10-10-01 A

Case Docket No. DE 000173

THE COMMISSIONER FOR PATENTS, Washington, D.C. 20231

Enclosed for filing is the patent application of Inventor(s): CHRISTOPH HERRMANN

For: WIRELESS NETWORK WITH A DATA EXCHANGE ACCORDING TO THE ARQ METHOD

ENCLOSED ARE:

[X] Appointment of Associates;
[ ] Information Disclosure Statement, Form PTO-1449 and copies of documents listed therein;
[ ] Preliminary Amendment;
[X] Specification (14 Pages of Specification, Claims, & Abstract);
[X] Declaration and Power of Attorney: (1 Page of a [ ]fully executed [X]unsigned Declaration);
[X] Drawing (3 sheet of [ ]informal [X]formal sheets);
[X] Certified copy of a GERMAN application Serial No.10050117.6;
[X] Authorization Pursuant to 37 CFR ∋1.136(a)(3)
[ ] Other: ;
[ ] Assignment to .

FEE COMPUTATION

CLAIMS AS FILED				
FOR	NUMBER FILED	NUMBER EXTRA	RATE	BASIC FEE - $740.00
Total Claims	10 - 20 =	0	X $18 =	0.00
Independent Claims	3 - 3 =	0	X $80 =	0.00
Multiple Dependent Claims, if any			$270 =	0.00
TOTAL FILING FEE			=	$740.00

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[ ]Amend the specification by inserting before the first line as a centered heading --Cross Reference to Related Applications--; and insert below that as a new paragraph --This is a continuation-in-part of application Serial No. , filed , which is herein incorporated by reference--.

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J1040 U.S. PTO 09/973312 10/09/01

J1048 U.S. PTO 10/09/01

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Natale A. Manzo (signature)
Typed Name **Signature**

(signature)
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Wireless network with a data exchange according to the ARQ method

The invention relates to a wireless network comprising a radio network controller and a plurality of assigned terminals, which are each provided for exchanging data and which form a receiving and/or transmitting side.

Such a wireless network is known from the document "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Report on Hybrid ARQ Type II/III (Release 2000), 3G TR 25.835 V0.0.2, TSG-RAN Working Group 2 (Radio L2 and Radio L3), Sophia Antipolis, France, 21-15 August 2000". For the secured transmission of data a method is used here which is called the hybrid ARQ-method type II or III (ARQ = Automatic Repeat Request). The data sent in Packet Data Units (PDU) by the Radio Link Control layer (RLC layer) are additionally provided for the error correcting coding with an error control through repetition of transmission. This means that in the case of an error-affected reception of a packet data unit packed in a transport block coded by one of the assigned physical layers, the received packet data unit affected by error is sent anew. With the hybrid ARQ method type I the received packet data unit affected by error is rejected and an identical copy is requested anew. With the hybrid ARQ methods types II and III the received packet data unit affected by error is buffered and, after additional incremental redundancy relating to the received packet data unit, decoded together with the received packet data unit affected by error. Since only incremental redundancy and not the whole error-affected packet data unit is transmitted anew, the amount of data to be transmitted anew is reduced. With the ARQ method type II the incremental redundancy is useless without the buffered (error-affected) packet, with the ARQ method type III the incremental redundancy can be decoded also without the buffered (error-affected) packet. The coded transport blocks are sent over at least one transport channel. A message about the error-free reception in said document is sent only when the receiving RLC layer establishes on the basis of the so-called RLC sequence number that packet data units are lacking, even if the physical layer has already recognized the packet data unit as being error-affected. This means that the packet data unit is to be buffered over long time spaces until an incremental redundancy is requested and then, after a successful decoding, the reception may be acknowledged as correct, especially when the receiving side is the network side, while the physical layer and the RLC layer are usually located on different hardware components. In addition to the packet data units contained in the transport blocks, the RLC sequence numbers of the packet data unit and a redundancy version are to be transmitted in synchronism with the coded transport block when the hybrid ARQ methods of type II or III are implemented. This transmission is generally effected over a clearly better protected transport channel to safeguard that this information is error-free already at first reception. The information is decisive if after a repetition of transmission with incremental redundancy the buffered (error-affected) packet data unit is decoded together with the incremental redundancy, because the incremental redundancy is to be assigned to the respective packet data unit via the redundancy version.

