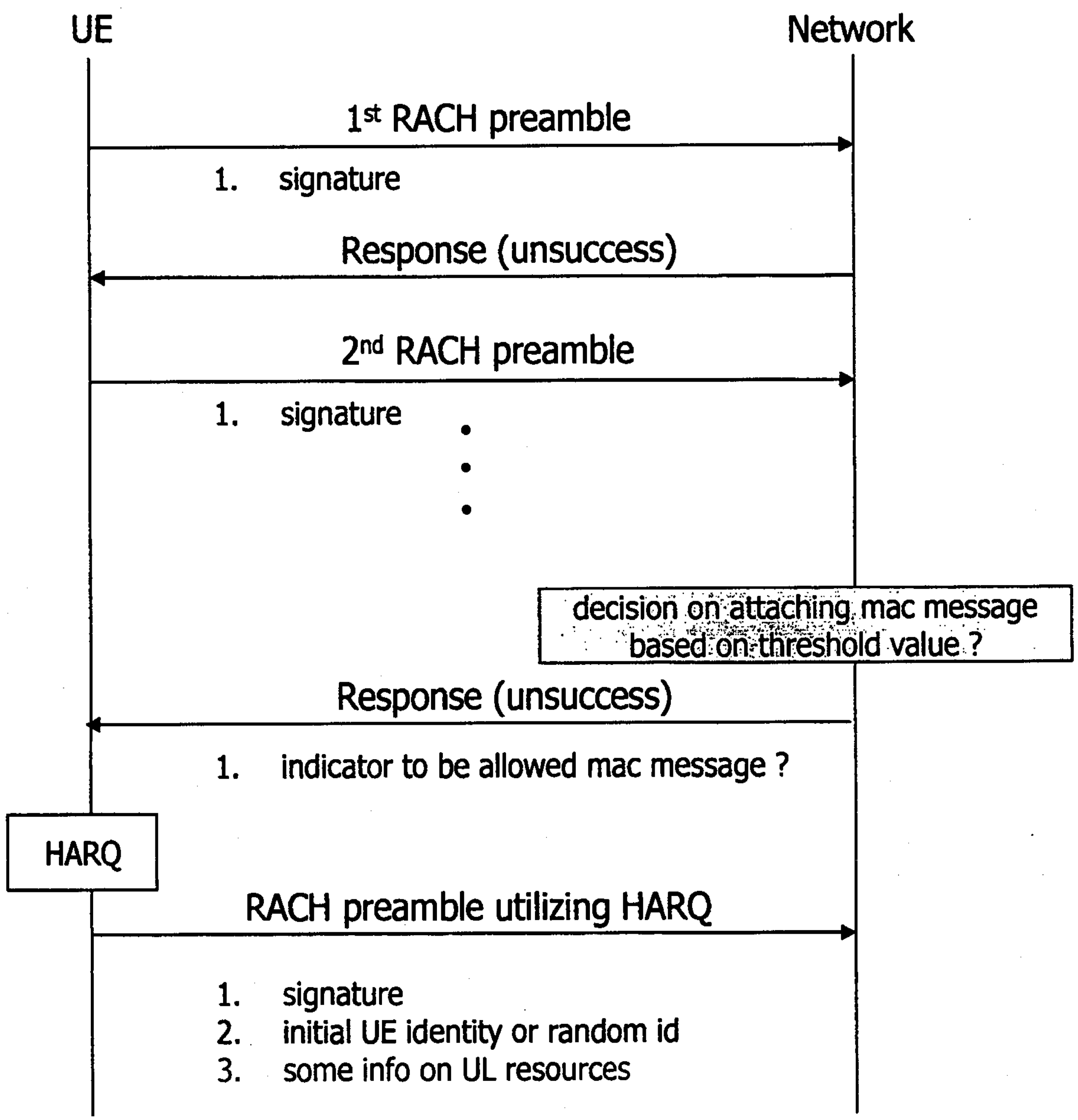


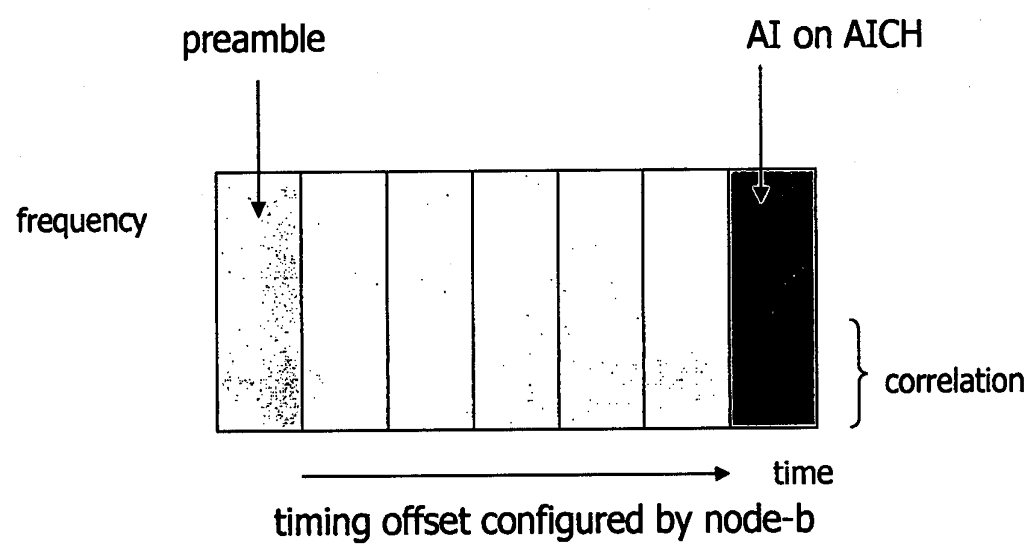
Frequency hopping for multiple attempts?
Data transmission
BW$_{RACH}$
BW$_{RACH}$
T$_{RACH}$
0.5 ms sub-frame
T$_{RACH-REP}$
over 2.5MHz UE(?)
1.25MHz UE (?)
Access Slot Selection (?)
(Scheduled) Data transmission
RACH burst
Guard time

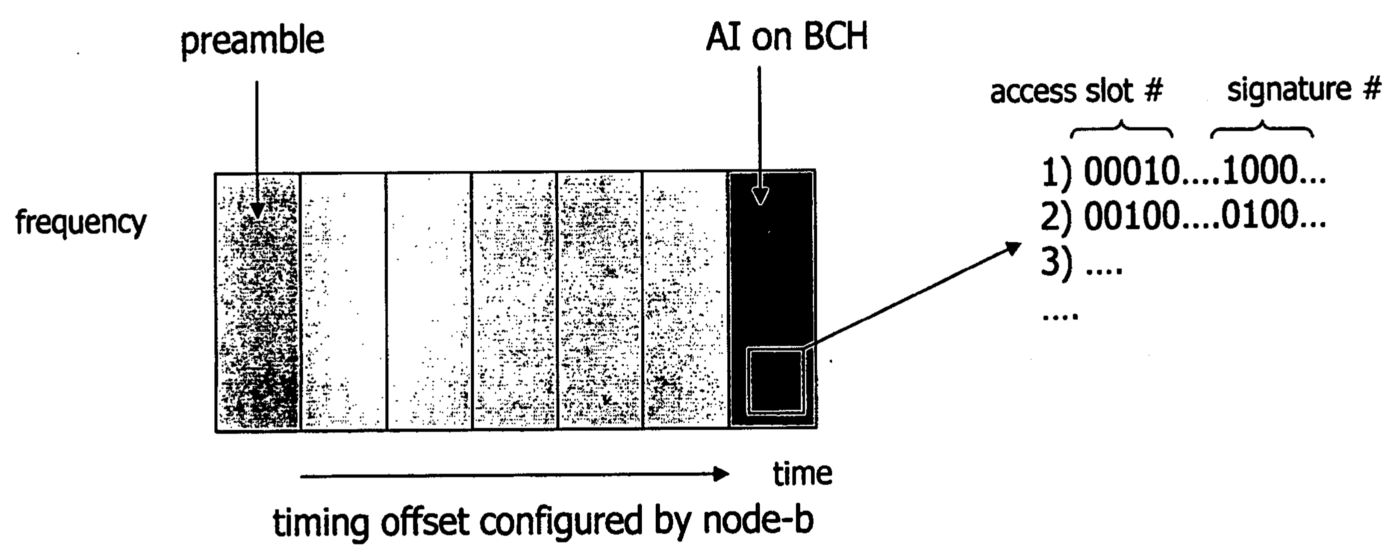

Signature sequence
X bits (UE ID, cause value and so on)
Time

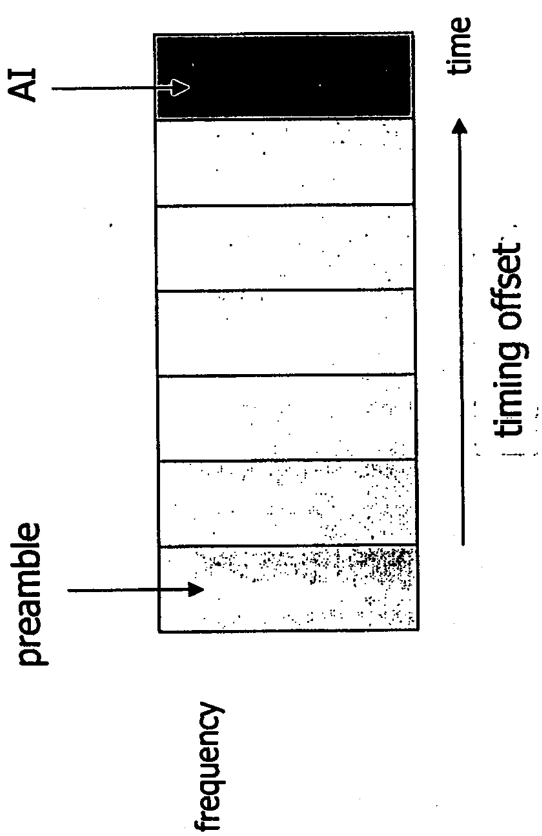

UE
Network
RACH preamble
1. signature
2. initial UE identity or random id
3. etc
Response
1) Signature
2) Initial UE identity or random id
3) needed adjustment
4) Status= "unsuccss"
1) C-RNTI ?

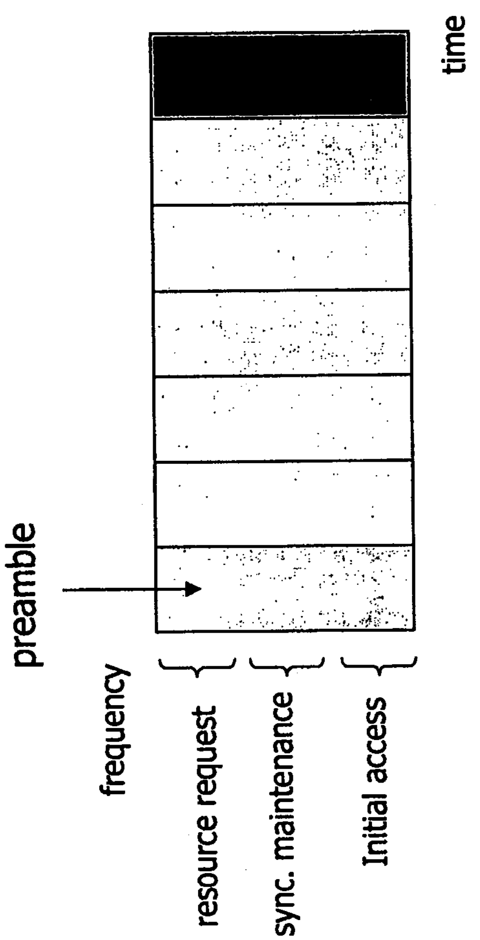

UE
Network
1st RACH preamble
1. signature
2. initial UE identity or random id ?
Response (unsuccess)
2nd RACH preamble
1. signature
2. initial UE identity or random id ?
decision on attaching mac message based on threshold value ?
Response (unsuccess)
1. indicator to be allowed mac message ?
RACH preamble
1. signature
2. initial UE identity or random id
3. some info on UL resources

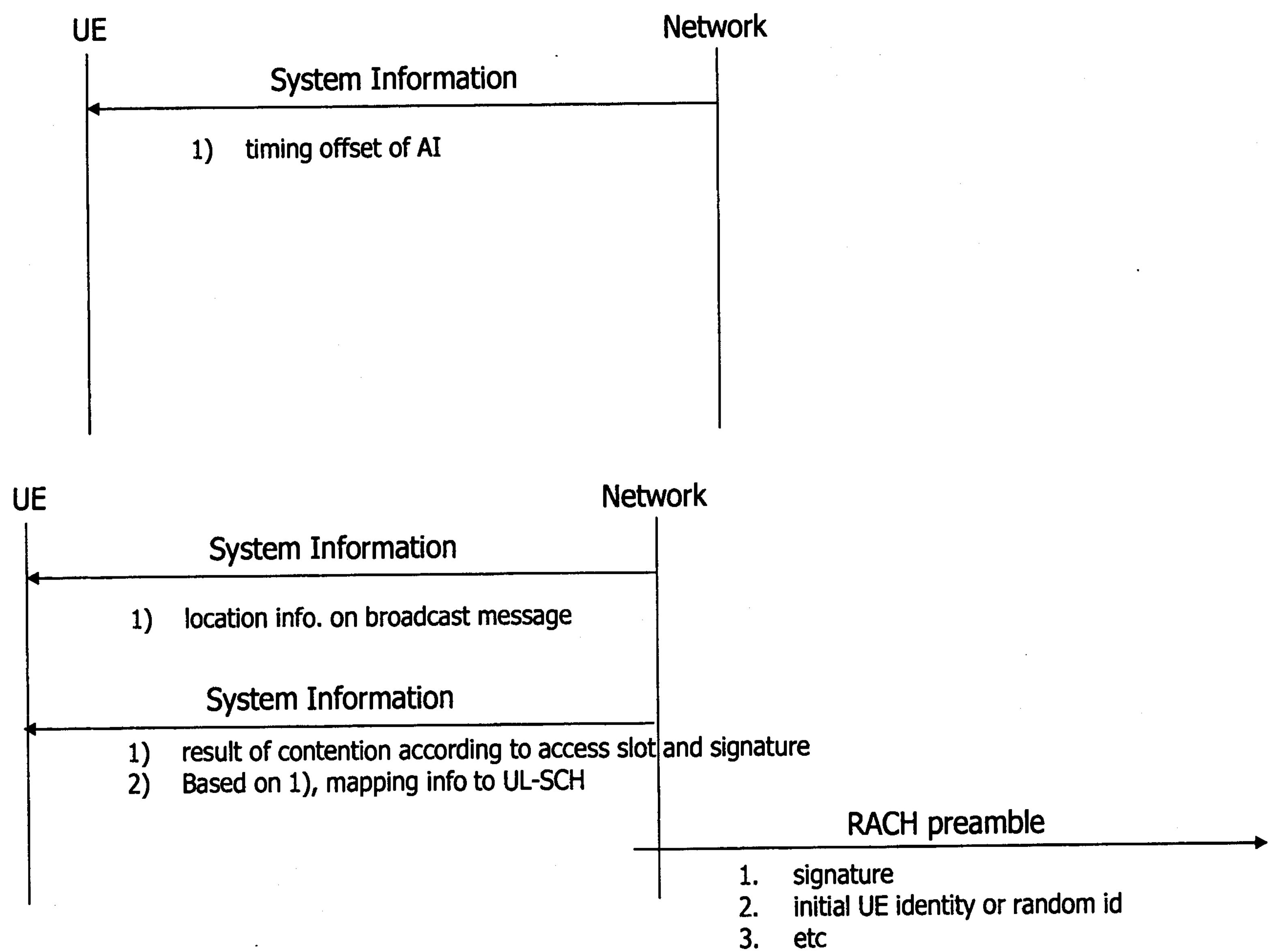

UE
Network
1st RACH preamble
1. signature
Response (unsuccess)
2nd RACH preamble
1. signature
decision on attaching mac message based on threshold value ?
Response (unsuccess)
1. indicator to be allowed mac message ?
HARQ
RACH preamble utilizing HARQ
1. signature
2. initial UE identity or random id
3. some info on UL resources

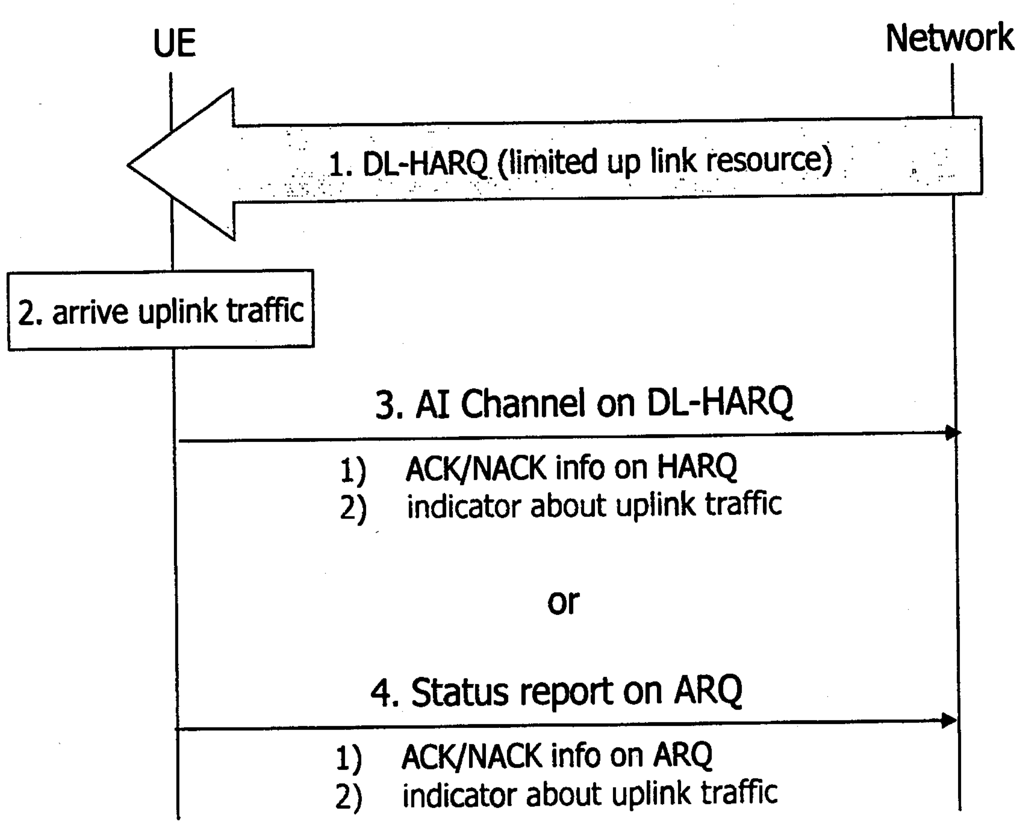

preamble
AI on AICH
frequency
correlation
time
timing offset configured by node-b

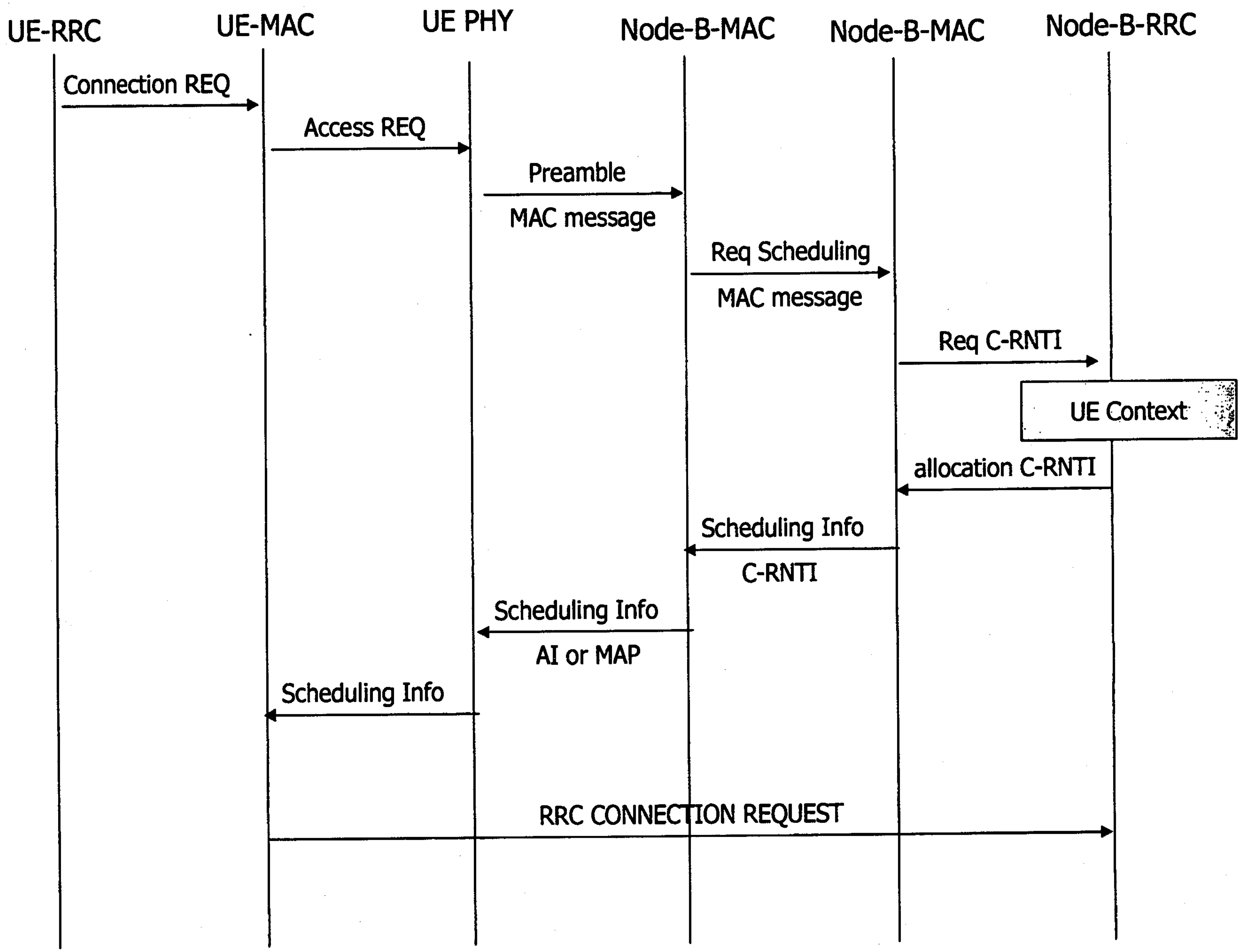

preamble
AI on BCH
access slot #
signature #
frequency
1) 00010....1000...
2) 00100....0100...
3) ....
....
time
timing offset configured by node-b