It is an object of the invention to provide a wireless network in which error-affected data repeatedly to be transmitted according to the ARQ method of the type II or III are buffered for a shorter period of time on average.

The object is achieved by the following features by the wireless network mentioned in the opening paragraph which comprises a radio network controller and a plurality of assigned terminals which are each provided for exchanging data and which form each a receiving and/or transmitting side:

A physical layer of a transmitting side is provided for

- storing coded transport blocks in a memory, which blocks contain at least a packet data unit which is delivered by the assigned radio link control layer and can be identified by a packet data unit sequence number,
- storing abbreviated sequence numbers whose length depends on the maximum number of coded transport blocks to be stored and which can be shown unambiguously in a packet data unit sequence number, and for
- transmitting coded transport blocks having at least the assigned abbreviated sequence number and

a physical layer of a receiving side is provided for testing the correct reception of the coded transport block and for sending a positive acknowledge command to the transmitting side over a back channel when there is correct reception and a negative acknowledge command when there is error-affected reception.

The wireless network according to the invention may be, for example, a radio network according to the UMTS standard (UMTS = Universal Mobile Telecommunication System). With this system, when, for example, data are transmitted according to the ARQ method of type II or III, the transmission of an acknowledge command over a back channel unknown thus far between a physical layer of a transmitting side (for example, a radio network controller) and the physical layer of a receiving side (for example, a terminal) provides that a correct or error-affected transmission of a transport block is announced to the transmitting side much more rapidly than known until now. As a result, a repetition of transmission with incremental redundancy may be effected rapidly. This enables the receiving side to buffer the received coded transport block affected by error clearly more briefly, because the additional redundancy necessary for the correct decoding is available at an earlier instant. In this manner, the memory capacity or memory area needed on average for buffering received coded transport blocks affected by error is also reduced.

The use of abbreviated sequence numbers reduces the extent of information that is required to be additionally transmitted for managing the transport blocks and packet data units and simplifies the assignment of the received acknowledge command to the stored transport blocks. The physical layer of a receiving side is provided here for sending a positive or negative acknowledge command with the abbreviated sequence number of the correctly or received transport block affected by error over the return channel.

In lieu of transmitting the abbreviated sequence number, an abbreviated sequence number of a transport block which a received acknowledge command relates to can also implicitly be determined based on the length of time between the transmission of the transport block and the reception of the acknowledge command and on the transmission sequence of the acknowledge command in case of a plurality of received acknowledge commands. This is made possible in a simple manner in that a transmission of the transport blocks is provided in radio frames and in that the transmission of an acknowledge command from the transmitting side to the receiving side is provided in the F^{th} radio frame at the earliest after the radio frame that contains the respective transport block (with $F \geq 1$). The order of a plurality of acknowledge commands corresponds to the order of the transmission of transport blocks in a preceding radio frame.

If the physical layer of a transmitting side has received a negative acknowledge command, the physical layer once again requests the radio link control layer to transmit the packet data unit that has been transmitted affected by error via the coded transport block. After a packet data unit has been received, the physical layer forms therefrom a coded transport block which contains an incremental redundancy.

The invention also relates to a radio network controller and a terminal in a wireless network which exchange data according to the hybrid ARQ method.

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

In the drawings:

Fig. 1 shows a wireless network comprising a radio network controller and a plurality of terminals,

Fig. 2 shows a layer model for explaining different functions of a terminal or of a radio network controller and

Fig. 3 shows a plurality of radio frames which contain data to be transmitted over the radio path between radio network controller and terminals.

Fig. 1 shows a wireless network, for example, radio network, including a radio network controller (RNC) 1 and a plurality of terminals 2 to 9. The radio network controller 1 is responsible for controlling all the components taking part in the radio traffic such as, for example, the terminals 2 to 9. An exchange of control and useful data takes place at least between the radio network controller 1 and the terminals 2 to 9. The radio network controller 1 sets up a respective link for the transmission of useful data.

As a rule, the terminals 2 to 9 are mobile stations and the radio network controller 1 is fixedly installed. A radio network controller 1 may, however, also be movable or mobile, as appropriate.

In the wireless network are transmitted, for example, radio signals in accordance with the FDMA, TDMA or CDMA method (FDMA = frequency division multiple access, TDMA = time division multiple access, CDMA = code division multiple access), or in accordance with a combination of the methods.

In the CDMA method, which is a special code-spreading method, binary information (a data signal) coming from a user is modulated with a respective code sequence. Such a code sequence includes a pseudo-random square-wave signal (pseudo-noise code), whose rate, also called chip rate, is generally considerably higher than that of the binary data.

The length of time of a square-wave pulse of the pseudo-random square-wave signal is referred to as a chip interval T_C. $1/T_C$ is the chip rate. The multiplication or modulation respectively, of the data signal by the pseudo-random square-wave signal has a spreading of the spectrum by the spreading factor $N_C = T/T_C$ as a result, where T is the length of time of the square-wave pulse of the data signal.

Useful data and control data are transmitted between at least one terminal (2 to 9) and the radio network controller 1 over channels predefined by the radio network controller 1. A channel is determined by a frequency range, a time range and, for example, in the CDMA method, by a spreading code. The radio link from the radio network controller 1 to the terminals 2 to 9 is referred to as the downlink and from the terminals to the base station as the uplink. Thus data are sent over downlink channels from the base station to the terminals and over uplink channels from the terminals to the base station.

For example, a downlink control channel may be provided which is used for broadcasting, prior to a connection setup, control data coming from the radio network controller 1 to all the terminals 2 to 9. Such a channel is referred to as downlink broadcast control channel. For transmitting control data from a terminal 2 to 9 to the radio network controller 1 prior to a connection setup, for example, an uplink control channel assigned by the radio network controller 1 can be used which, however, may also be accessed by other terminals 2 to 9. An uplink channel that can be used by various terminals or all the terminals 2 to 9 is referred to as a common uplink channel. After a connection setup, for example, between a terminal 2 to 9 and the radio network controller 1, useful data are transmitted by a downlink and an uplink user channel. Channels that are set up between only one transmitter and one receiver are referred to as dedicated channels. As a rule, a user channel is a dedicated channel which may be accompanied by a dedicated control channel for transmitting link-specific control data.

For exchanging useful data between the radio network controller 1 and a terminal, it is necessary for a terminal 2 to 9 to be synchronized with the radio network controller 1. For example, it is known from the GSM system (GSM = Global System for Mobile communication), in which a combination of FDMA and TDMA methods is used, that after a suitable frequency range is determined based on predefined parameters, the position in time of a frame is determined (frame synchronization), with the aid of which frame the order in time for transmitting data is determined. Such a frame is always necessary for the data synchronization of terminals and base station in TDMA, FDMA and CDMA methods. Such a frame may contain several sub-frames, or together with various other successive frames, form a superframe.

The exchange of control and useful data via the radio interface between the radio network controller 1 and the terminals 2 to 9 can be explained with the layer model or protocol architecture shown by way of example in Fig. 2 (compare for example 3rd Generation Partnership Project (3GPP); Technical Specification Group (TSG) RAN; Working Group 2 (WG2); Radio Interface Protocol Architecture; TS 25.301 V3.2.0 (1999-10)). The layer model comprises three protocol layers: the physical layer PHY, the data link layer having the sub-layers MAC and RLC (in Fig. 2 various objects of the sub-layer RLC are shown) and the layer RRC. The sub-layer MAC is equipped for Medium Access Control, the sub-layer RLC for Radio Link Control and the layer RRC for Radio Resource Control. The layer RRC is responsible for the signaling between the terminals 2 to 9 and the radio network controller 1. The sub-layer RLC is used for controlling a radio link between a terminal 2 to 9 and a radio network controller 1. The layer RRC controls the layers MAC and PHY via control links 10 and 11. By doing this, the layer RRC can control the configuration of the layers MAC and PHY. The physical layer PHY offers transport links 12 to the layer MAC. The layer MAC renders logic connections 13 available to the layer RLC. The layer RLC can be reached by applications via access points 4.

In such a network a method of securely transmitting data is used, which is called the hybrid ARQ (ARQ = Automatic Repeat Request) method. The data sent in packet data units PDU are additionally provided for a forward error correction by means of an error control via repetitions of transmissions. This means that in case a packet data unit is received affected by error, the received packet data unit affected by error is sent anew. With the hybrid ARQ methods of type II or III it is possible to send only certain parts of the data of an error-affected transmission once again. This is referred to as incremental redundancy.