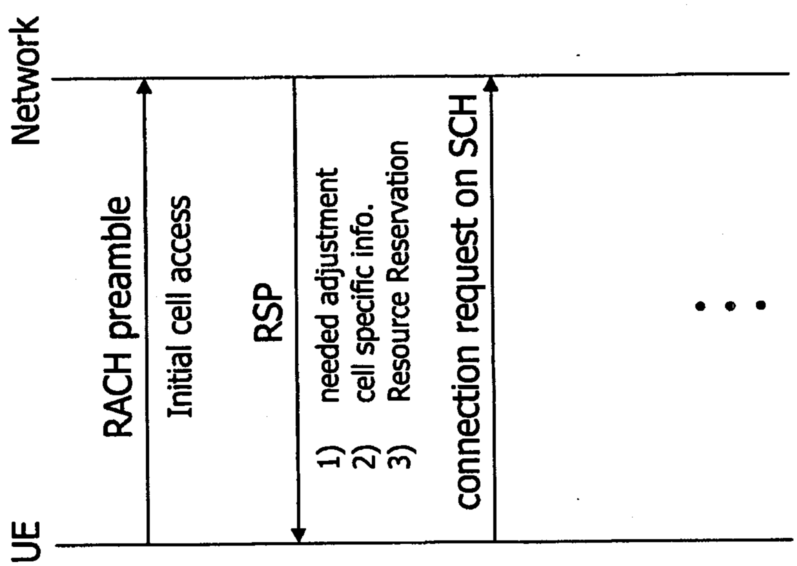

AI
preamble
frequency
time
timing offset

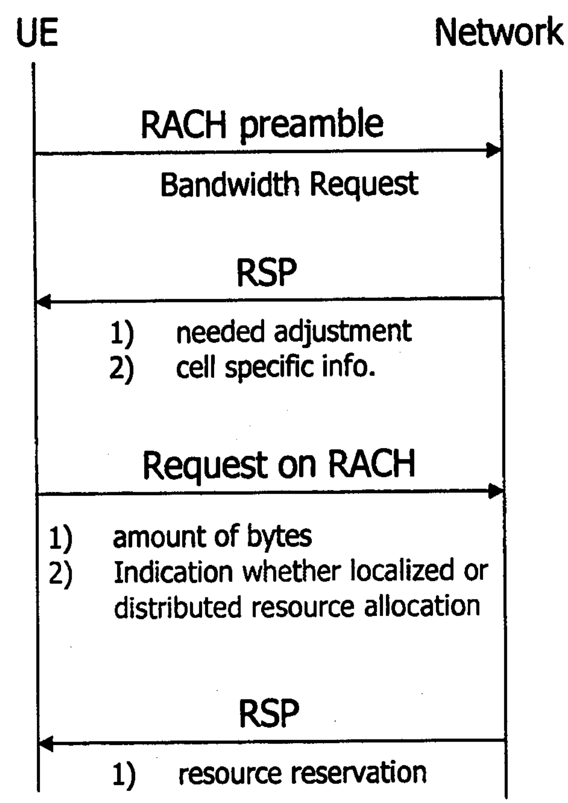

preamble
frequency
resource request
sync. maintenance
Initial access
time

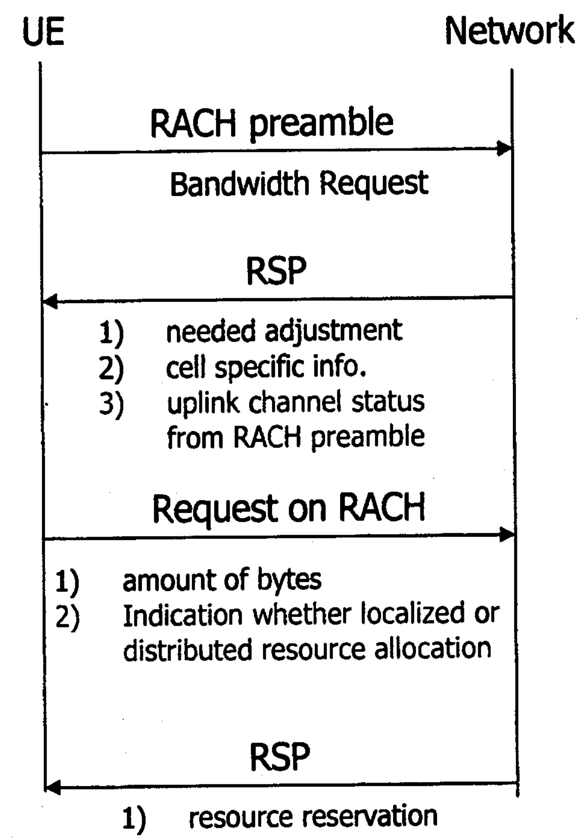

UE
Network
System Information
1) timing offset of AI
UE
Network
System Information
1) location info. on broadcast message
System Information
1) result of contention according to access slot and signature
2) Based on 1), mapping info to UL-SCH
RACH preamble
1. signature
2. initial UE identity or random id
3. etc

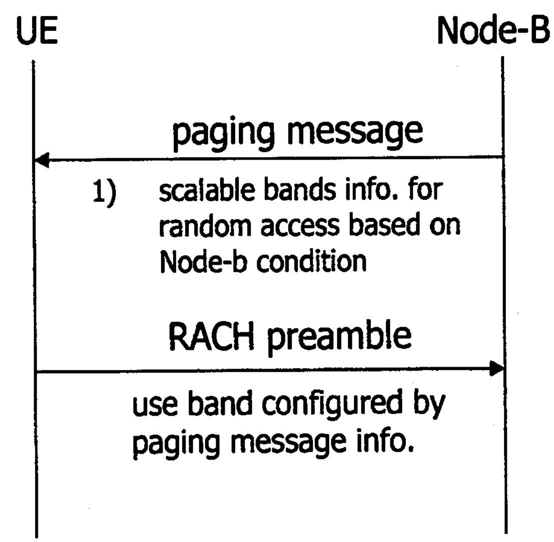

UE
Network
1. DL-HARQ (limited up link resource)
2. arrive uplink traffic
3. AI Channel on DL-HARQ
1) ACK/NACK info on HARQ
2) indicator about uplink traffic
or
4. Status report on ARQ
1) ACK/NACK info on ARQ
2) indicator about uplink traffic

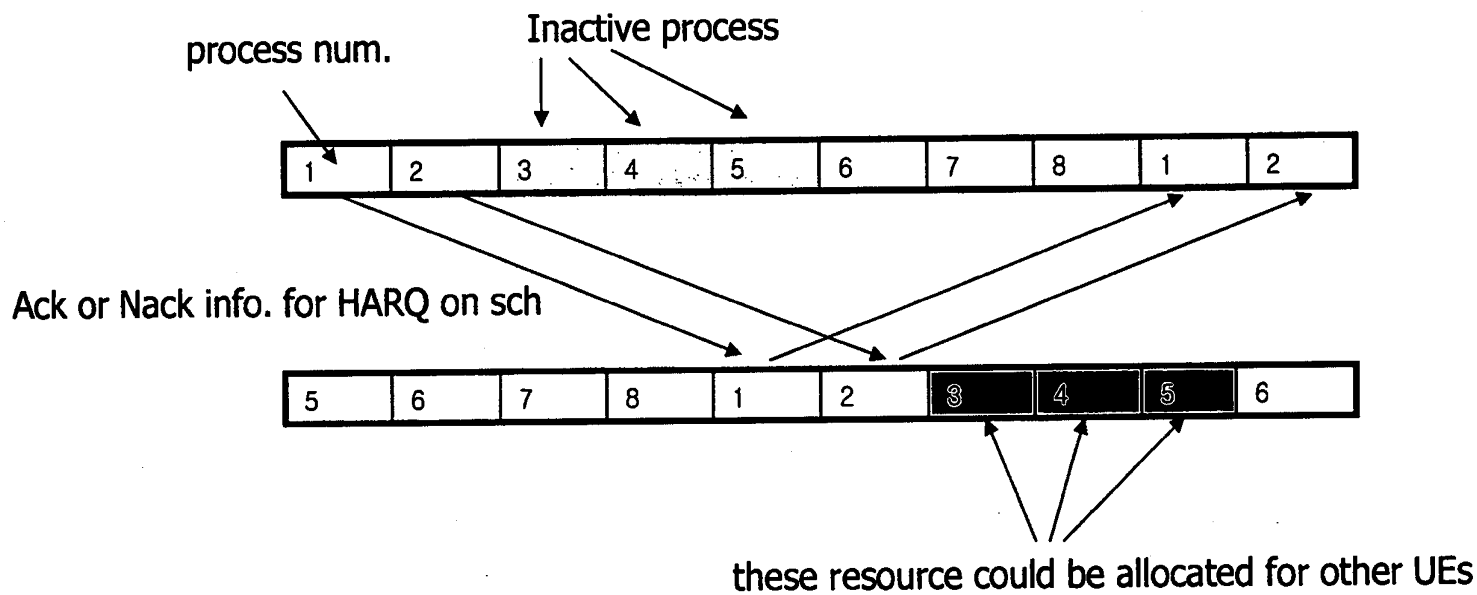

UE-RRC
UE-MAC
UE PHY
Node-B-MAC
Node-B-MAC
Node-B-RRC
Connection REQ
Access REQ
Preamble
MAC message
Req Scheduling
MAC message
Req C-RNTI
UE Context
allocation C-RNTI
Scheduling Info
C-RNTI
Scheduling Info
AI or MAP
Scheduling Info
RRC CONNECTION REQUEST

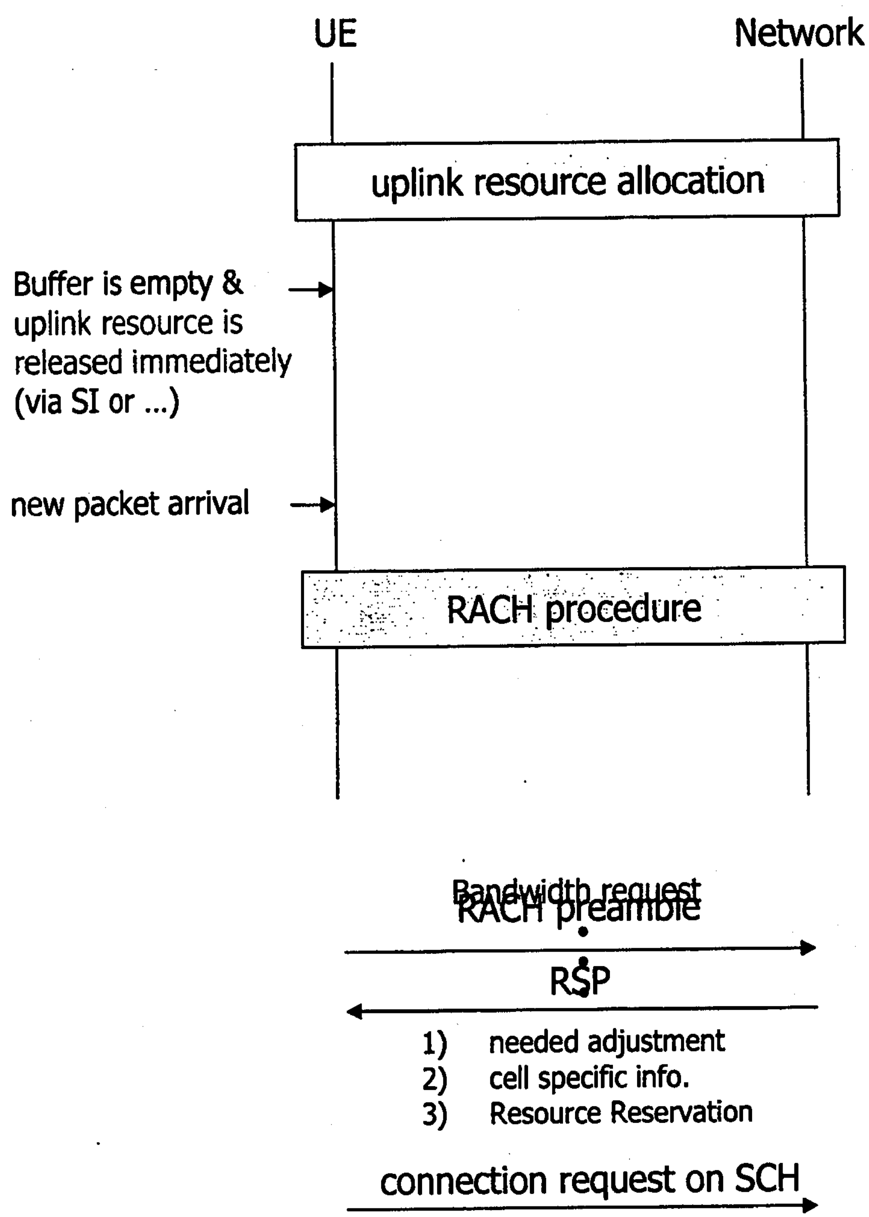

Network
UE
RACH preamble
Initial cell access
RSP
1) needed adjustment
2) cell specific info.
3) Resource Reservation
connection request on SCH
• • •

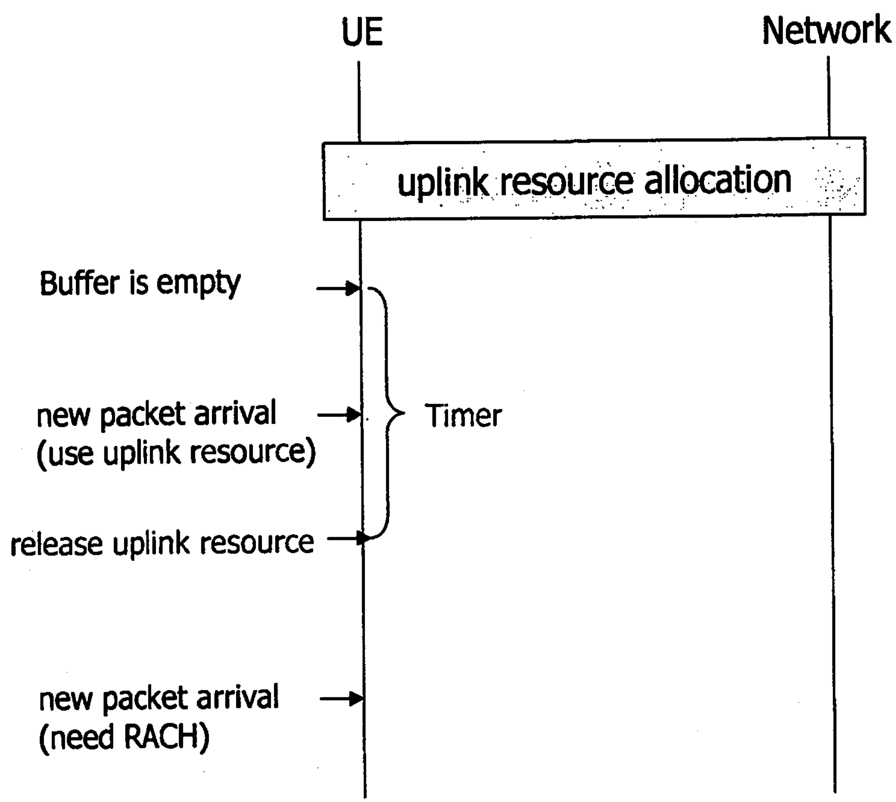

UE
Network
RACH preamble
Bandwidth Request
RSP
1) needed adjustment
2) cell specific info.
Request on RACH
1) amount of bytes
2) Indication whether localized or distributed resource allocation
RSP
1) resource reservation

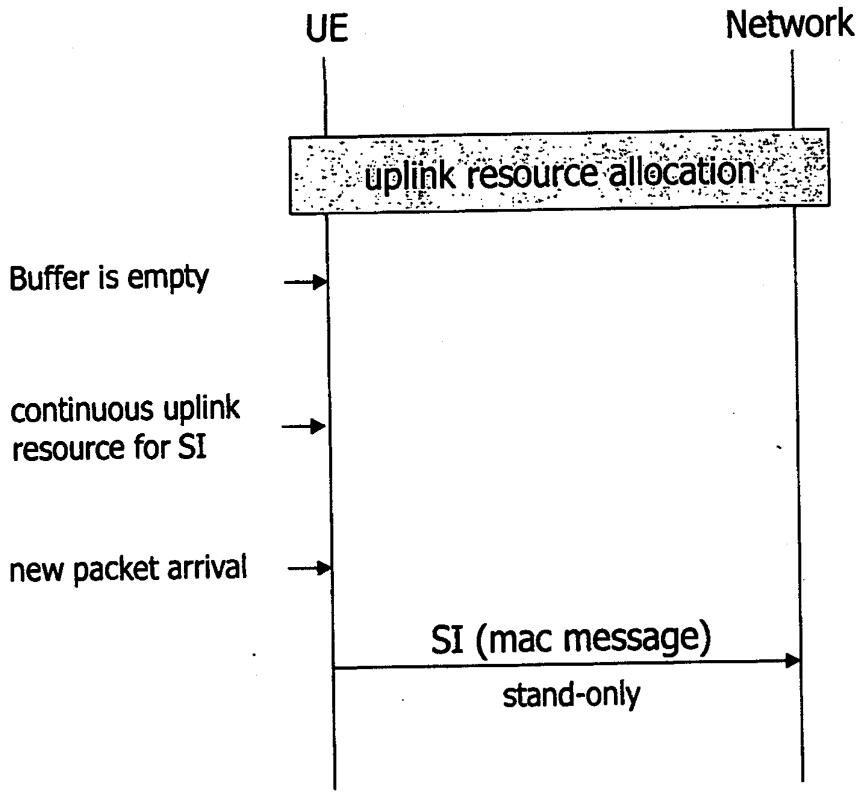

UE
Network
RACH preamble
Bandwidth Request
RSP
1) needed adjustment
2) cell specific info.
3) uplink channel status from RACH preamble
Request on RACH
1) amount of bytes
2) Indication whether localized or distributed resource allocation
RSP
1) resource reservation

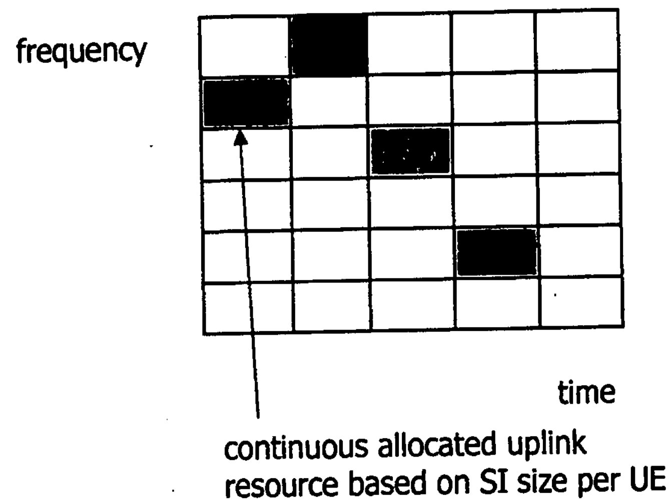

UE
Node-B
paging message
1) scalable bands info. for random access based on Node-b condition
RACH preamble
use band configured by paging message info.