The packet data units are formed in the RLC layer and packed to transport blocks in the MAC layer, which transport blocks are transmitted by the physical layer from the radio network controller to a terminal or vice versa over the available transport channels. In the physical layer the transport blocks are provided with a cyclic redundancy check (CRC) and coded together. The result of this operation is referred to as a coded transport block. The coded transport blocks contain a packet data unit and control information.

Coded transport blocks affected by error that were transmitted are buffered in the physical layer of the receiving side for the conversion according to the hybrid ARQ method of type II or III until the incremental redundancy required afterwards makes an error-free decoding possible. It is known that at least the RLC sequence number or packet data unit sequence number, which features a packet data unit, and a redundancy version is to be transmitted, in parallel with the coded transport block or the incremental redundancy required afterwards, as so-called side information (compare: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Report on Hybrid ARQ Type II/III (Release 2000), 3G TR 25.835 V0.0.2, TSG-RAN Working Group 2 (Radio L2 and Radio L3), Sophia Antipolis, France, 21-15 August 2000"), so that the receiving side can detect which coded transport block is concerned or which buffered coded transport block the additionally transmitted redundancy refers to when a coded transport block affected by error or additional incremental redundancy affected by error is received. The redundancy version indicates whether it is a first-time sent incremental redundancy or which next incremental redundancy possibly repeated several times is concerned.

According to the invention, an abbreviated sequence number in lieu of the RLC sequence number is used for the transmission of the side information over the radio interface, the length of which abbreviated sequence number is clearly shorter than the RLC sequence number. This abbreviated sequence number is determined by the number of M coded transport blocks which, on the receiving side, can at most be buffered simultaneously, and consists of $\lceil \mathrm{ld}\, M \rceil$ bits. ($\lceil \mathrm{ld}\, M \rceil$ means the logarithm to the base of 2 rounded to the next higher natural number).

For this purpose, the transmitting physical layer generates an abbreviated sequence number from the RLC sequence number locally received as side information from the RLC layer. The physical layer contains another table or a memory which stores the abbreviated sequence number and the RLC sequence number, so that an image of the RLC sequence number follows the abbreviated sequence number. If the physical layer receives from the RLC layer a transport block containing side information, but all the abbreviated sequence numbers have already been issued, this transport block cannot be transmitted and the RLC layer is to be informed of this queue situation. In another case the physical layer selects a non-issued abbreviated sequence number, writes the relation to the RLC sequence number in the table and codes the transport block and sends it as a coded transport block with the side information via the radio interface. For an incremental redundancy to be sent afterwards, which relates to this coded transport block, again this abbreviated sequence number is taken from the table and sent in the side information in parallel with the incremental redundancy.

To inform the transmitting side (transmitting terminal or radio network controller) of the fact that a transport block has not been transmitted error-free, according to the invention a fast back channel is provided which is inserted directly between the receiving physical layer and the sending physical layer and not between the RLC layers concerned. The back channel is built up if a terminal and the radio network controller have agreed that data are transmitted according to the hybrid ARQ method of type II or III. The receiving physical layer checks whether the coded transport block has been transmitted correctly. If it has, a positive acknowledge signal ACK is sent to the sending physical layer over the back channel. Conversely, if the coded transport block has not been received error-free, a negative acknowledge command NACK is sent to the sending physical layer.

The positive and negative acknowledge commands ACK and NACK may each contain the abbreviated sequence number of the correctly or erroneously received coded transport block. The sending side can also identify the transmitted transport block affected by error on account of the number of a radio frame, which contains the positive or negative acknowledge command. The acknowledge commands in a radio frame of the back channel relate to coded transport blocks which were transmitted in transmission time intervals TTI which ended in a radio frame that preceded by exactly F radio frames (with $F \geq 1$) the radio frame containing the acknowledge commands. Fig. 3 shows this. A transport time interval TTI indicates the time which a transport block lasts and corresponds at least to the length of time of one radio frame RF which determines the time necessary for the transport blocks to be sent over the radio link or radio interface. The numbers of the radio frames are generally broadcast to the mobile stations via a broadcast channel. In Fig. 3 are shown various transport blocks TB0 to TB4 which are to be transmitted for the length of time of two radio frames RF. The transport block TB0 in this example is not transmitted according to the hybrid ARQ method of type II or III, whereas the other transport blocks are to be transmitted indeed according to the hybrid ARQ methods of type II or III. The announcement about a correct or error-affected transmission thus only occurs for the transport blocks TB1 to TB4 via a positive or negative acknowledge command over the physical back channel.