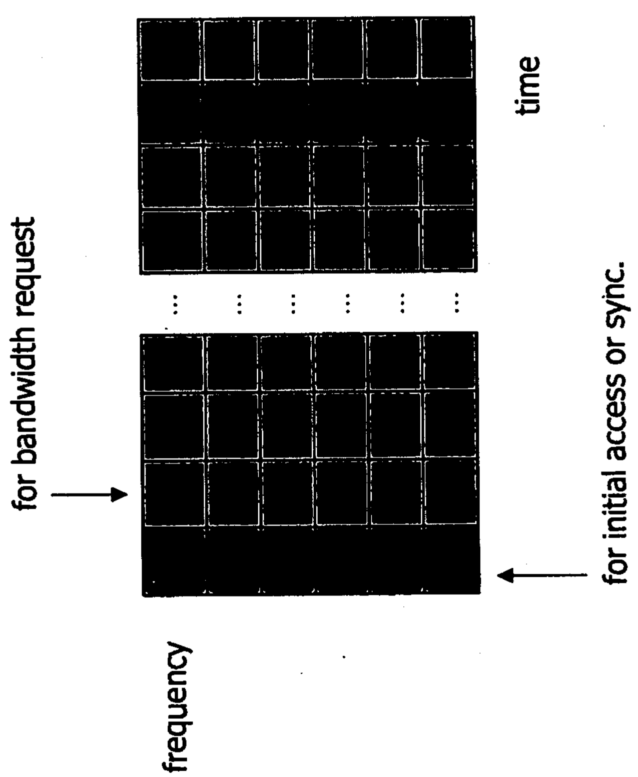

process num.
Inactive process
1
2
3
4
5
6
7
8
1
2
Ack or Nack info. for HARQ on sch
5
6
7
8
1
2
3
4
5
6
these resource could be allocated for other UEs

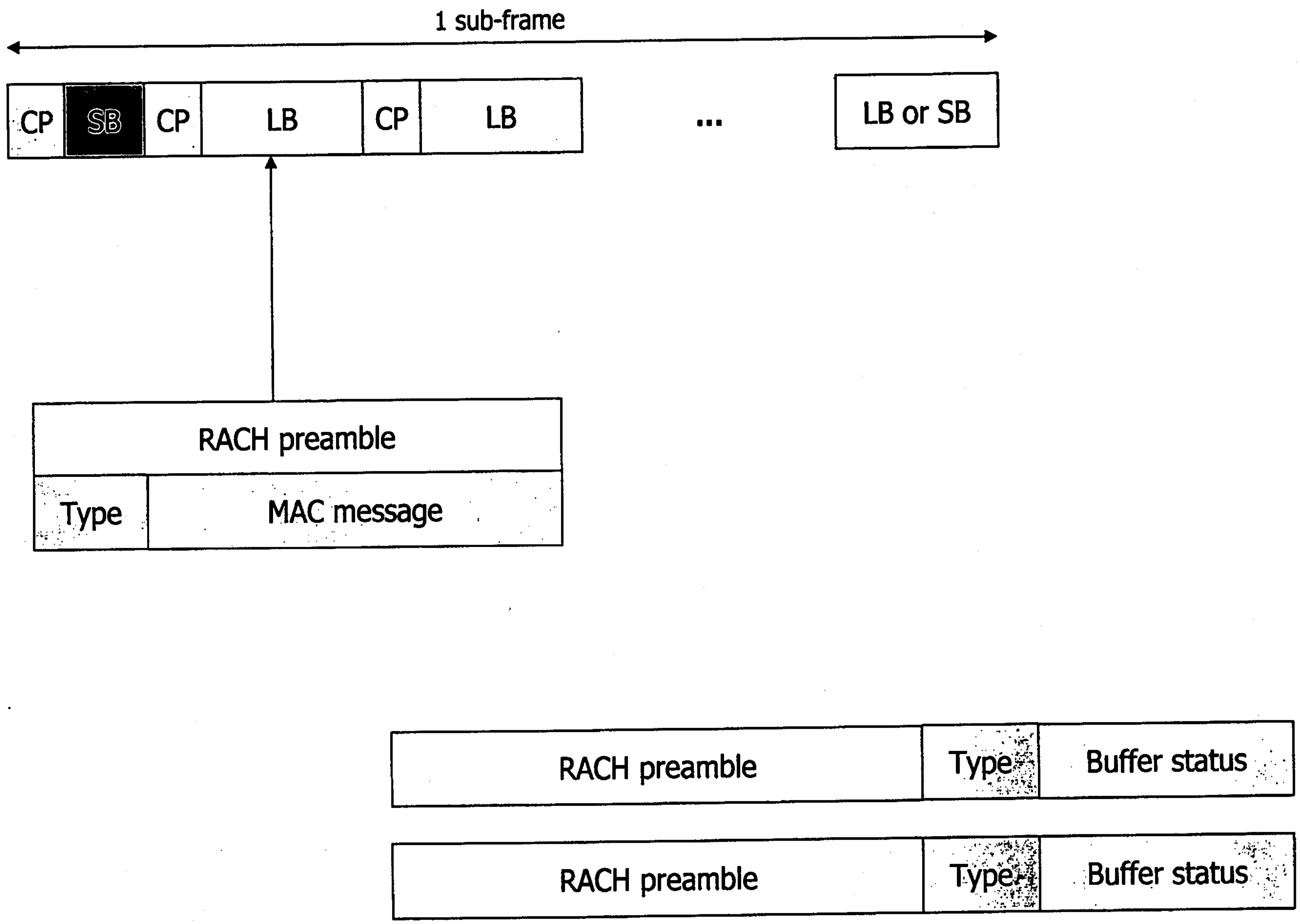

UE
Network
uplink resource allocation
Buffer is empty & uplink resource is released immediately (via SI or ...)
new packet arrival
RACH procedure
Bandwidth request
RACH preamble
RSP
1) needed adjustment
2) cell specific info.
3) Resource Reservation
connection request on SCH

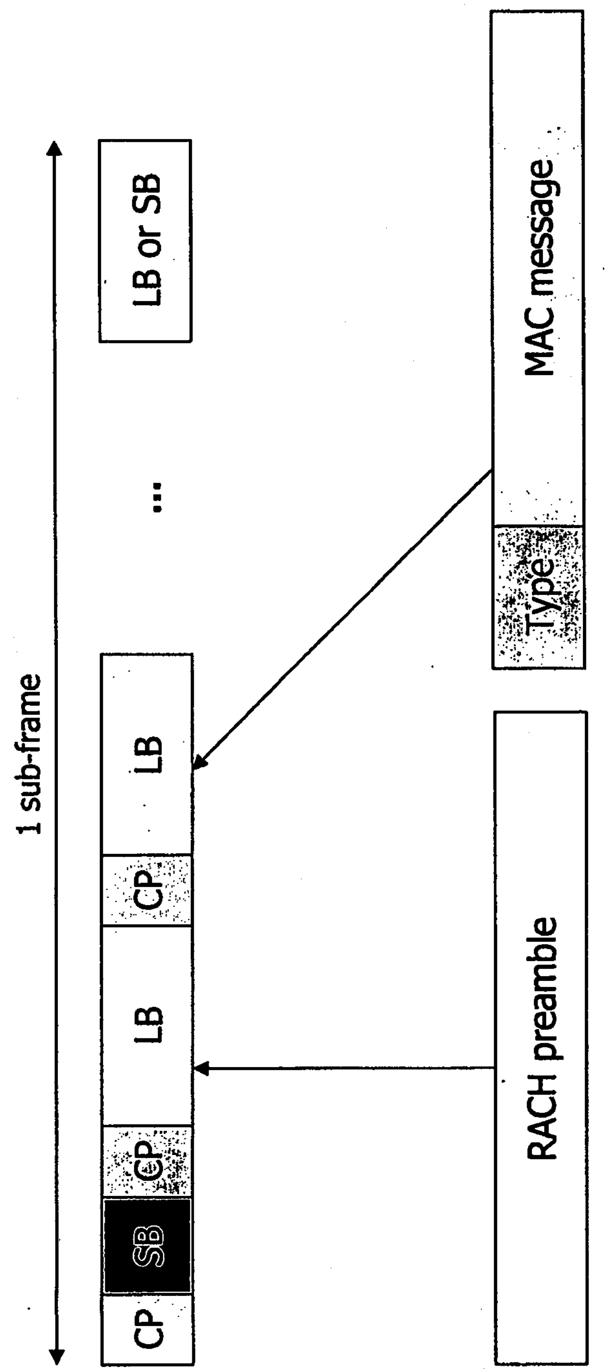

UE
Network
uplink resource allocation
Buffer is empty
new packet arrival
(use uplink resource)
release uplink resource
Timer
new packet arrival
(need RACH)


UE
Network
uplink resource allocation
Buffer is empty
continuous uplink
resource for SI
new packet arrival
SI (mac message)
stand-only


frequency
time
continuous allocated uplink
resource based on SI size per UE


for bandwidth request
frequency
time
for initial access or sync.


1 sub-frame
CP
SB
CP
LB
CP
LB
...
LB or SB
RACH preamble
Type
MAC message
RACH preamble
Type
Buffer status
RACH preamble
Type
Buffer status


1 sub-frame
CP
SB
CP
LB
CP
LB
...
LB or SB
RACH preamble
Type
MAC message

Life's Good

BCH scheduling

Different possibilities for RACH

Patrick FISCHER

LG Electronics Mobilecomm France

Ref.:RDE-0603-PFI-021-V0.1_BCH_SCH scheduling

Great Company Great People

Profitable Growth thru Blue Ocean

SCH

- Cell search
- Determining the frame timing
- SCH is used for determining the SFN
- SCH is used for channel estimation
  - Question:
    - For BCH there should be anyway dedicated pilots
    - Is there a significant benefit to send SCH together with BCH?

BCH usage in RAN2

- BCH carries amongst others:
  - PLMN Id
  - Cell Id
  - Measurement configurations for active and idle mode
  - Default configurations for active mode
  - Neighbouring cells for active and idle mode
  - Cell reselection for idle mode
  - Cell access restrictions

Scenarios for BCH usage

- BCH needs to be read when
  - UE is switched on
  - UE is moving in idle mode
  - UE is transferred from active mode to idle mode for cell reselection

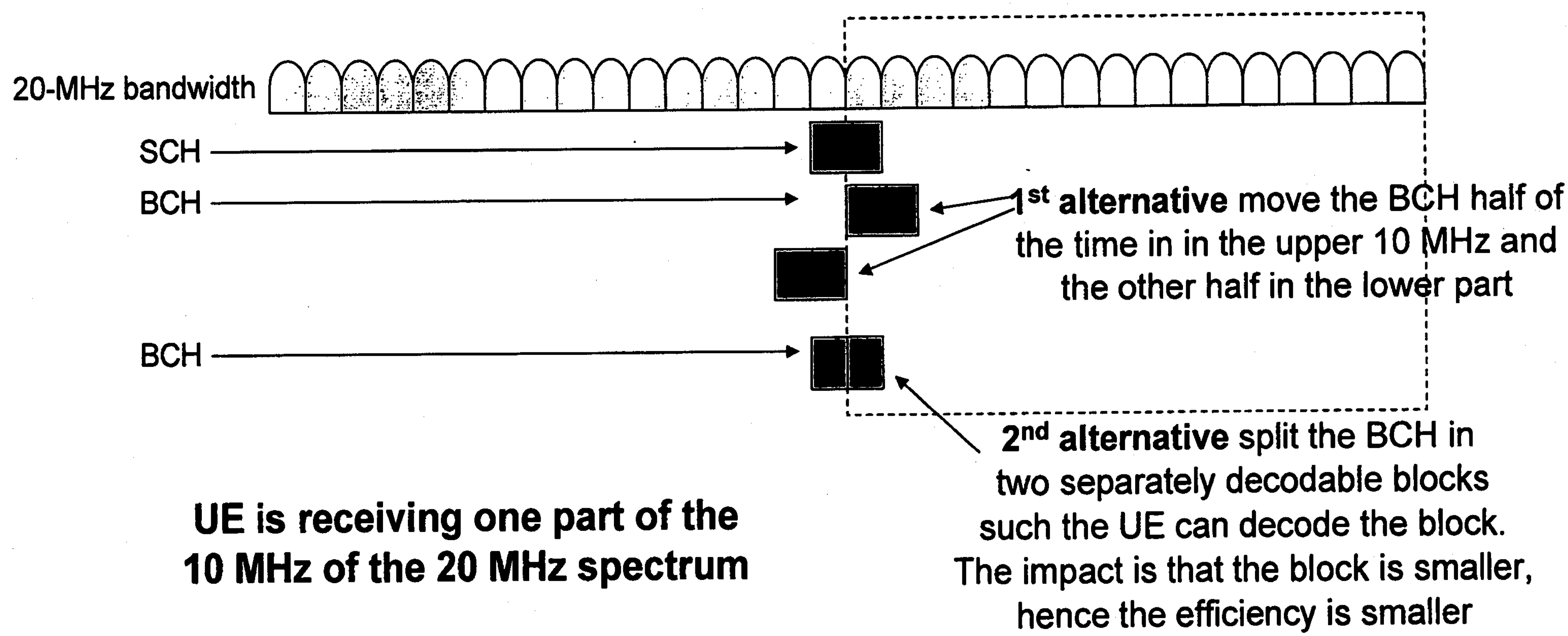
- Requirements for transmissions / reading of the BCH
  - BCH should be read quickly (i.e. no long repetition cycle), different requirements for different information types
  - UE may need to read the BCH from different cells, so scheduling should be available so that the UE does not need to tune to a neighbouring cell too long

Bandwidth

- The BCH could be sent on a small bandwidth similarly to the SCH
  - Advantage:
    - SCH might be used as pilot
    - UE can continuously read SCH and BCH for measuring the channel
  - Disadvantage
    - BCH on small channel requires more reception time
    - smaller bandwidth means less frequency diversity?

Frequency / Time

- In the case of the 20 MHz scenario there is the possibility that the UE in active mode is required to receive the upper or lower part of the 10 MHz



UE is receiving one part of the 10 MHz of the 20 MHz spectrum

Proposal

- Propose the alternative 1 in order to ensure that the efficiency is similar in both cases
- The bigger the code blocks the better
  - Code the total bandwidth in the SCH or primary BCH, and define a fixed BCH bandwidth, and a frequency hopping scheme
  - Potentially transmit BCH in DL SCH

Life's Good

Integrity for MAC signalling

Private / Public key concept for DL-MAC integrity

Patrick FISCHER

07/03/2006

LG Electronics Mobilecomm France

Ref. RDE-0603-PFI-017-V0.1_Integrity for DL-MAC signalling

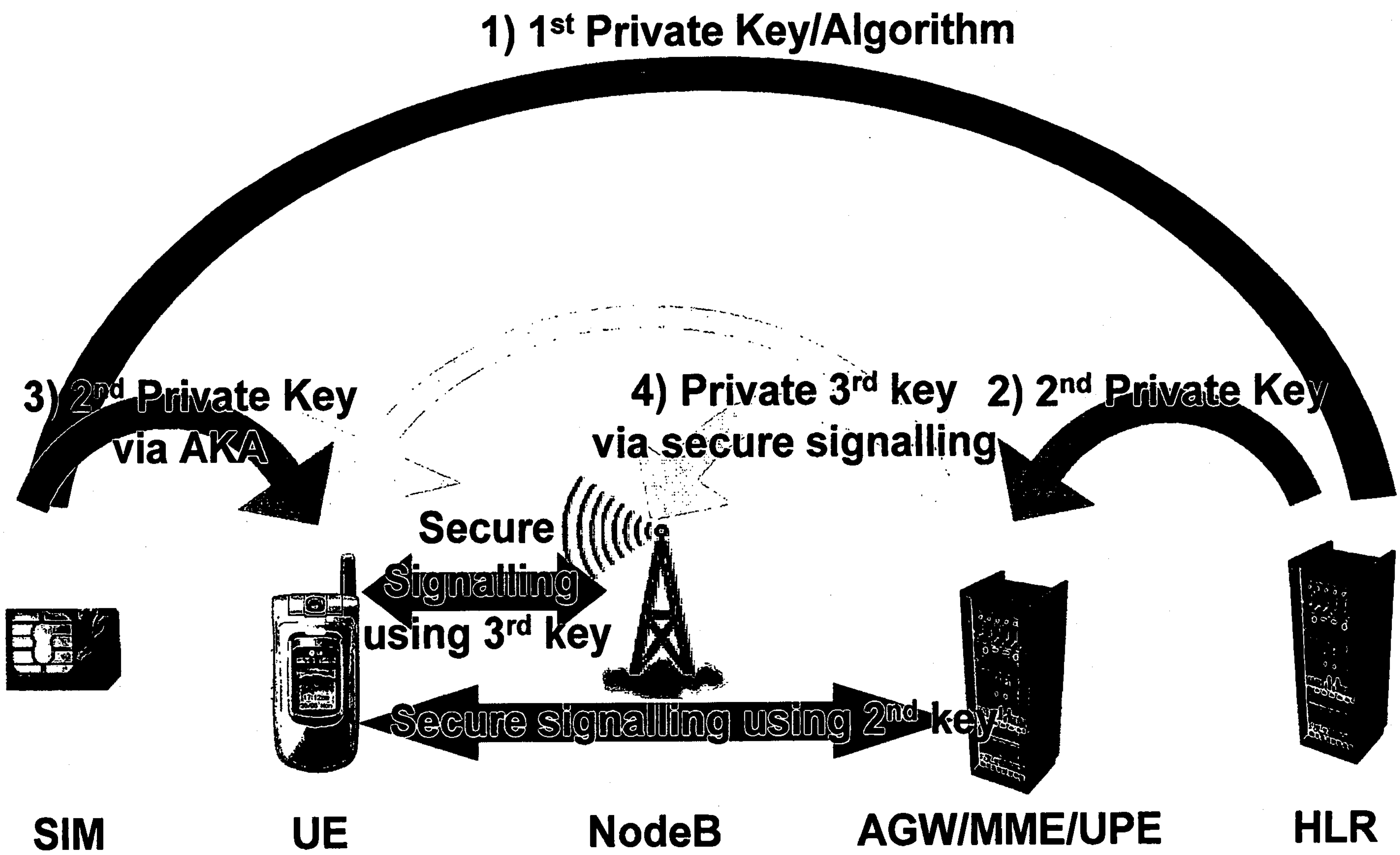
Great Company Great People

Profitable Growth thru Blue Ocean

MAC Integrity Introduction

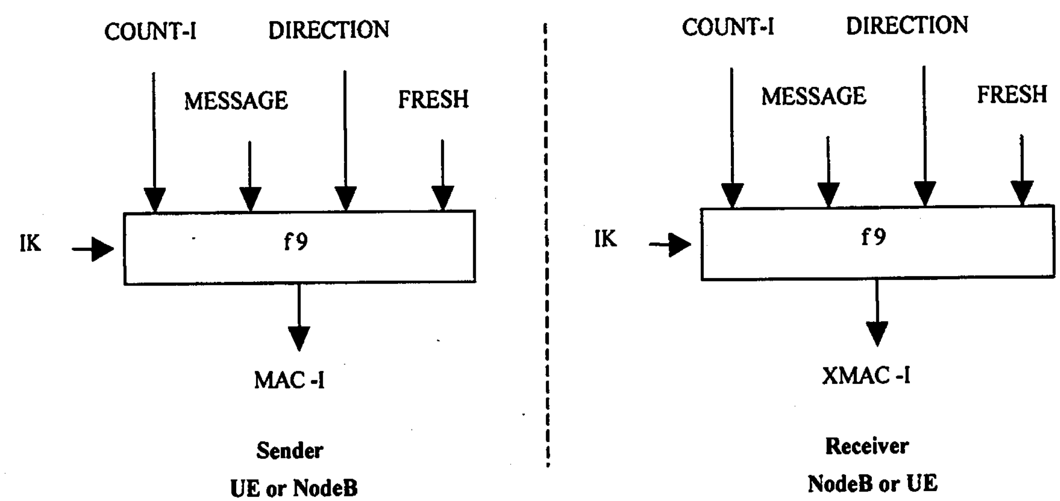
- The problem of the integrity of MAC signalling has been discussed on R2#50 (adhoc with SA3) in Sophia Antipolis 2006-01-09 to 2006-01-13
  - DL MAC signalling gives resource assignment
  - Need for integrity protection
- MAC signalling consists mostly of few bits
  - Efficient integrity protection using a private key algorithm means huge overhead
- LTE mostly uses OFDM
  - DL MAC signalling for different users is grouped together
  - UE always reads the MAC signalling for multiple users

Todays proposals



Problem

- In order to secure the signalling (integrity protection) today a MAC (Message authentification code) is attached
  - MAC size is 32 bits in order to have sufficient security



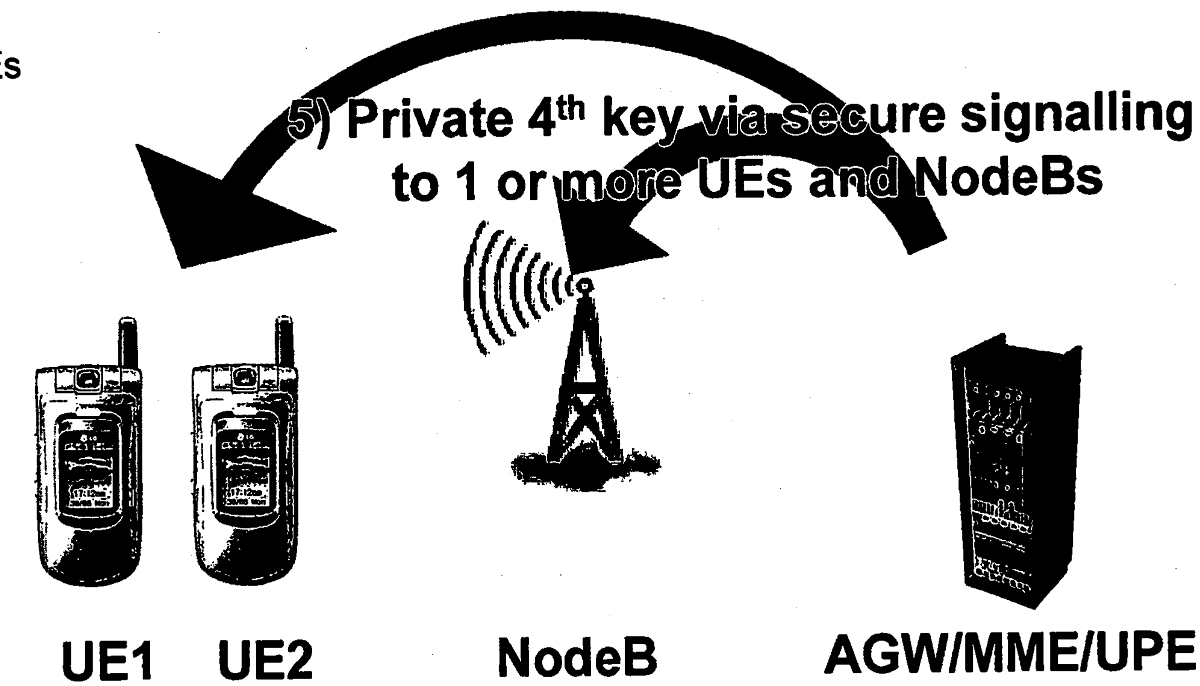
  - This is done for each message
  - In the case of MAC signalling the data for each individual user is small

Possible 1st solution

- Add an integrity check to a set of messages
  - Only one MAC added for the set of messages

Creation of "super" message consisting of one or several messages for one or several UEs

Message for UE 1: •Identifier •message
Message for UE 2: •Identifier •message
Message for UE 3: •Identifier •message
Other info e.g.: •Sender Id •Timer / Counter reference



Problem 1st solution

- Every UE that receives the 4th key can create fake messages
- Solution:

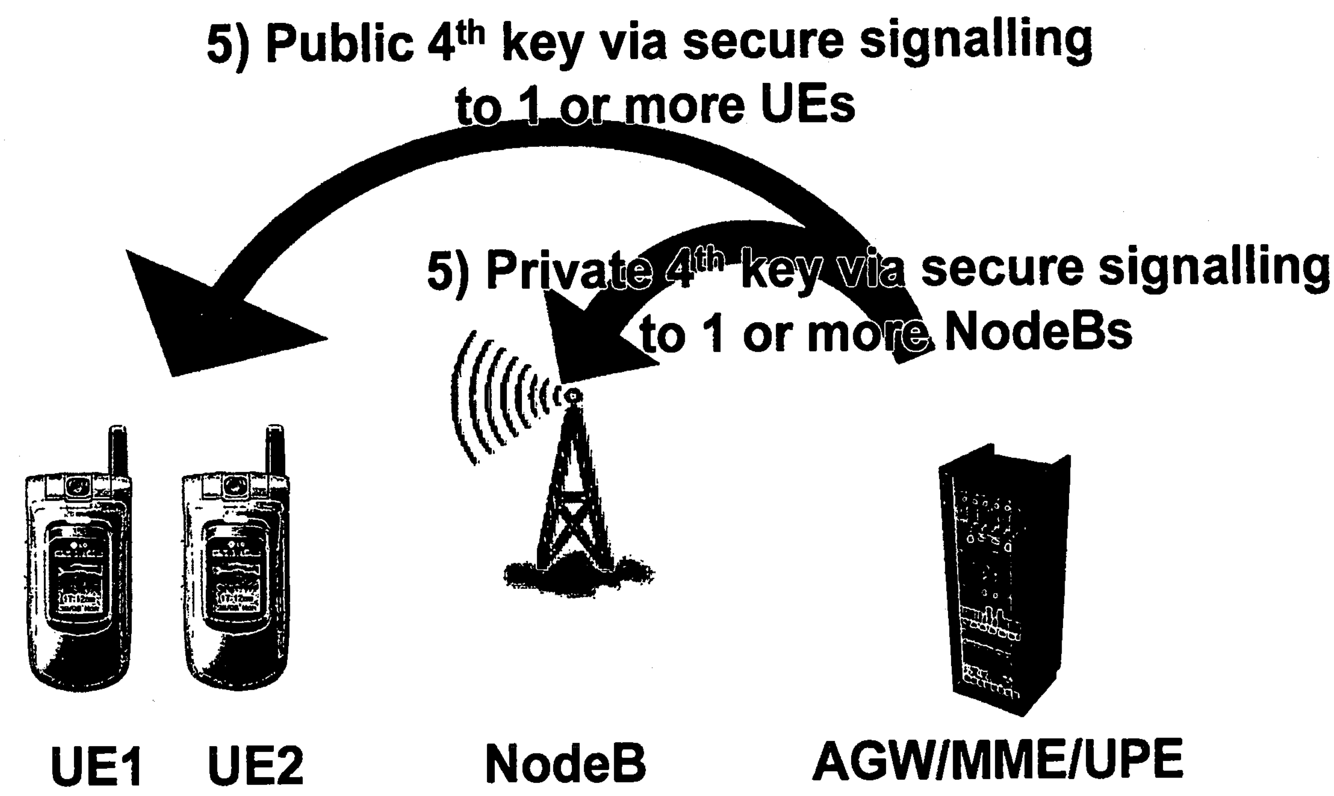
Private / public key system

Possible 2nd solution

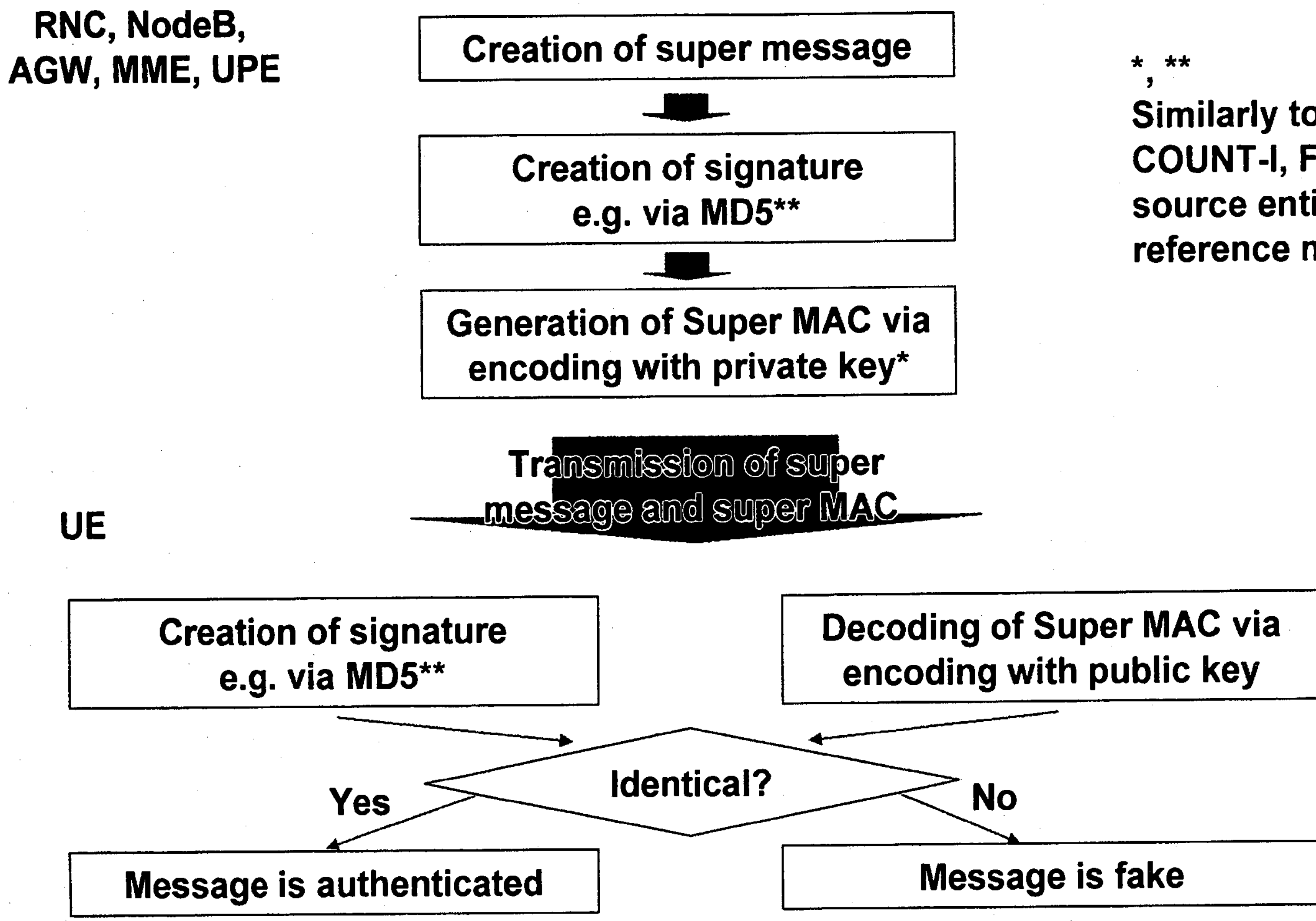
•

Creation of "super" message consisting of one or several messages for one or several UEs

Message for UE 1: •Identifier •message
Message for UE 2: •Identifier •message
Message for UE 3: •Identifier •message
Other info e.g.: •Sender Id •Timer / Counter reference



Details



*, **
Similarly to UMTS, Direction, COUNT-I, FRESH, Bearer, source entity Id/type, timer reference might be used

Details

- Transmission of public key for integrity check of MAC signalling should be as early as possible
  - Possible to transmit ciphered and integrity protected key during the AKA procedure?
  - Or only ciphered, and key is returned with integrity protection and ciphering in return?

Generalization

- In general in the case the complexity is reasonable it might be possible that all downlink traffic is integrity protected with the same private key
- Uplink integrity protection could be done using a private key in the UE and a public key in the NodeB / RNC
  - removing the need for different key handling in the UE depending on whether the target is the NodeB or the AGW or the MME or the UPE
  - Removing security threads regarding the NodeB

Updates on 3GPP LTE Activities

Research and Standards Group

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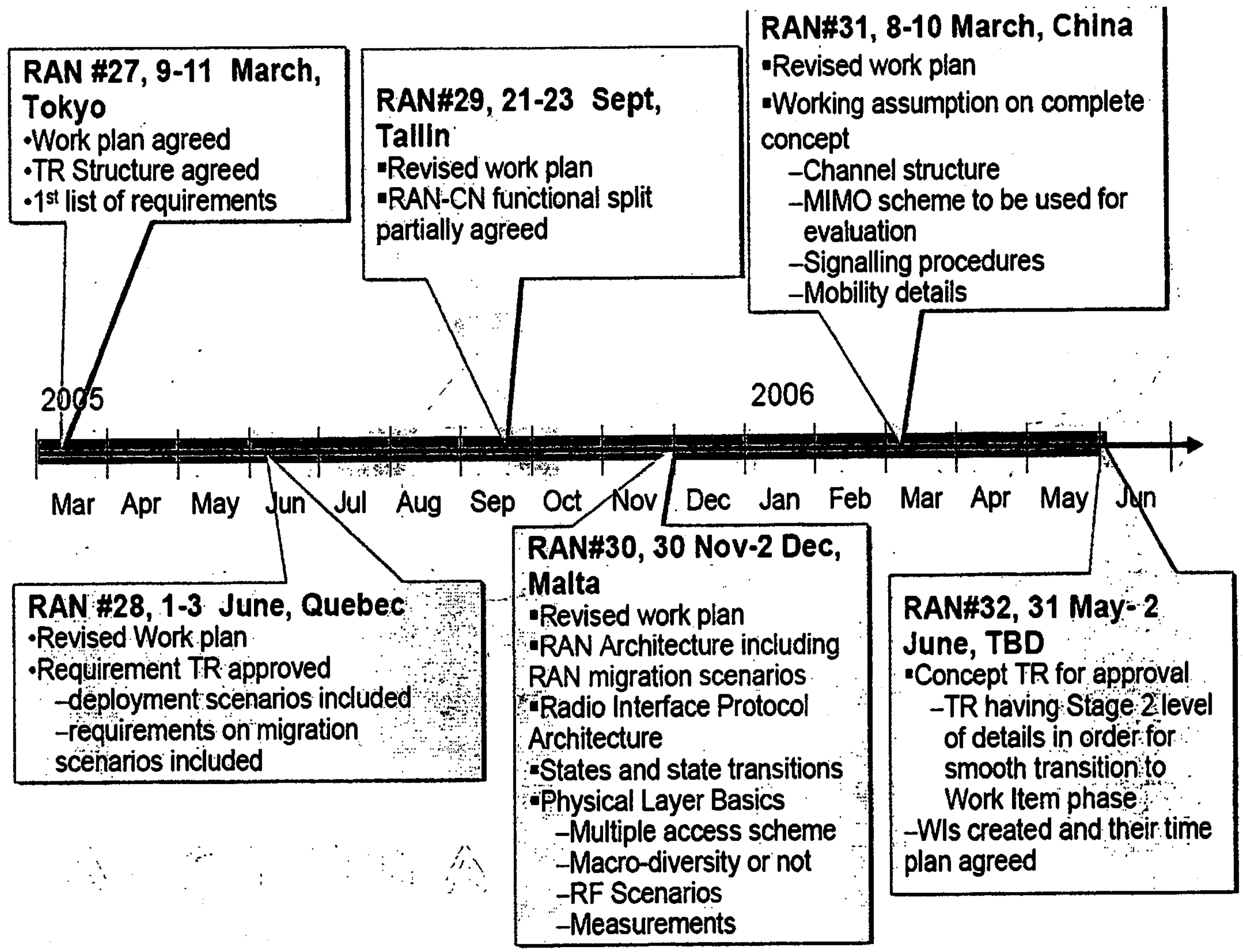
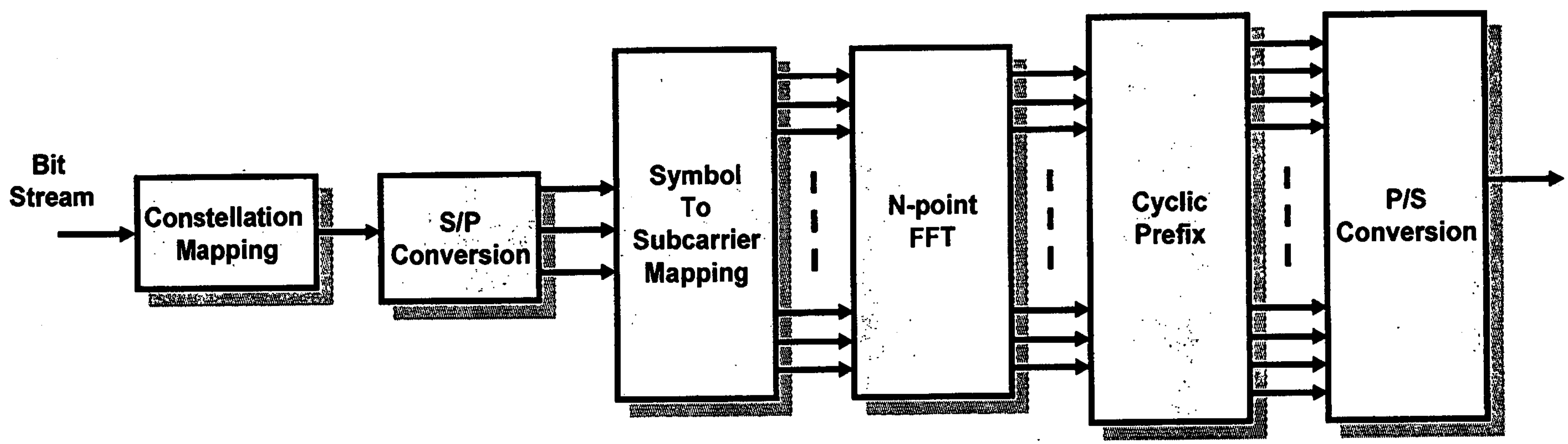
3GPP LTE Activities (1)

❑ LTE Study Item Schedule



3GPP LTE Activities (2)

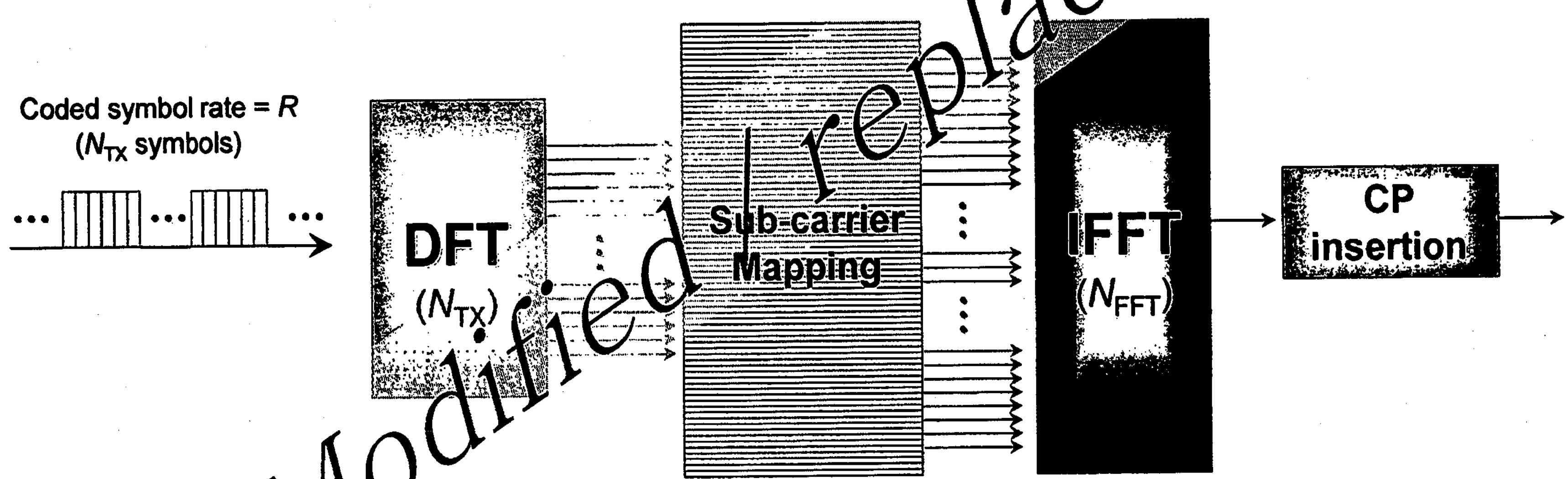
❑ Downlink Multiple Access Scheme - OFDMA



- *TSG-RAN #30 (December 2005) has decided that the Long-Term Evolution feasibility study will focus on OFDMA based downlink and SC-FDMA based uplink.*

3GPP LTE Activities (3)

- Uplink Multiple Access Scheme – SC-FDMA (DFT-s OFDMA)



3GPP LTE Activities (4)

❑ DL Frame Structure with Scalable Bandwidth

Modified / replaced

Transmission BW		1.25 MHz	2.5 MHz	5 MHz	10 MHz	15 MHz	20 MHz
Sub-frame duration		0.5 ms					
Sub-carrier spacing		15 kHz					
Sampling frequency		1.92 MHz (1/2 × 3.84 MHz)	3.84 MHz	7.68 MHz (2 × 3.84 MHz)	15.36 MHz (4 × 3.84 MHz)	23.04 MHz (6 × 3.84 MHz)	30.72 MHz (8 × 3.84 MHz)
FFT size		128	256	512	1024	1536	2048
Number of occupied sub-carriers†, ††		76	151	301	601	901	1201
Number of OFDM symbols per sub frame (Short/Long CP)		7/6					
CP length (μs/samples)	Short	(4.69/9) × 6, (5.21/10) × 1*	(4.69/18) × 6, (5.21/20) × 1	(4.69/36) × 6, (5.21/40) × 1	(4.69/72) × 6, (5.21/80) × 1	(4.69/108) × 6, (5.21/120) × 1	(4.69/144) × 6, (5.21/160) ×1
	Long	(16.67/32)	(16.67/64)	(16.67/128)	(16.67/256)	(16.67/384)	(16.67/512)

• *Parameters for Downlink Transmission Scheme. Numerology are for evaluation purpose only*

3GPP LTE Activities (5)