The transmission time interval TTI of the transport blocks TB1 and TB4 is equal to the length of time of a single radio frame RF and the transmission time interval TTI of the transport blocks TB0, TB2 and TB3 is equal to two radio frames RF. A first part of the transport blocks TB2, TB3 and TB0 and transport block TB1 are used for transmitting coded transport blocks during a first radio frame RF and a second part of the transport blocks TB2, TB3 and TB0 and transport block TB4 during a second subsequent radio frame RF over the physical channel PHC. It is assumed that the transport blocks TB1, TB2 and TB4 have been received correctly and the transport block TB3 from a terminal or from the network controller. The correct or error-affected reception is checked in a radio frame RF which comes after the ended Transmission Time Interval (TTI) and is announced to the sending side (F=2) in the next radio frame RF via the back channel BC. Fig. 3 shows in the third radio frame RF the positive acknowledge command ACK for the transport block TB1 and in the fourth radio frame RF the positive acknowledge command ACK for the transport blocks TB4 and TB2 and the negative acknowledge command NACK for the transport block TB3. No acknowledge command is sent for the transport block TB0, because this command is not transmitted according to an ARQ method of type II or III. The acknowledge commands are sorted in the sequence in which the transport blocks have been sent. The acknowledge command can, however, also be sent during a later radio frame RF. The number F of radio frames RF which occur between the reception of a transport block (i.e. after the transmission time interval has ended) or a number of transport blocks (i.e. after their transmission time intervals have ended, ending all at the same frame boundary) and the sending of an acknowledge command should be selected so that the receiving side has enough time to decode all co-transmitted transport blocks and check them for errors.

The transmission of the transport blocks TB0 to TB4 is accompanied with data called side information, which contain at least information about the redundancy version and about the abbreviated sequence number of a transport block. This side information is referred to as SI in Fig. 3.

If a sending side receives a negative acknowledge command NACK, additional incremental redundancy is prompted to be sent. The physical layer that has received the negative acknowledge command (NACK) for one or more received coded transport blocks affected by errors, determines the RLC sequence number of the packet data unit which the negative acknowledge commands relate to and announces to the associated RLC layer the RLC sequence numbers of the error-affected packet data units. At the same time, the receiving physical layer stores the RLC sequence numbers of the packet data units that have been announced to be error-affected. The RLC layer then sends each one of these packet data units again, as in the case where the opposite RLC layer requests to send a packet data unit again (hybrid ARQ method type I). The MAC layer generates a transport block from the packet data unit, which transport block is then transferred with the side information to the physical layer. The physical layer compares the RLC sequence number contained in the side information with the buffered sequence number and recognizes that this transport block is to be sent as a repetition of transmission. The physical layer generates a coded transport block which contains the necessary incremental redundancy and no longer the whole coded packet data unit – as defined by the hybrid ARQ method type II or III.

If the physical layer has received a positive acknowledge command ACK, it deletes the stored RLC sequence number. Via this RLC sequence number the physical layer can also acknowledge the correct reception of the packet data unit to the associated RLC layer, which RLC layer then deletes the packet data unit that has this RLC sequence number from its buffer. This is particularly possible in the case of the downlink direction, when physical layer and RLC layer are not accommodated on separate hardware components in the receiving mobile station. On the other hand, it may be more favorable for the sending RLC layer to wait for the acknowledgement of receipt from the RLC layer on the receiving side, because it is still possible for transmission errors to occur when the transport block is transferred from the receiving physical layer to the receiving RLC layer (more particularly in the uplink direction, because here the receiving physical layer and the receiving RLC layer are accommodated on different hardware components).

CLAIMS:

1. A wireless network comprising a radio network controller and a plurality of assigned terminals, which are each provided for exchanging data according to the hybrid ARQ method and which form a receiving and/or transmitting side, in which a physical layer of a transmitting side is arranged for

- storing coded transport blocks in a memory, which blocks contain at least a packet data unit which is delivered by the assigned radio link control layer and can be identified by a packet data unit sequence number,
- storing abbreviated sequence numbers whose length depends on the maximum number of coded transport blocks to be stored and which can be shown unambiguously in a packet data unit sequence number, and for
- transmitting coded transport blocks having at least the assigned abbreviated sequence number and

a physical layer of a receiving side is provided for testing the correct reception of the coded transport block and for sending a positive acknowledge command to the transmitting side over a back channel when there is correct reception and a negative acknowledge command when there is error-affected reception.