❑ UL Frame Structure with Scalable Bandwidth

1 sub-frame = 0.5 msec

CP	LB#1	CP	SB #1	CP	LB #2	CP	LB #3	CP	LB #4	CP	LB #5	CP	SB #2	CP	LB#6

Spectrum Allocation (MHz)	Sub-frame duration (ms)	Long block size (µs/#of occupied sub carriers /samples*2)	Short block size (µs/#of occupied sub carriers /samples)	CP duration (µs/samples *1)
20	0.5	66.67/1200/2048	33.33/600/1024	(4.13/127) × 7, (4.39/135) × 1*
15	0.5	66.67/900/1536	33.33/450/768	(4.12/95) × 7, (4.47/103) × 1*
10	0.5	66.67/600/1024	33.33/300/512	(4.1/63) × 7, (4.62/71) × 1*
5	0.5	66.67/300/512	33.33/150/256	(4.04/31) × 7, (5.08/39) × 1*
2.5	0.5	66.67/150/256	33.33/75/128	(3.91/15) × 7, (5.99/23) × 1*
1.25	0.5	66.67/75/128	33.33/38/64	(3.65/7) × 7, (7.81/15) × 1*1

Modified / replaced

3GPP LTE Activities (6)

❑ Network Architecture for Macro Diversity

- No inter-Node B macro diversity for Downlink
- No inter-Node B macro diversity for Uplink
- Fast cell switching or fast handover should be investigated further
- Single frequency network for broadcast traffic is being considered positively (However, synchronized network is not basic assumption for EUTRAN)

3GPP LTE Activities (7)

❑ Open-loop MIMO Schemes in LTE (Downlink)

- Spatial Multiplexing (SM)
  - MIMO Architectures for 3GPP UTRA Evolution (Institute for Infocomm Research, R1-051193)
  - MIMO Transmission Techniques for E-UTRA (Institute for Infocomm Research & NTT DoCoMo, R1-051399)
  - MIMO Scheme Proposal for E-UTRA DL (Nokia, R1-051413)
  - Description and Link Simulations of MIMO Schemes for OFDMA Based E-UTRA Downlink (Qualcomm, R1-050903)
  - System Evaluation of MIMO for OFDMA Based E-UTRA Downlink (Qualcomm, R1-050904)
  - Initial Comparison of MIMO Schemes for OFDMA Based E-UTRA Downlink (Qualcomm, R1-051505)
  - Spatial Temporal Turbo Channel Coding (STTCC) for MIMO (Philips, R1-050722)
  - Further Link Level Simulation Results on Spatial Temporal Turbo Channel Coding (STTCC) for MIMO (Philips, R1-051214)
  - Coded MIMO-OFDM Schemes for E-UTRA (Philips, R1-051468)
  - Transmission Phase Control for Compensating High Fading Correlation in MIMO Multiplexing (NTT DoCoMo *et al.*, R1-051150)

3GPP LTE Activities (8)

- Space Time Coding (STC)
  - Qualitative Evaluation of MIMO Schemes for OFDM-based E-UTRA Downlink (Qualcomm, R1-051124)
  - MIMO Scheme Proposal for E-UTRA DL (Nokia, R1-051413)
  - Open Loop MIMO Scheme for EUTRA (LG, R1-051338)
  - MIMO Architectures for 3GPP UTRA Evolution (Institute for Infocomm Research, R1-051193)
- Cyclic Delay Diversity (CDD)
  - MIMO Architectures for 3GPP UTRA Evolution (Institute for Infocomm Research, R1-051193)
  - R1-051354

3GPP LTE Activities (9)

- Hybrid Scheme (STC+SM, STC+CDD or SM+CDD)
  - DSTTD with Sub-Group Rate Control (Mitsubishi, R1-031284)
  - Proposal for Downlink MIMO Transmission Schemes in E-UTRA (ETRI, R1-051375)
  - Transmit Diversity for Distributed, Common and Broadcast Channels (Huawei, R1-051406)
- Antenna Selection
  - Transmit Antenna Selection (Switching) in Evolved UTRA Uplink (Institute for Infocomm Research & NTT DoCoMo, R1-050794)

3GPP LTE Activities (10)

☐ Closed-loop MIMO Schemes in LTE (Downlink)

- Spatial Multiplexing
  - Coded MIMO-OFDM Schemes for E-UTRA (Philips, R1-051468)
  - Proposal for Downlink LTE MIMO Scheme (Alcatel, R1-051325)
- Transmit Beamforming
  - Modified PSRC Scheme with Stream Number Control for E-UTRA MIMO Downlink (CATT, R1-051403)
  - Multi-beam MIMO for EUTRA Downlink (Fujitsu, R1-051438)
  - MIMO Architectures for 3GPP UTRA Evolution (Institute for Infocomm Research, R1-051193)
  - MIMO Transmission Techniques for E-UTRA (Institute for Infocomm Research & NTT DoCoMo, R1-051399)
  - MIMO Techniques for Downlink E-UTRA (NEC, R1-051455)
  - Pre-coded MIMO DL for E-UTRA Exploiting X-Pol Antennas (TenXc Wireless Inc, R1-051326)
  - Downlink Beamforming with Opportunistic Scheduling (BenQ Mobile, R1-051416)
  - Downlink MIMO for EUTRA (Samsung, R1-051353)
  - Multiple Antenna Technology for E-UTRA (CATT, R1-051175)

3GPP LTE Activities (11)

- Rate Control
  - Downlink MIMO for E-UTRA (Huawei, R1-051407)
  - Modified PSRC Scheme with Stream Number Control for E-UTRA MIMO Downlink (CATT, R1-051403)
  - Multiuser Precoding MIMO for E-UTRA Downlink (ETRI, R1-050809)
  - MIMO OFDMA E-UTRA Proposal for Different Antenna Configurations (TI, R1-051315)
  - Throughput Comparison of Single User and Multiuser MIMO for Downlink OFDMA E-UTRA (TI, R1-051056)
- Antenna Selection
  - Antenna Selection Techniques (Mitsubishi Electric, R1-050944)
- Hybrid Scheme (STC + SM)
  - Adaptive MIMO Modes (Nortel, R1-051424)
  - Text Proposal for MIMO for DL OFDM (Nortel, R1-051425)
  - Space Time Block Coding Based H-ARQ (Nortel, R1-051426)

3GPP LTE Activities (12)

❑ Open-loop MIMO Scheme in LTE (Uplink)

- Virtual MIMO
  - UL Virtual MIMO Transmission for E-UTRA (Nortel, R1-051162)
  - Text Proposal for Virtual MIMO for UL OFDMA (Nortel, R1-051163)
  - Text Proposal for Virtual MIMO for UL SC-FDMA (Nortel, R1-051164)
- SDMA with Random Hopping
  - Description of Simultaneous Multi-user Transmission Scheme for xFDMA based E-UTRA Uplink Evaluation (Qualcomm, R1-051118)

❑ Closed-loop MIMO Scheme in LTE (Uplink)

- SDM with Beamforming
  - Uplink MIMO SC-FDMA Scheme for EUTRA (InterDigital, R1-051368)
- Antenna Selection
  - Transmit Antenna Selection Techniques for Uplink E-UTRA (Institute for Infocomm Research, Mitsubishi, and NTT DoCoMo, R1-051398)

Items for Further Consideration (RAN 1)

3GPP

Research and Standards Group

2006. 03. 16

Uplink Scheduling Mechanism

❑ Basic Decision To Be Made

- Scheduling in which domain?
  - Time domain scheduling with pre-assigned transmission bandwidth
  - Time and frequency domain scheduling
- Scheduling in terms of time
  - Fast scheduling
    - 1 Sub-frame (fast scheduling)
    - Large overhead
    - Efficient usage of resource
    - Delay-sensitive application
  - Multi sub-frame (slow scheduling)
    - Of how many sub-frames does a time unit for scheduling consist?
    - Small overhead
    - waste of resource in case of small size of buffered data
    - May not be appropriate to real-time service with small packet (e.g. VoIP)

❑ Further Consideration

- Pilot allocation mechanism according to scheduling method
- Additional pilot transmission for fast scheduling and fast AMC

Uplink Link Adaptation Mechanism

❑ Link Adaptation Mechanism for Uplink

- Fast AMC + Slow Power Control
  - Link adaptation for residual path loss and fast fading variation
  - SINR measure pilot is required for UE (semi-fixed pilot power level)
  - High sector/user throughput ?
  - What does Slow PC mean? : Distance-based power level determination
    - proper power transmission at cell edge (in case of high frequency reuse factor): minimize inter-NodeB interference :
    - High power transmission at cell edge : maximize worst user's throughput (This scheme needs inter-cell interference coordication?)
- Slow AMC + Fast Power Control
  - Do not necessarily require SINR measure pilot
  - R-CQICH, or power head room report can be used for slow AMC

❑ Future Consideration

- Power control mechanism for data non-associated control signal such as R-CQICH and ACKCH

Pilot Design for Uplink

☐ Pilot Structures

- Pilot for Channel Estimation
  - Distributed pilot or localized pilot : related to resource allocation mechanism for uplink
  - How to maintain orthogonality between multiple UEs :
    - Frequency domain orthogonality
    - Code domain orthogonality
    - Time domain orthogonality
- Pilot for Link Adaptation / Scheduling
  - Definition of link adaptation pilot or reuse of power controlled pilot with power headroom report
  - How to maintain orthogonality between multiple UEs : Frequency : localized or distributed
    - Time
    - Code

HARQ Scheme for Uplink/Downlink

☐ Possible Consideration on HARQ Mechanism

- Synchronous/Non-adaptive
  - Lower overhead
  - Less flexibility
  - Maybe less throughput
- Asynchronous/Adaptive
  - Larger overhead
  - More flexible
  - Higher throughput

☐ Further Consideration

- Control Signal Design for HARQ Mechanism
  - Possible extension of control channel message using a kind of flag in case of large overhead

Control Channel Design for Downlink

❑ Location of Control Channel in a Subframe

- Should be close to pilot channel for better channel estimation
- Should be located in the first and second symbol of subframe

❑ AMC for Control Channel?

- AMC region

❑ What Kind of Information?

- For downlink shared channel
  - Information on resource block allocation for scheduled UE
  - Target UE ID
  - MCS Information
  - HARQ related information
- For uplink
  - Information on resource block allocation for scheduled UE
  - Power control bit
  - MCS Information
  - HARQ related information

❑ Coding Scheme for Control Channel

- Joint coding for multiple UE?
- Control channel transmission in case of multiple antenna configuration in Node B
- Control channel design in case of variable control signal length
- Any method for overhead reduction?
  - Compression
  - Power ranking

CQI Reporting in Uplink

❑ Concept:

- Procedure and method for transmitting channel quality information (CQI) for efficient DL scheduling and AMC through UL control channel

❑ Classification

- Which types of uplink control channels for reporting CQI or SINR can be exploited?
  - Physical control channel, MAC signaling or both channels
- Which types of contents are carried by control channel?
  - Full CQI values (with compression, e.g. DCT), N-best band CQI, Differential Modulation (DM) or combined schemes of previous method
- Reporting period (cycle)
  - Periodic, aperiodic or event-triggered

❑ Further Consideration

- Relationship (i.e. dependency or not) with ACK/NAK, data-associated control channel, CQI and synchronous random access (scheduling request, resource request)

Modified / replaced

LTE Activities of Other Companies (RAN1) (1)

❑ Ericsson

- Occupying leadership in LTE discussion. Seems to focus on harmonization and making a big picture rather than individual proposals.
- Conservative position in LTE network architecture, that is, supporting macro diversity (to have RNC and Node B as in previous releases), while most companies don't support macro diversity.

❑ NTT DoCoMo

- Rapporteur of LTE SI. Quite active in technical proposals. Faster than other companies in most of the LTE technical issues.
- All the japanese companies cooperate well with NTT DoCoMo in LTE issues.

❑ Nokia

- Little bit inactive in LTE activity compared with its activity in previous releases, but still powerful in decision stages.

❑ Nortel

- Seems to mostly focus on LTE MIMO issues. Gave up its position of objecting SC-FDMA during Seoul meeting (RAN #43, November 2005) to join the main discussion.

LTE Activities of Other Companies (RAN1) (2)

Qualcomm

- Showing best capability in simulation works. Constantly showing strong support for WCDMA evolution (besides LTE) and re-inputting technologies for WCDMA and 802.20 into LTE

Samsung

- Growing capability by enlarging its work scope to most of LTE technical areas. Showing strong objection of big evolution of WCDMA and only focusing on LTE

Chinese companies (Huawei, CATT, RITT, ZTE, etc.)

- Collaboration btw chinese companies in most LTE issues.
- Gave up its position of objecting to UL SC-FDMA in LTE TDD mode during Seoul meeting to join the main discussion.

LTE activities of other companies (RAN1) (3)

❑ Operators (Vodafone, Cingular, Three, T-mobile, etc.)

- It seems that operators are changing their position from radical one to conservative one (or, seems to want to delay LTE standardization process). Cingular and three are now supporting conservative network strategy and even making comments to support Qualcomm's MC-WCDMA proposal and Rel-7 MIMO proposals.
- Vodafone is keeping rather neutral position.

3GPP LTE RAN 2 Activities

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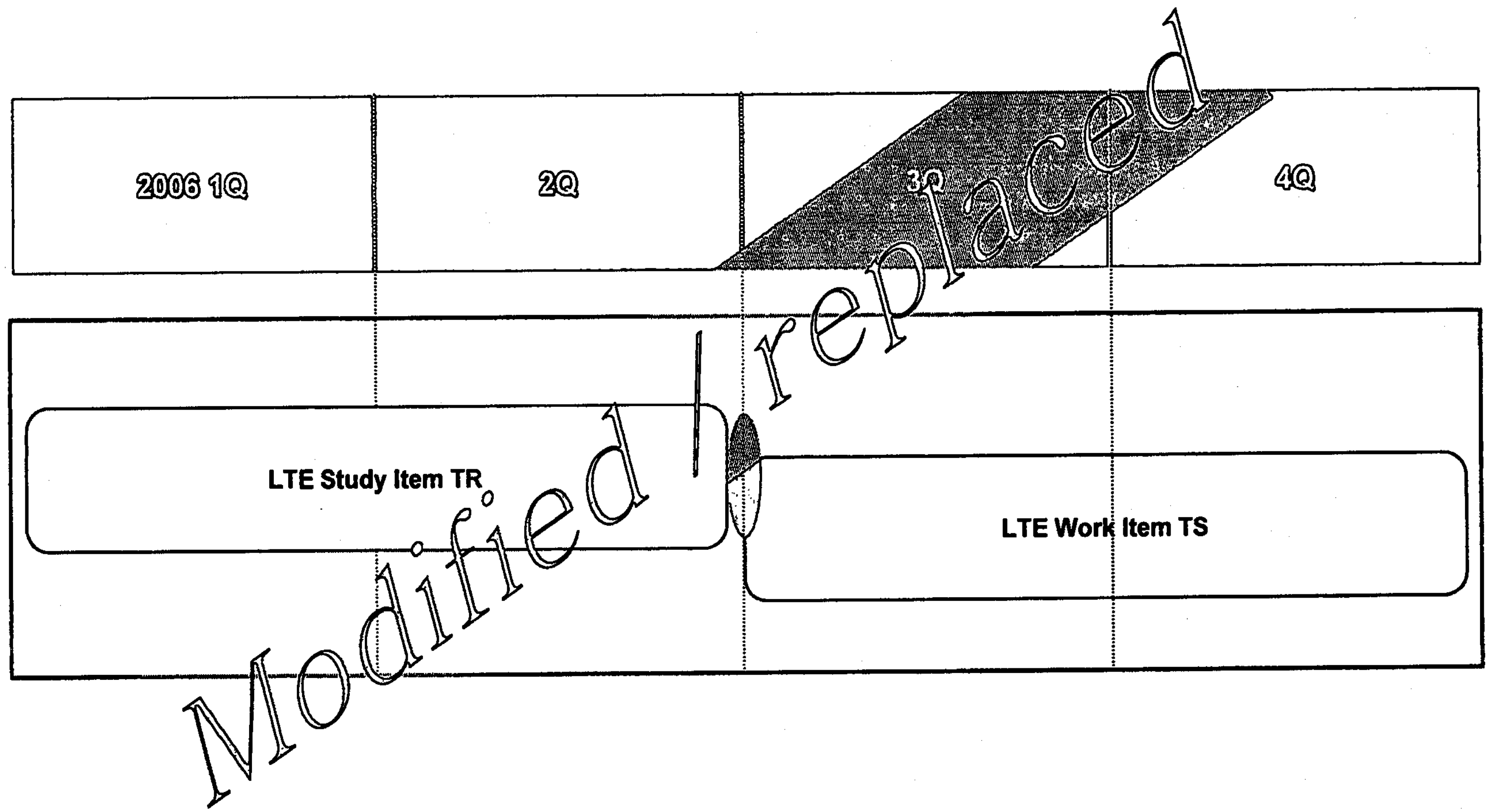
3GPP RAN WG2 LTE

- Timeline of LTE in 2006



3GPP RAN WG2 LTE

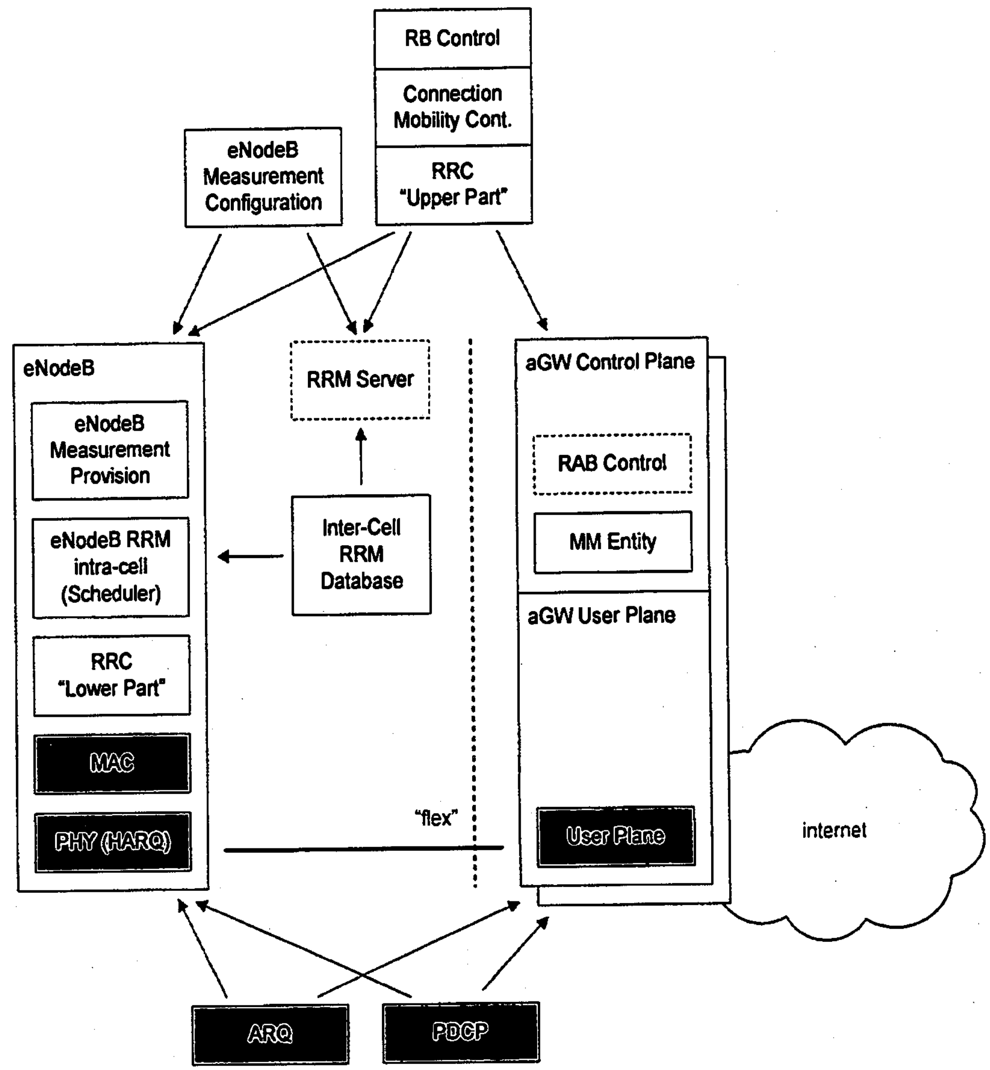
Item	RAN2's Agreement & Status
Network & Radio Interface Protocol Architecture	• Two Node architecture between E-NB and AGW • Simplification of channel types • Use shared channel (no dedicated Channel) • No Macro diversity • User Traffic Security in aGW
MAC Procedure& Operation	• Two level Acknowledgement: • ARQ + HARQ • Location of ARQ in E-NB •Following will be discussed: • Multiplexing/Scheduling/ Random Access Procedure
RRC Procedure& Operation	• RRC terminated in E-NB • High level RB establishment procedure • Following will be discussed: • RRC Signaling Procedures • Radio Bearer Management.
Mobility	• Handover procedure : Two main candidates • AGW centric Handover • E-NB centric Handover • Cell Selection & Reselection procedure is not discussed yet.
Multicast/Broadcast	• Not much discussion yet • Detailed MBMS scenario is not identified.

Modified/replaced

3GPP RAN WG2 LTE (Appendix)

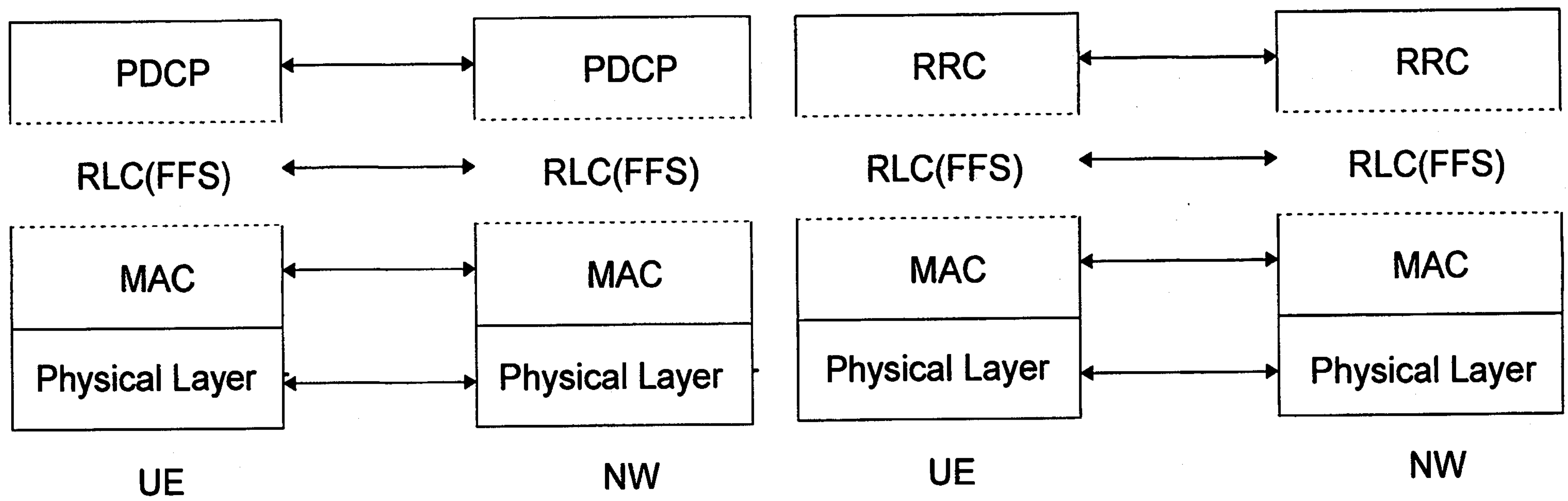
☐ Current Status In RAN2

- Logical nodes are yellow frame.
- Functional entity of control plane are white frame.
- Functional entity of user plane are blue frame.
- Solid Frame are agreed
- Dashed Frame are not yet agreed
- Agreed functional entity in the logical nodes are agreed
- Not yet agreed functional entity are outside of logical nodes.



3GPP RAN WG2 LTE (Appendix)

Current Status In RAN2



User Plane Protocol Stack　　Control Plane Protocol Stack

MAC: **Provides data transfer services on logical channels. Logical channel type is defined by what type of information is transferred.**

RLC: **Existence of RLC is FFS.**

RRC, PDCP: **Functionality is under discussion.**

Source: Ericsson

Title: **MAC procedures for DRX and DTX in LTE_Active**

Agenda Item: 4.2 (e, k.1)

Document for: Discussion, Decision

1. Introduction

During previous RAN2 discussions, there has been a fairly broad consensus for supporting UE power-saving in the LTE_Active state. There are several plausible reasons for facilitating this, e.g.:

- **Resource efficiency:** Always moving inactive UEs to LTE_Idle can result in excessive paging, since LTE_Idle deploys paging over a Tracking Area that may cover many cells. Thus, it is more efficient to keep stationary but inactive UE:s in LTE_Active, where the UE is known on a cell level. UE:s experiencing short activity bursts interleaved with dormancy periods would also gain from such power-saving in LTE_Active.
- **Wake-up delays:** The requirements for waking up a dormant UE are very stringent [1]. These requirements are easier to meet if the UE is known in the cell, and the wake-up only involves interaction on a MAC-level in LTE_Active.

In practice, UE dormancy means discontinuous transmission and reception (DTX and DRX) affecting functionality such as UL synchronization, Random Access, UE identification and Scheduling.

In this contribution, we describe our view on the procedures involved for facilitating such dormancy in LTE_Active. If deemed appropriate by RAN2, we suggest that this functionality is captured in a UE MAC state model (as proposed e.g. in [4], and hinted in [2]).

2. Power-saving and the LTE state model

The LTE state model agreed so far includes three states characterized by ([2], Annex C):

LTE_Detached:
-The location of the UE is not known by the network (e.g. UE switched off);

LTE_Idle:
- State in which the UE has a low power consumption and can thus be kept for many days;
- Fast state transition to LTE_Active shall be supported (<=100ms excluding DTX);
- Mobility: cell reselection by the UE and traffic area change registration to the network;

LTE_Active
- UE is able to perform Uplink/Downlink transport with very limited access delay;
- Mobility: network directs the UE to serving cells;

The reference [2] also includes a note:"There is a power saving substate within the Active Mode. This is the dormant substate". The present contribution deals with methods facilitating this power-saving aspect in LTE_Active.

3. UE power-saving in LTE_Active

In this section, we describe our understanding of the functions affected by UE DTX and DRX in LTE_Active.

3.1 Uplink aspects

The UE access to the uplink is mainly dependent on availability of UL synchronization and/or the availability of dedicated (orthogonal) UL resources.

UL Synchronization:

The LTE uplink requires strict time-alignment. A UE that has been in DTX for a certain period therefore need to synchronize itself with the network. This is done by a Random Access Burst in the uplink followed by a timing adjustment in the downlink (see **Figure 1**). This timing-adjustment response may include a grant to a dedicated UL resource. See [5] and [6] for further details on RACH.

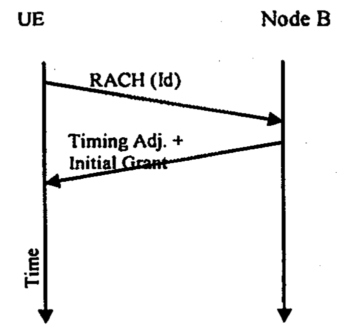


Figure 1: Illustration of the synchronization procedure for an UE with an unsynchronized uplink. Whether the UE identifies itself with a unique or a random id in the initial RACH burst is depending on the outcome of RAN1 discussions.

At the same time, the UE need to identify itself with the network. In LTE_Active, the UE is known in the cell and could therefore be identified with a unique cell-specific identity (Cell Id, C-RNTI or similar). However, transmitting the full Cell Id in the synchronization request can be costly. One possible solution is to use a random Id in the first time-alignment RACH burst, and use the longer unique cell-specific identity only when the UL has been synchronized, see [5] and [6].

UL synchronization can be maintained also in cases when the UE has nothing to send, provided the network allows the UE to send some dummy "data" for the purpose of UL synchronization. For example, the UE could be configured to send periodic CQI reports based on which the UL is kept synchronized. At the same time, the DL quality estimate is regularly updated.

Maintaining UL synchronization for an inactive UE could be motivated e.g. for time-critical applications and for terminals which are not limited by battery power. We assume that such activity is configured by upper layers. Once the timing adjustment is terminated, the UL must be considered unsynchronized after a period of time. This "transition" from "synchronized" to "unsynchronized" could be governed by a timer.

UL synchronization is a procedure needed in LTE_Idle and LTE_Detached. Our view is that the procedures for synchronizing the UL shall be available also in LTE_Active, thereby allowing for longer UE standby times and better resource efficiency for bursty data transmission and for stationary UEs. Thus, we conclude that a UE should be allowed to have an unsynchronized uplink in LTE_Active.

Availability of uplink grants:

A UE without dedicated (orthogonal) resources need to send a scheduling request. If the UL is synchronized, it is possible to define resources which have a strict time-alignment structure allowing for smaller guard-times. Thus, with a synchronized uplink, we expect that a unique Cell Id could be used in the scheduling request. Note, however, that in case the request is carried over a non-orthogonal resource it can be prone to collision (in a Random Access sense) meaning that solutions for resolving such collisions may be needed.

3.2 Downlink aspects

One major aspect affecting the UE stand-by time is the possibility to inactivate the UE receiver circuitry. In UTRAN, this is mainly utilized in the paging states, where the UE is listening periodically to the paging channel. In RAN2, there has been a fairly broad consensus for facilitating DRX periods in LTE_Active meaning that the UE is discontinuously listening to the downlink scheduling channel. These DRX cycles should also influence the frequency of downlink channel quality measurements and the frequency and/or discontinuation of Channel Quality Indicator reports sent in the uplink.

Observe that HARQ operation in the downlink requires the uplink to be synchronized for carrying the ACK/NACK feedback. Thus, in case the UL synchronization is lost (due to DTX in the UE), there may be a need for a two-stage procedure such that the UL is synchronized prior to any scheduled data-transmission on the downlink channel.

We assume that the DRX period(s) and triggers/timers which result in DRX are configured by upper layers. Alternatively, the network may direct inactive UEs to DRX by explicit commands. Configuring long DRX periods allows for long standby times with the expense of elevated wake-up times for network-initiated data-transfers.

3.3 Mobility aspects

One main difference between LTE_Idle and LTE_Active is in the mobility handling. Mobility in LTE_Active is controlled by the network. Thus, there are measurements and measurement reports needed to guide the network in its selection of the most appropriate cell.

An inactive UE in LTE_Active deploying DRX cycles should be allowed to perform less frequent measurements, since the standby-time is heavily affected from the possibility to inactivate the UE receiver.

The frequency of measurement reports is another aspect affecting the power-consumption of the UE. By trigger-based measurement reports (similar to those available in UTRAN), it is possible to avoid any burden from obsolete and/or periodic reports.

Thus, it is shall be possible to configure the measurements and measurement reports for mobility support in LTE_Active such that the burden on the UE is very low. With trigger-based reports, no measurement reports should be triggered by stationary UEs.

For stationary UEs, we therefore conclude that it shall be possible to implement mobility measurements in LTE_Active, which are as resource efficient as the UE cell selection methods needed in LTE_Idle. A typical trigger for transferring an inactive UE from LTE_Active to LTE_Idle could then be the detection of UE mobility.

4. Conclusion and proposal

Within LTE, it shall be possible to realize means for UE power-saving in LTE_Active, such that UEs can remain in LTE_Active for considerable periods of time without loss of UE standby-performance. This is particularly beneficial for stationary UEs, and for transmissions characterized by discontinuous activity.

In this contribution, we describe our view on the functionality needed to realize power saving for UEs in LTE_Active. These functions include UL synchronization, UL scheduling request, DL scheduling and measurements for mobility.

Based on our analysis, we find that the loss of uplink synchronization is the main aspect affecting both the access to UL resources and the scheduling of DL traffic. In both cases, there may be a need for two-stage procedure before the transmission of user-plane data can commence. The state of UL synchronization is thus the main aspect distinguishing the procedures needed for the UE to access the uplink as well as for the scheduling on the downlink.

Well-configured measurements for network-controlled cell re-selection shall allow for low signalling overhead and long standby-times for UEs in LTE_Active. Triggers for measurements, DRX periods, state-transitions etc., shall be configurable by upper layers.

If deemed appropriate by RAN2, we suggest that the described UE behaviour, mainly characterized by its handling of UL synchronization, is captured by a MAC state model, c.f. [4].

5. References

[1] TR 25.913 Requirements for Evolved UTRA and UTRAN

[2] TR 23.882 "3GPP System Architecture Evolution: Report on Technical Options and Conclusions"

[3] TR 25.813 Evolved Universal Terrestrial Radio Access (UTRA) and Universal Terrestrial Radio Access Network (UTRAN): Radio interface protocol aspects

[4] R2-052425 "LTE States in E-UTRAN", Source: Ericsson

[5] R1-060584 " E-UTRA Random Access", Source: Ericsson

[6] R2-060592 "Initial Random Access and Identity Handling", Source: Ericsson

TSG-RAN WG1 #44 **R1-060576**
Denver, CO, USA, February 13–17, 2006

Source: **Ericsson**
Title: **Paging for E-UTRA**
Agenda Item: **13.1.3**
Document for: **Discussion and Decision**

1. Introduction and Discussion

Paging is used for network-initiated connection setup. An efficient paging procedure should allow the UE to sleep with no receiver processing most of the time and to briefly wake up at predefined time intervals to monitor paging information from the network.

In WCDMA, a separate paging indicator channel, monitored at predefined time instants, is used to signal the UE to receive the paging information. If the UE receives a paging indicator, it performs further processing of paging information transmitted on a separate channel. As the paging indicator is significantly shorter than the duration of the paging information, this approach minimizes the time the UE is awake.

For LTE, paging can rely on the shared control channel[1], monitored at predefined time instants (DRX cycle, configured by higher layers). This is illustrated in Figure 1. No paging indicator channel is necessary as the potential power savings are very small thanks to the short subframe duration. Instead, the shared control channel serves the purpose of a paging indicator. If the UE detects scheduling control information, through the presence of its own identity or a common paging group identity, the data part of the downlink transmission is received and further processed by higher layers. Otherwise, the UE reverts to sleeping until the next paging occasion.

Relying on the shared control channel for paging avoids having to introduce specific L1 structures. Instead, paging relies on already existing L1 structures and can be seen as scheduling implementation. The same principle can be applied to both FDD and TDD. The DRX cycle is configured by higher layers, as is the location in frequency for the shared control channel used for the paging operation.

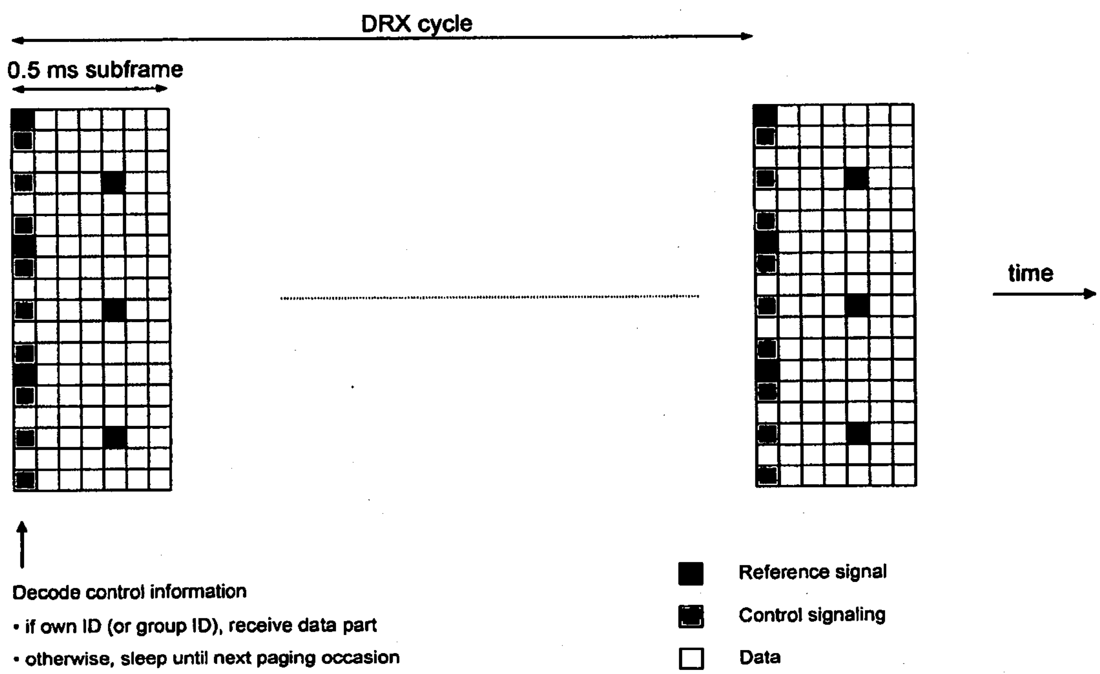


Figure 1: Schematic illustration of the paging mechanism (the amount of reference signals, location of control information, etc is not to scale).

[1] The name 'shared control channel' is used to denote the part of the subframe carrying control information for operation of downlink scheduling, similar to the HS-SCCH in HSDPA.

2. Conclusion

It is recommended to include the text proposal in [1] into TR25.814.

3. References

[1] R1-060577, "Text Proposal on E-UTRA Paging", Ericsson

RAN2 in Athens

RAN2 only

- Multiplexing
- HARQ/ARQ
  - ARQ location
  - ARQ scheme
  - HARQ scheme (Synchronous/Asynchronous)
- Scheduling
- QoS control
  - Default RB configurations
- Upper RRC vs. NAS
- Handover Procedure (RAN3, as well)
- TA update (RAN3, as well)
- UE BW scenarios / Measurement Procedure
- MBMS

RAN1/2 Joint

- UL synchronization : YD Lee (RAN2, as well)
- RACH : SJ Park
- SCH/BCH : Patrick
- PICH/PCH : YD Lee
- MBMS : YD Lee

TSG-RAN Working Group 2 #51 *R2-06xxxx*
Denver, Colorado, USA, 13th – 17th February 2006

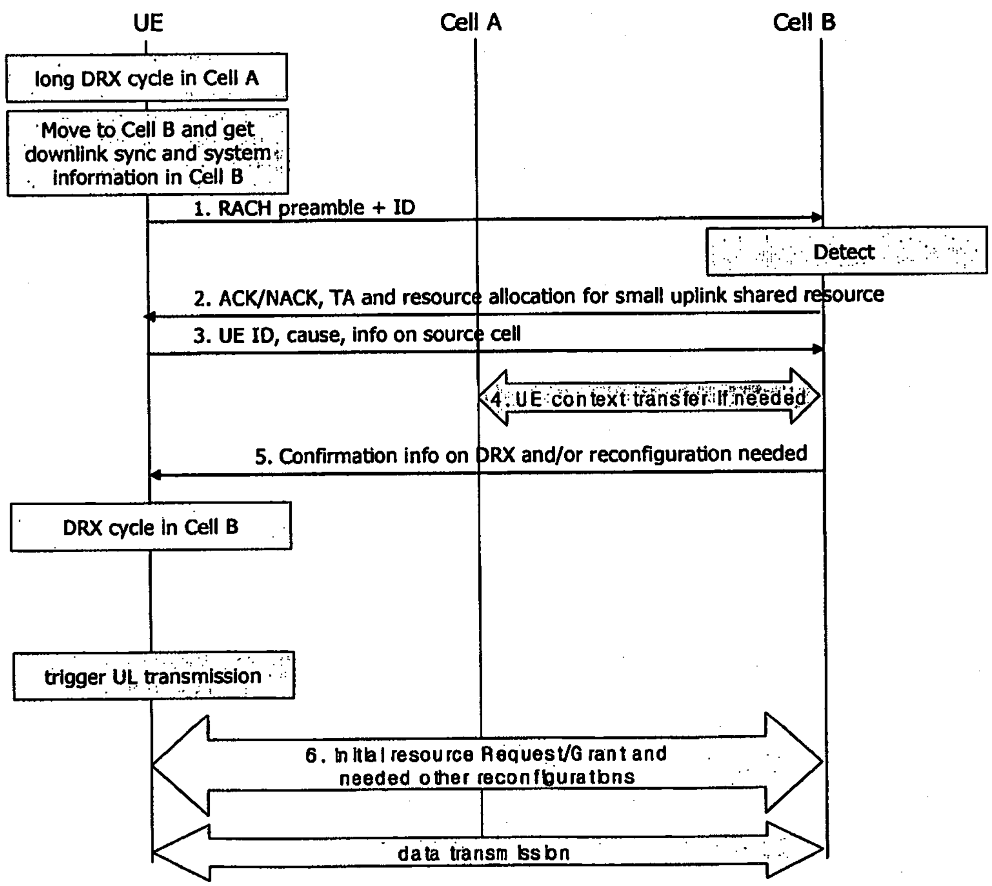
Agenda Item :
Source : SungJun Park / LG Electronics (8 March 2006)
Title : Handover in DRX cycle
Document for : LG internal Discussion

Some Considerations for DRX in case of handover

We are assuming that UE moves to long DRX cycles when there is no transmission between UE and Network within a certain period of time and no UL pilot to maintain uplink synchronization. However, UE is still in LTE_ACTIVE.

In this document, we focus on mobility of UE in long DRX cycle in order to preserve its DRX cycle. Normally, when UE in LTE_ACTIVE move to new cell, handover procedure would occur. However, if it is in long DRX cycle, we think that requirements on mobility would be not strictly needed due to the fact that there is no transmission between UE and Network. In addition, from DRX management perspective it seems to UE in long DRX cycle that frequent measurement report is not good.

Therefore, we propose handover procedure like cell update in DRX. An example procedure is as follows.



1. UE sends RACH preamble + ID

2. In the response to the preamble, UE receive ACK/NACK, TA and resource allocation (see details in [1])
3. UE send RACH message including source cell info or U-RNTI (see details in [1]).
4. Context transfer between source node and target node if it is not intra-ENB case. At this time, ENB can determine DRX info of UE from context.
5. ENB in Cell B sends confirmation information on DRX cycle and at least needed reconfiguration info to UE
6. when UE needs to transmit, UE perform remaining reconfiguration.

TSG-RAN Working Group 2 #51 **R2-06xxxx**
Denver, Colorado, USA, 13th – 17th February 2006

Agenda Item :
Source : SungJun Park / LG Electronics (08 March 2006)
Title : RACH in LTE
Document for : LG internal Discussion

Introduction

This document discusses some consideration of RACH. And we propose one RACH procedure in order to keep system simple, regardless purpose of RACH.

Discussion

Regarding one and two part procedures which are discussed in RAN1, if it is important to keep the system simple, we think that two part procedure are better than one part. This is because information on scheduling information would be not a few, e.g. 18 bits in E-DCH and in case of retrial due to collision or timing adjustments a combined burst in one part procedure would introduce longer delay than additional step and RTT in two part procedure.

Therefore, we propose two part procedure as follows. In the first part, UE sends preamble. In the response to the preamble , UE receives timing adjustment, ACK or NACK, scheduled information on uplink shared channel for RACH message. RACH message means that it could contain UE ID, Id type if needed, Cause value and scheduling information for needed amount. Hence, once ENB allocates uplink shared channel resource for RACH message to the UE, it can obtain appropriate uplink resource from ENB by utilizing this RACH message. Consequently, in the second part, UE sends RACH message over shared channel indicated by ENB. Then, finally UE can send control or data traffic, e.g., connection request, user traffic and other control message, to ENB according to purpose of RACH.

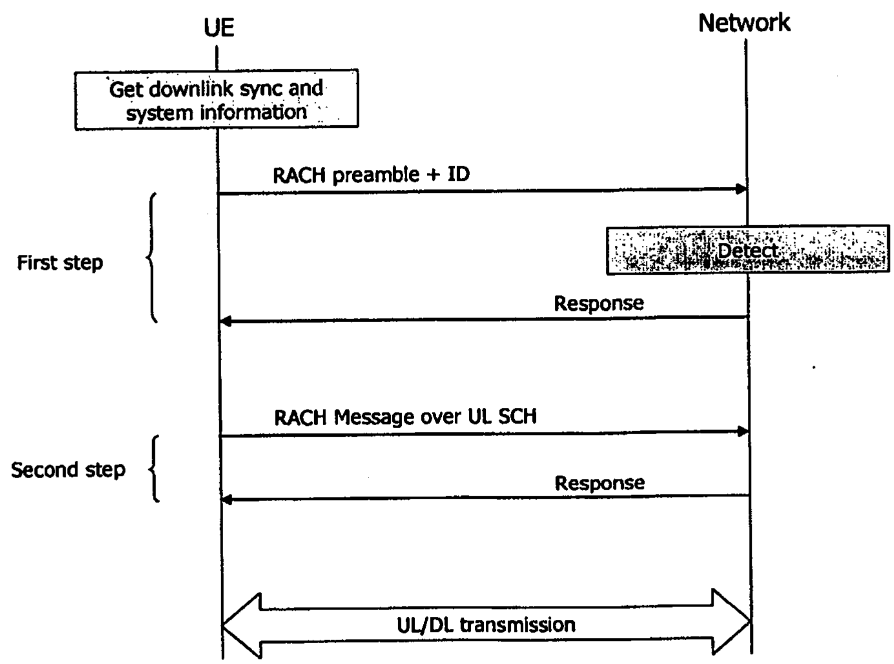


Fig 1. General RACH procedure on two part in LTE

Regarding response to the preamble, since it is not good to separate resource channel i.e., fixed radio resource, for the response from resource efficiency perspective, we propose that it can also use downlink shared channel. For example, If uplink system band and downlink system band are the same a one to one mapping for the resources for the RACH signature and the resources for the response message could be defined. Alternatively the physical resource of the response RACH message could be allocated based on UE specific Info such as UE identity. For instance, system information could contain the method of calculation in order to map between UE identity and downlink resource of response RACH message. Then UE can know the position (frequency/time) of response RACH message after sending RACH message according to its calculation. Details of this method of calculation should be investigated.

Regarding UE ID, we believe that UE ID such as a C-RNTI and U-RNTI can be involved in RACH message. However, these information to identify should be needed for resolution of a collision due to selected one preamble by multiple UEs and mapping between preamble and the response to it. However, as one might expect, the size of it is not needed to long like UMTS (16bits). Therefore, in case of initial access, it could become random sequence chosen by UE and in case of other case, e.g., scheduling request, it could be also the information to identify. However, it is FFS whether this information is based on random number or UE Id such as C-RNTI or U-RNTI. On the other word, although random number or UE Id can be used to mixed up in order to avoid collision and map preamble and response to it, full UE-ID should be not used due to size of UE id (at least 16bits in legacy UMTS).

This is not clear to me. Is the intention to have:

- random signature for preamble
- then NodeB allocates the C-RNTI and transmits the C-RNTI and the Id of the detected random signature in the Response message
- then the UE includes the C-RNTI and the U-RNTI/temporary identity and the RACH message.

Unsynchronized in Uplink

Initial access

In general when a UE power on, goes from idle mode to active mode and move to new cell in not active mode, UE needs to initially access to the cell when it needs to transmit. As one might expect, in this case UE has not achieved uplink synchronization yet. Therefore, UE, after getting DL synchronization and system information, needs to use preamble for timing adjustment.

As we mentioned above, in the first step, UE sends preamble and receives TA, scheduled info and ACK/NAK in the response to the preamble. Then, in the second step, UE sends RACH messages and gets appropriate uplink resource needed according to scheduling information in RACH message sent

Handover in DRX mode (idle mode)

Reference [1] describes usage of RACH in case of handover in DRX. We are assuming that long DRX is that there is no transmission between UE and network and no allocated UL reference signal like pilot. In long DRX, we think that it is significantly important to keep its DRX cycle from power saving perspective. In order to adjust this requirement we propose that when UE move to new cell in long DRX cycle, UE only send small information on UL location for updating its location and DRX for keeping DRX cycles continuously over RACH. Then UE, after receiving confirmation on DRX and anything, can go into DRX cycle directly.

UL synchronization

It is commonly agreed that if UE does not regularly maintain uplink synchronization (long DRX) or UE move to where is out of synchronization, failure to transmit toward network and so on, UE should obtain UL synchronization when it needs to transmit. In this case, our proposed general RACH procedure is also used.

Scheduling Request

In this case, it also used procedure above. And RACH message could contain scheduling information like E-DCH.

Handover

Yes or No ?

Synchronized in Uplink

Basically, an active UE which means that it does have a transmission between it and network would use RACH in synchronized in uplink in order to get uplink resource when it has not valid uplink resource and needs to transmit.

From cell load perspective, we believe that it is significantly considered whether or not there is a problem on cell load. Therefore, UE has to know that the cell is too loaded by implicit or explicit means in order to avoid overload situation.

If no problem of cell, RACH procedure could be used for getting uplink scheduling resource. However, in comparison with unsynchronized in uplink, the number of sub frame needed to send preamble or combined preamble with control date could lower due to small guard band. But we believe that in this case needed sub-frame is not quietly different(?). In addition, from a retrial for collision, simplicity and available size perspective, we propose that it could also use general RACH procedure above in case of scheduling information.

However, in case of scheduling request in synchronized in uplink, we can consider means of piggyback to other control signalling, e.g., downlink data associated control signal (see details in Reference [2]).

Conclusion

In order to be agreed ...

Reference

[1] DRX

[2] scheduling request utilizing AI

TSG-RAN Working Group 2 #51 *R2-06xxxx*
Denver, Colorado, USA, 13th – 17th February 2006

Agenda Item :
Source : SungJun Park / LG Electronics (08 March 2006)
Title : CQI
Document for : LG internal Discussion

Discussion

In general, principle of AMC is to change the modulation and coding in accordance with variations in the channel conditions.

- UE who closes to the cell site : higher order modulation with higher code rates.
- UE who closes to the cell edge : lower order modulation with lower code rates.

Main benefit of AMC

- Higher data rate for user close to the cell site : increase average cell thoughtput
-

TSG-RAN Working Group 2 #51 *R2-06xxxx*

Denver, Colorado, USA, 13th – 17th February 2006

Agenda Item :

Source : SungJun Park / LG Electronics (08 March 2006)

Title : Identities

Document for : LG internal Discussion

Discussion

Now discussion on UE identities is discussing via e-mail. In my understanding, UE identities as follows has been agreed, especially cell specific them.

1. U-RNTI (C-RNTI + Cell ID) / temporary / eNodeb / addressing
2. C-RNIT / temporary / eNodeb / addressing

However, I believe that it is not clear when to be allocated and de-allocated and how to use for which usage.

According to e-mail discussion, U-RNTI is used for case of handover failure. And C-RNTI is used to request resource.

Question

1. U-RNTI could be identified a UE within the whole UTRAN. Therefore, although cell is changed, U-RNTI should not be changed if Tracking Area is not changed. However, according to email discussion, U-RNTI consists of C-RNTI and Cell ID. In that case, when

TSG-RAN Working Group 2 #51 **R2-06xxxx**

Denver, Colorado, USA, 13th – 17th February 2006

Agenda Item :

Source : SungJun Park / LG Electronics (27 Jan 2006)

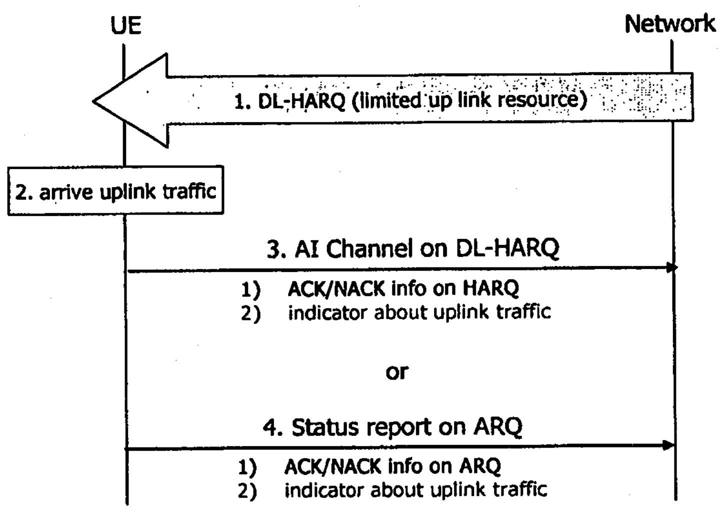
Title : RACH on LTE

Document for : LG Internal Discussion

UL-SCH resource request utilizing AI of DL-HARQ

If UE has achieved RB setup on DL-HARQ. downlink traffic could be sent to UE. In this case, a few uplink control information related to DL-HARQ would be sent to ENB. This control information would become AI(Acquisition Indicator) on HARQ, Status report on ARQ and so on. Of course, UE may have some uplink resource when it has achieved RB setup. However, if UE has no data traffic, ENB would control to decrease uplink resource. Therefore, UE only have a few uplink resource for control information.

At that time, if uplink data arrive to buffer of UE, UE has to request uplink resource to ENB because there is no uplink resource for sending SI or uplink data. In order to request uplink resource UE could use RACH process, AI channel, Status report of ARQ according to priority. Detial method is described below.



1. UE has achieved RB setup on DL-HARQ. Then downlink traffic is sent to UE. In this case, a few uplink control information would be sent to ENB. This control information would become AI(Acquisition Indicator) on HARQ, Status report on ARQ and so on. Of course, UE can have some uplink resource when it achieves RB setup. However, if UE has no data traffic, ENB would control to decrease uplink resource. Therefore, UE only have a few uplink resource for control information. It is FFS whether small uplink resource for sending scheduling information to ENB is continuously allocated to UE or not. But we believe that it is not efficient. Therefore, ENB could periodicly schedule uplink resource for control information. Then, ENB indicates this configuration to UE and UE would set timer of status report of ARQ configured by ENB.

2. UE has no empty buffer because of arrival of uplink data from higher layer. In this case, UE cannot directly send scheduling information to ENB because UE has not uplink resource which is enough to send scheduling information (like HSUPA). Therefore, if the property of this data has low priority such as internet traffic which is not sensitive to delay, the transmission of scheduling information could be waited unitl next periodic resource for AI or status report. But if the data has high priority such as voice traffic, UE could directly use RACH procedure. Other solution is that UE calculates residual time of periodic transmission time of control

information and compares with average of time of RACH procedure. Then if residual that time is shorter than average time of RACH procedure, it is reasonable to be waited.

3. If residual time is short or priority is low, indicator (called "ping") on "I request small uplink resource for transmission of SI" could be involved in AI channel. this indicator is 1 bit. If uplink data to be transmitted is present, this bit is set to "1", otherwise it is set to "0".

4. The condition meets same criteria of bullet 3 above. In this case, the indicator could be involved in status report of ARQ. It also can calculate the time which is shorter than residual time of AI and status report.

Life's Good

RACH summary

- Different possibilities for RACH

Patrick FISCHER / Dragan VUJCIC

LG Electronics Mobilecomm France

Ref.:RDE-0603-PFI-020-V1.0_RACH_summary

Great Company Great People

Profitable Growth thru Blue Ocean

Usage of RACH

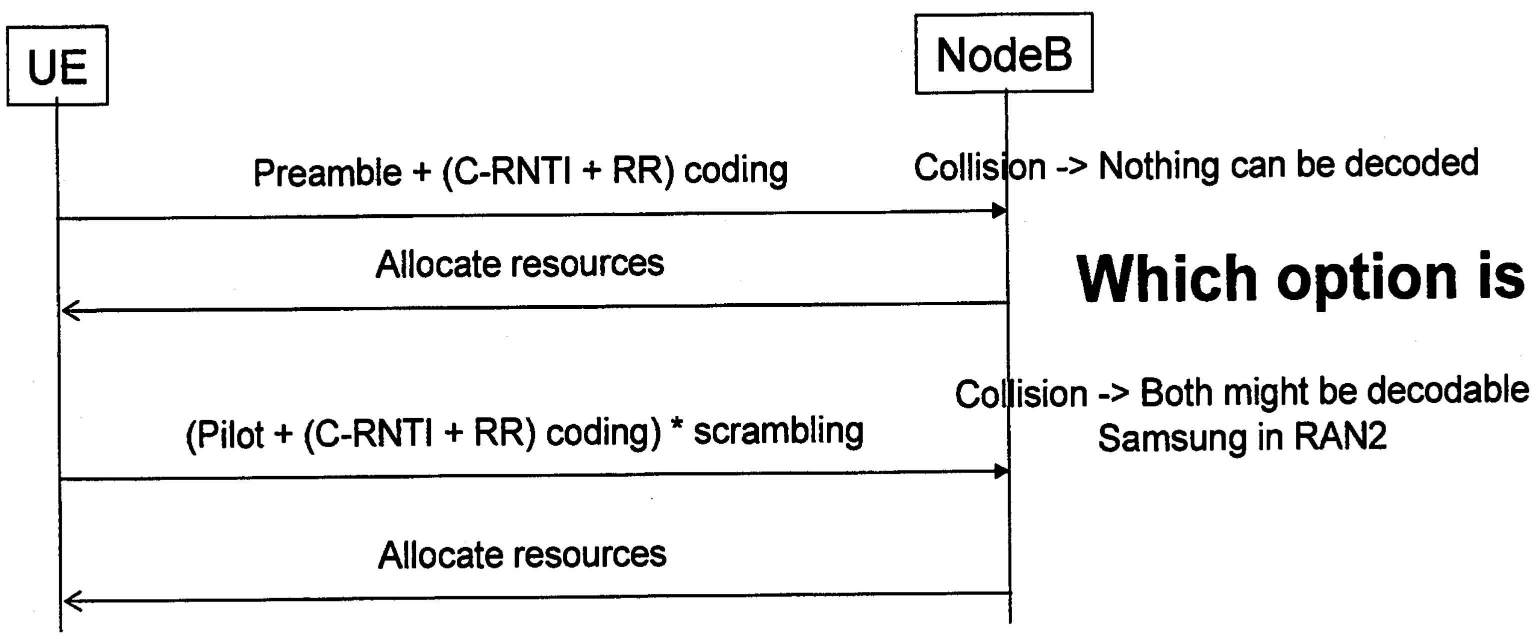
- Mobility, e.g. Cell Update
- Transition from idle to active
- Transition from active unsynchronized to active synchronized
  - FFS whether active unsynchronized exists
- According to SungDucks analysis there are 3 possible cases for RACH procedure
  - Idle mode UE / detached UE / UE controlled Mobility
  - Sync active UE without resources
  - NonSync active UE without resources (FFS)

Document Microsoft Word

Sync active UE without resources

- Only small bandwidth needed for transmission
  - Synchronization is already established
  - Need to transmit C-RNTI
  - Need to transmit RR

LG Status:
•**Need for Investigation**



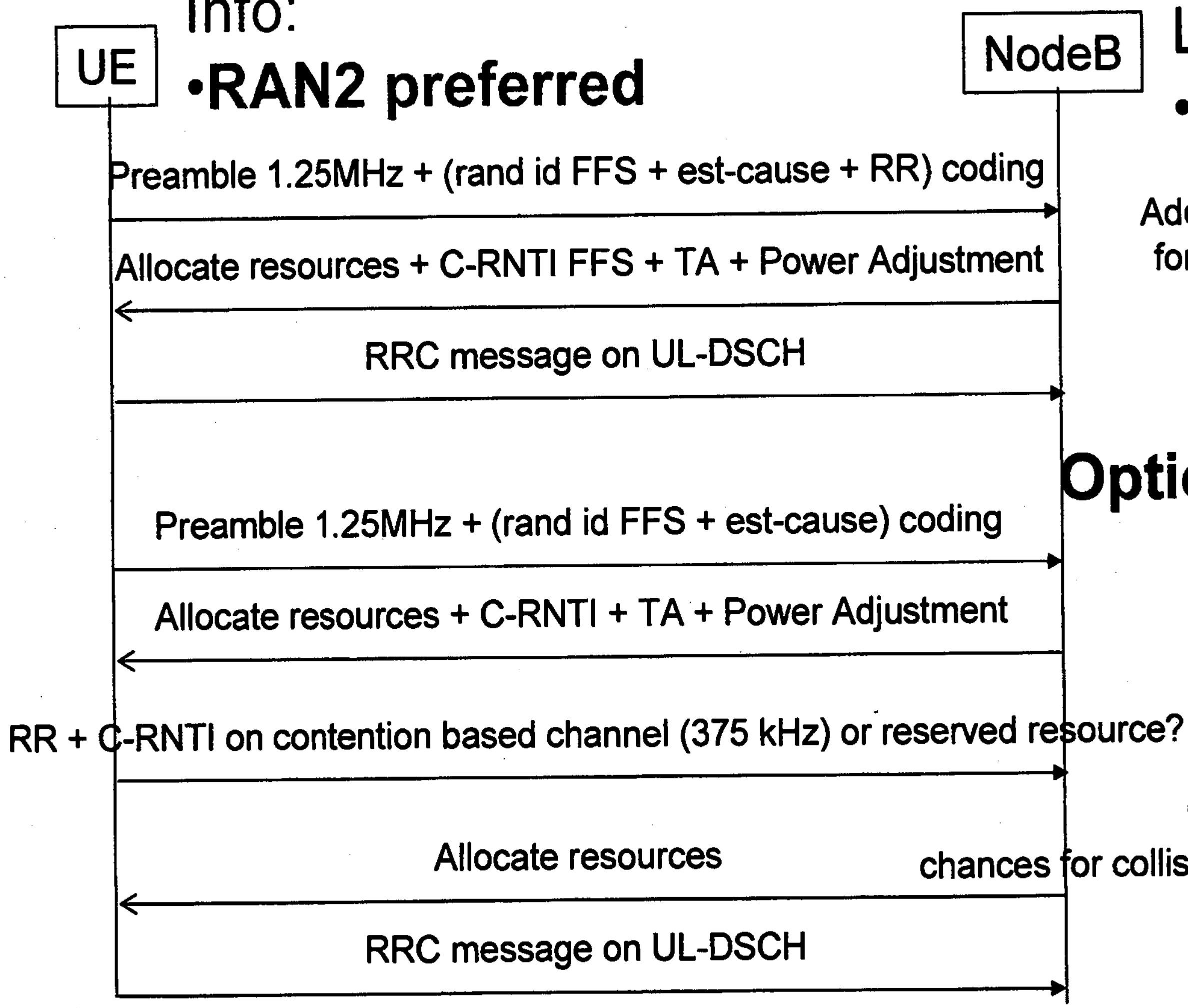
Which option is preferred?

Idle mode UE / detached UE / UE controlled Mobility

- Need for min 1.25 MHz for synchronization

Info:
•RAN2 preferred

LG Status:
•Need for Investigation



Additionally required bandwidth for RR seems to be negligible

Option 1 seems better

Introduces delay, increases chances for collision in case contention based channel is used

NonSync active UE without resources

- Same as idle mode UE?
  - Need for additional bit to distinguish message part
  - Allows multiplexing gain by using a bigger resource pool
- C-RNTI available
  - Need to transmit C-RNTI
  - Need to transmit RR
    - Either complete RR
      - Might be no problem since minimum RB is sufficient
    - RR will be sent on scheduled resource
      - Reduces number of different options

LG Status:

•**Need for Investigation**

RAN2 - LS R2-060144

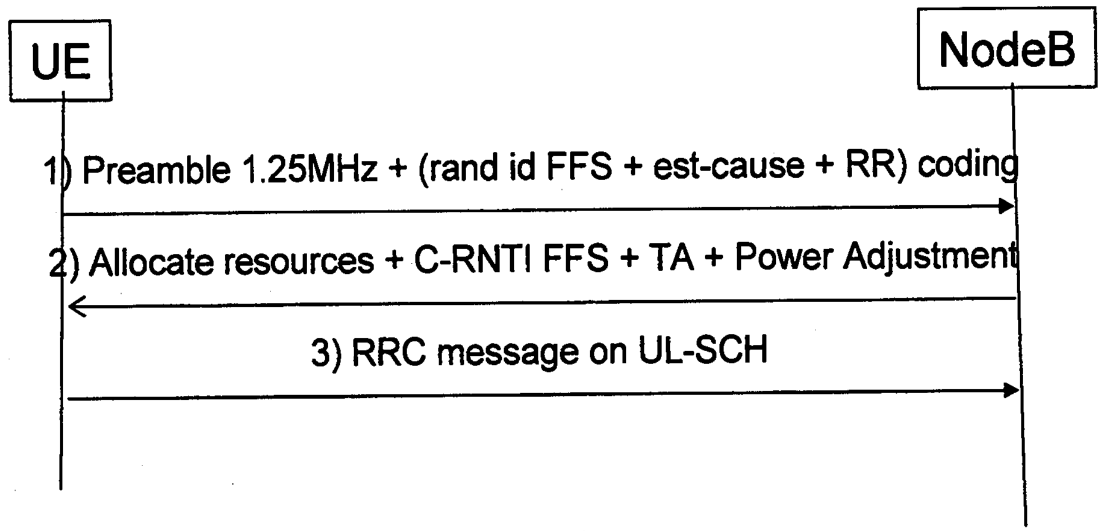
- Request to RAN1 to send some small payload with the initial request
  - E.g. C-RNTI or RR
- Size of response message
  - Should be able to be multiplexed, so no limit?
- RAN2 assumes it might be beneficial to combine RR and UL timing alignment
  - Specific procedure for transmission of RR is anyway needed for Sync active UE without resources
- Should UE transmit Rand-Id with the preamble for contention resolution?
  - This increases the payload, and decreases the preamble size
    - Allows detection of collision at AICH and not at higher layer response
    - Need for high energy in order to have reliable Rand-Id
- Synchronization in the case of UE mobility
  - Network controlled
  - UE controlled

LG Status:

•**Need for Investigation**

Procedure for non-synch UEs

•



1) Choice of resource depending on:
- Est-cause
- Priority
- Downlink measurement
- Random
- Sent on SIB or via dedicated signalling (e.g. for acitve mode UEs)

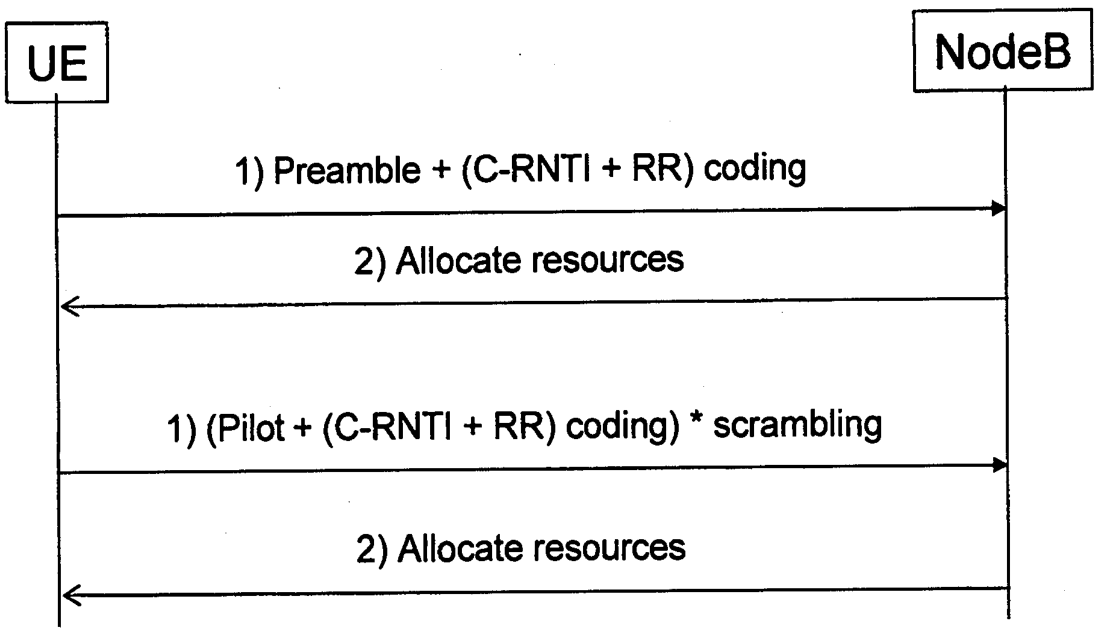
2) Response sent on:
- DL-SCH (possibly DL-SCCH)
- Choice of DL-SCH depending on
  - UL channel used

3) RRC message sent on:
- UL-SCH allocated in 2

LG Status:

•Need for Investigation

Procedure for sync UEs



1) Resource allocated by:
•Dedicated signalling

2) Response sent on:
•Resource that the UE is monitoring based on the DRX
 •DRX can be smaller than DTX
•Specific resource linked with the UL resource, i.e. when UE transmits on the UL it expects a specific response

LG Status:
•Need for Investigation

Maintenance of UL Sync

- UE must maintain DL sync
- UL sync depends on the distance to the BS
  - UE:
    - can not detect change in the distance
  - NodeB:
    - Is able to measure the UL timing
      - if the UE transmits UL 1.25 MHz
      - For smaller UL BW this is FFS
- UE should consider to be out of sync based on timer
  - Criteria to start the timer
    - Timer started after the UE has done its last transmission is a bad idea
      - Might have been lost by NodeB
      - Might be with insufficiant BW
    - UE periodically performs synchronization
    - NodeB can re-start the timer if it feels that it is able to calculate the timing sufficiantly
  - Timer given on SIB or via dedicated signalling?
    - Both should be possible

LG Status:

•Need for Investigation

Preamble design

- Proposal to use CAZAC preambles due to
  - Good cross-correlation properties?
  - Good PAR properties?
  - LG would like to introduce extended CAZAC sequences?

LG Status:

•**Need for Investigation**

3GPP TSG RAN WG2 Meeting #51 *R2-060584*
Denver, USA, 13 – 17 February, 2006

Source: LG Electronics

Title: Considerations on BCH

Agenda item: 12.3.5

Document for: Discussion & Decision

Introduction

The purpose of this paper is to analyze the usage, and the way that system information should be organized in the future LTE system. As already discussed in R2-060578 especially the possibility of UEs that are able to receiv only a smaller bandwidth than the system bandwidth is taken into consideration.

General organization of broadcast in UMTS

In the UMTS system System Information is sent on the P-CCPCH which is characterized by a fixed spreading factor, and fixed code, and the fact that it is scrambled using the primary scrambling code of the cell. So once the UE has discovered the primary scrambling code by the cell search procedure the UE is ready for reception of the P-CCPCH. After this step the UE will need to receive the MIB and evtl. Scheduling Information blocks. MIB and Scheduling information blocks contain information on the scheduling of the remaining system information which can be used by the UE to optionally optimize the reading of the usage, compared to a UE that would just continuously to read the P-CCPCH until it has received all necessary system information that is listed in the MIB.

In order to allow the updating of the system information SIBs have value tags and area scopes or are linked to timers that control their validity. In addition to this a system information update procedure is defined.

Allthough we do not propose to go into further details before the main issues on the system architecture are fixed we believe that it is worthwhile to consider some principle decisions for the broadcast of system information.

Today we have the following that allows the reading of the system information:

- Primary scrambling code which allows to identify the channel for the transmission of the SIB, fixed coding and spreading code / factor
- List of existing system information blocks including value tags, area scopes and timers
- Scheduling information for the different system information blocks related to the system frame number
- RRC ASN.1 coding to allow to map system information to the TM transport blocks

Options for LTE

In the following we discuss the different options and additional constraints that we see for the LTE system due to the fact that we consider flexible bandwidths, and an OFDM air interface. We assume that principal Layer 1 mechanisms allow that the UE detects the cell, including the system bandwidth. Also we assume that L1 mechanisms allow to detect a specific code for a given cell which could be e.g. a scrambling code, interleaving code or similar means in order to allow the UE to separate the desired signal from interference from other cells.

Fixed configuration for system information

In order to allow UEs to receive the system information it is necessary that the UE is able to decode system information. The format for the coding of the system information should comply with the minimum UE receiver capabilities in terms of data rate, coding, TTI length, number of subcarriers etc. The coding of the system information would of course also need to include a cell specific scrambling to protect the UE from receiving the neighbouring cell. Since the system bandwidth is flexible (e.g. 1.25MHz, 2.5MHz, 5MHz, 10MHz, 15MHz, 20MHz or others) the format of the coding of the system information should depend on the system bandwidth of the cell.

Bandwidth for system information

The current assumptions for the different bandwidths of LTE are that there are at least 6 symbols available in one frame, which multiplied by the number of subcarriers gives the number of symbols per frame as:

1.25 MHz ~ 76 subcarriers ~ 456 symbols (without taking into account pilots and modulation)

5MHz ~ 301 subcarriers ~ 1806 symbols (without taking into account pilots and modulation)

Compared with todays data rate of 30kbps used for the BCH, and assuming QPSK modulation and a coding rate of 1/3 this implies that for a similar data rate we would need roughly 30kbps / 456*2(QPSK)/3(conv.coding)/0.5msec = 5% of the time / frequency resources of a system with 1.25 MHz bandwidth for BCH, and 30kbps / 1806*2/3/0.5msec = 1,25% of the time / frequency resources of a system with 5 MHz bandwidth. Allthough we agree that these calculations are very rough, the conclusioin that we draw are that in principle there is no reason to send the BCH over a bandwidth larger than 5 MHz (if this can be assumed as minimum receiver capability) and even to restrict the BCH to 1.25 MHz bandwidth might be envisageable. However in order to optimize the sleeping mode of the UE we believe that for BCH the maximum between the system bandwidth and the UE minimum receiver bandwidth should be used.

Frequencies for the BCH information

One straight forward approach could be to transmit the BCH on the same frequency as the SCH, i.e. on a central frequency as proposed in [5] and [6]. However as also explained in [6] this implies that a UE that is scheduled for receiving data on a subband that is different from the center frequency needs to change the central frequency for reception in order to read the BCH of the current or neighbouring cells. In order to avoid this we propose that the system information should be scheduled on different frequencies across the complete system bandwidth.

The ability for receiving the system information already in active state is usefull in order to allow a quick transition from active to idle state, and reduces the delay that UEs need to tune to another frequency and thus can not be scheduled.

The broadcast channel should be sent in a frequency hopping manner such that UEs in idle and detached mode can receive all successive transmissions of the broadcast channel, and that UEs in active mode that are scheduled to receive a distinct frequency are able to receive the system information of the current cell, and evtl. the system information of some neighbouring cell. In order to allow all UEs to receive the the BCH at each time instant the system information should be sent on resource blocks that do not span across more subcarriers than the minimum required bandwidth a UE supports, or even across smaller bandwidth. This is shown in Figure 1, where the pink blocks indicate frequency and time where system information is allowed to be broadcast according to the frequency hopping scheme. Inside the pink blocks system information may only occupy parts of the available resources for system information. In order to ensure that a UE that would only listen e.g. to the Sub-band A during the two periods where system information can be scheduled it is necessary that the network ensures that all system information blocks that are broadcast are available in each possible subband. The Figure 1 shows an example where four system information blocks (A, B, C, D) and Control information (including e.g. the list of SIBs, value tags andn scheduling) are transmitted such that they are available in each possible subband.

In order to allow a maximum power saving scheduling information should be sent which indicates the detailed location of the different system information blocks.

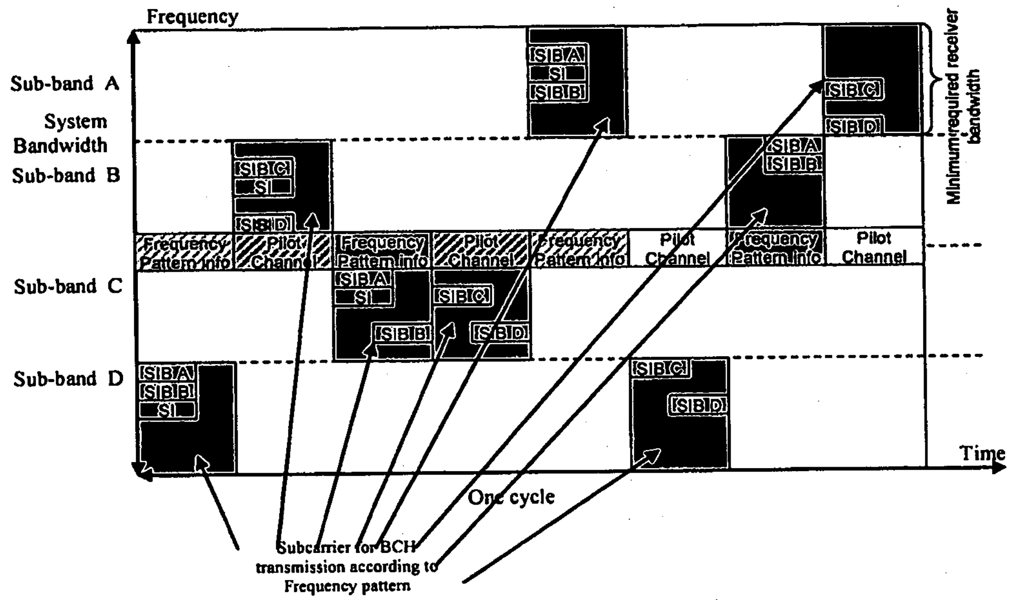


Figure 1: Proposal for system information scheduling

For a basic reception of the scheduling information the frequency hopping scheme would be sufficient, such that a UE that has not received the scheduling information can know to which frequency to tune in order to receive the complete system information by continuously receiving all resource blocks in the identified subband.

In order to allow the UE to receive the system information on the current cell in active mode scheduling information of the current cell could either be sent on dedicated channels or it should be sent periodically on the different frequency subbands such that UEs in active mode that are scheduled to receive a distinct subband are able to receive it.

Organization of system information

Similarly to the UMTS system we believe that we should still maintain the global concepts for system information, such as fixed coding and spreading code / factor, list of existing system information blocks including value tags (as broadcast today in the MIB), area scopes and timers, and scheduling information for the different system information blocks related to the system frame number. Whether UM or TM mode would be used should be studied further. For the above proposal of frequency hopping the scheduling information, the list of available system information blocks as well as the value tags might be sent in the central frequency as well as on the different subbands according to the frequency hopping scheme. The schedule of the frequency hopping scheme would also need to be sent on the central frequency together with the synchronization information in order to allow the UEs in idle / detached mode to tune to the correct frequency for reception of BCH.

Conclusion

It is proposed to discuss the above considerations and to capture the agreeable parts in the technical report for LTE.

Annex:

[1] TR 25.813 V.0.3.0, Evolved Universal Terrestrial Radio Access Network (E-UTRAN), Release 7

[2] TR 25.913 V7.2.0, Requirements for Evolved UTRA (E-UTRA) and Evolved UTRAN (E-UTRAN) , Release 7

[3] TR 23.882 V0.10.0, 3GPP System Architecture Evolution, eport on Technical Options and Conclusions, Release 7

[4] TR 25.814 V1.0.1 Physical Layer Aspects for Evolved UTRA, Release 7

[5] R1-060197, Siemens, Considerations on E-UTRA Cell Search and Initial Access

[6] R1-060163, NTT DoCoMo, Cell Search Method in Connected and Idle Mode for E-UTRA Downlink

(Un)Synchronized UE & Contention Channel Procedure (Known as RACH)

(In the following, it is assumed that UE in Active mode can have unsynchronized uplink.
It seems that some companies does not want to have this. Because it will cause late handover decision..etc.
And some companies want to move the UE into idle mode because the transition time between idle<->active is short
And some proposed to freeze PDCP context in aGW for the UE which moves to idle mode.)

Basically UE can be classified into following 4type:

- Idle mode UE
    - This UE does not have C-RNTI which is knows to NB
    - This UE has to perform timing synchronization procedure.
    - If this UE has data to send, it should request resource allocation to NB
        - Because this UE has not synchronized uplink, this UE has to perform synchronization procedure.
- Active mode UE with synchronized uplink and with allocated uplink resource
    - This UE has C-RNTI which is knows to NB
    - This UE don't have to perform timing synchronization procedure.
    - If this UE has data to send, it should request resource allocation to NB
        - This UE don't need to perform resource request procedure
        - Because this UE has synchronized uplink and resource, this UE can send immediately.
- Active mode UE with synchronized uplink but without allocated uplink resource
    - This UE has C-RNTI which is knows to NB
    - This UE don't have to perform timing synchronization procedure.
    - If this UE has data to send, it should request resource allocation to NB
        - Because this UE has synchronized uplink, this UE need not perform synchronization procedure.
        - This UE needs to send only resource request message.

- Active mode UE without synchronized uplink
  - This UE has C-RNTI which is known to NB
  - This UE has to perform timing synchronization procedure.
  - If this UE has data to send, it should request resource allocation to NB
    - Because this UE has not synchronized uplink, this UE has to perform synchronization procedure.

: Accordingly, followings are possible options for UE procedure when there is data to send:

- Option 1: Send immediately using dedicated resource
- Option 2: First perform synchronization procedure and then send resource request message.
- Option 3: Send resource request message.

: Accordingly There are two procedure.

- First is procedure to synchronize uplink timing.
- second is procedure to send resource request.

If same amount resource is allocated for both procedure, then second procedure can send more bits because this is synchronized procedure.

And if resource for first and second procedure is separated, then the NB has more flexibility in assign resource for this two procedure:

- Because, calculating the number of active UE without synchronized uplink, the NB can increase or decrease the amount of resource for procedure 2.
- And because, for idle mode UE and active UE without synchronized uplink, resource for second procedure is needed only when first procedure is successful.

: Accordingly following two type of Contention channel is proposed. And resource for each is separately scheduled.

1. Preamble contention channel (Timing adjustment channel)
   a. This is used by UE which has unsynchronized uplink.
   b. Especially, this channel is used by idle UE which tries to establish RRC connection but does not have synchronized uplink

c. Especially, this channel is used by active UE which tries to send control/data in uplink direction, but does not have synchronized uplink.
d. After UE has synchronized uplink, then it uses message contention channel.
e. Counterpart channel in downlink direction is FFS.
f. UE identifies itself by Preamble signature.
g. Timing adjustment(+/-) is indicated per preamble signature. (FFS)
h. This can be considered physical layer procedure.
i. The Node-b may indicates the channel number of message contention channel for the preamble signature. FFS
j. Necessity of separate preamble contention channels for idle mode UE and active mode UE is unclear.

2. Message contention channel
   a. This is used by UE which has synchronized uplink
   b. When UE in active mode has synchronized uplink but does not have radio resource may use this channel to send resource request.
      i. The UE may include only its ID and amount of data in the buffer.
      ii. The UE may include part of data in the buffer to enhance padding efficiency.
   c. UE in idle mode use this message contention channel after it has synchronized uplink by using preamble contention channel.
      i. The UE may include only its ID and the size of RRC message in the buffer.
      ii. The UE may include part of RRC message in the buffer to enhance padding efficiency.
      iii. The UE may indicate the cause or type of RRC message.
   d. UE identifies itself by using NAS specific ID or cell specific ID included in the resource request message.
   e. This can be considered as MAC layer procedure.
   f. If there is message contention channel dedicated to Idle mode UE and there is preamble contention channel dedicated only to idle mode UE, then the resource allocation for this channel will be dynamic because Node-b will allocate resource for this channel only when there is activity in preamble contention channel.

g. If there is message contention channel dedicated to active mode UE, due to possibility of existence of active UE with synchronized uplink, resource allocation for this channel will not flexible.

Another possibility is that ACTIVE mode UE has always synchronized uplink.
To have synchronized uplink, the UE has to transmitted at least one of CQI/ack-nack/pilot/..etc
But this will cost some uplink resource. Thus it is necessary to lengthen DRX/DTX cycle of CQI/ack-nack/pilot/..etc
By the way, if the pilot (reference signal) can have +1/-1 value and all the active mode UE regularly transmits reference signal in uplink direction (whether it's for uplink synchronization purpose or not), then this can be used as resource request.
I.e,

a. When +1, resource request
b. When -1, no resource request
c.

Remaining Questions:

1. How a UE in active mode declares itself as not synchronized in uplink?
    a. By using Timer (Rough proposal by Ericsson)
    b. After last CQI/preamble/ACK/NACK/traffic transmission.
    c. Explicit signalling procedure.
    d. etc

2. How a UE declare that it has no resource or How UE decides to send resource request?