2. A wireless network as claimed in claim 1, characterized in that the radio network controller and the assigned terminals are provided for exchanging data according to the hybrid ARQ method of type II or III.

3. A wireless network as claimed in claim 1, characterized in that the physical layer of a receiving side is provided for sending a positive or negative acknowledge command with the abbreviated sequence number of the transport block received correctly or affected by error.

4. A wireless network as claimed in claim 1, characterized in that the physical layer of a sending side, after the reception of a positive or negative acknowledge command, is provided for determining the abbreviated sequence number of the respective coded

transport block transmitted correctly or affected by error based on the length of time between transmission of the transport block and reception of the acknowledge command and the sending sequence of the acknowledge command when there is a plurality of received acknowledge commands.

5. A wireless network as claimed in claim 3, characterized in that a transmission of the coded transport blocks is provided in radio frames and in that the transmission of an acknowledge command from the sending side to the receiving side is provided in a subsequent radio frame after the radio frame in which the transmission of the respective coded transport block ends.

6. A wireless network as claimed in claim 4, characterized in that the order of a plurality of acknowledge commands corresponds to the order of the transmission of last parts of transport blocks in a previous radio frame.

7. A wireless network as claimed in claim 1, characterized in that the physical layer of a sending side, upon reception of a positive acknowledge command, is provided for deleting the assigned transport block and the abbreviated sequence number and for announcing the correct reception to the radio link control layer.

8. A wireless network as claimed in claim 1, characterized in that the physical layer of a sending side, upon reception of a negative acknowledge command, is provided for requesting the radio link control layer to transmit a packet data unit that has been transmitted affected by error via the coded transport block and in that the physical layer, upon reception of a packet data unit repeatedly sent by the radio link control layer is provided for forming a coded transport block which contains an incremental redundancy.

9. A radio network controller in a wireless network comprising a plurality of terminals, which radio network controller is provided for exchanging data with the terminals and which forms a receiving and/or transmitting side, in which a physical layer of the radio network controller is arranged as a transmitting side for

- storing coded transport blocks in a memory, which blocks contain at least a packet data unit which is delivered by the assigned radio link control layer and can be identified by a packet data unit sequence number,

- storing abbreviated sequence numbers whose length depends on the maximum number of coded transport blocks to be stored and which can be shown unambiguously in a packet data unit sequence number, and for
- transmitting coded transport blocks having at least the assigned abbreviated sequence number and

a physical layer of the radio network controller is arranged as a receiving side for testing the correct reception of a coded transport block from a terminal and for sending a positive acknowledge command to a terminal over a back channel when there is correct reception and a negative acknowledge command when there is error-affected reception.

10. A terminal in a wireless network comprising further terminals and a radio network controller, which terminal is provided for exchanging data with the terminals and which forms a receiving and/or transmitting side, in which a physical layer of the terminal is arranged as a transmitting side for

- storing coded transport blocks in a memory, which blocks contain at least a packet data unit which is delivered by the assigned radio link control layer and can be identified by a packet data unit sequence number,
- storing abbreviated sequence numbers whose length depends on the maximum number of coded transport blocks to be stored and which can be shown unambiguously in a packet data unit sequence number, and for
- transmitting coded transport blocks to the radio network controller having at least the assigned abbreviated sequence number and

A physical layer of the terminal is arranged as a receiving side for testing the correct reception of a coded transport block from the radio network controller and for sending a positive acknowledge command to the radio network controller over a back channel when there is correct reception and a negative acknowledge command when there is error-affected reception.

ABSTRACT:

The invention relates to a wireless network comprising a radio network controller and a plurality of assigned terminals, which are provided for exchanging data according to the hybrid ARQ method of type II or III and each form a receiving and/or transmitting side. A physical layer of a transmitting side is arranged for

- storing coded transport blocks in a memory, which blocks contain at least a packet data unit delivered by the assigned radio link control layer and can be identified by a packet data unit sequence number,
- storing abbreviated sequence numbers whose length depends on the maximum number of coded transport blocks to be stored and which can be shown unambiguously shown in a packet data unit sequence number, and for
- transmitting coded transport blocks having at least the assigned abbreviated sequence numbers.

a physical layer of a receiving side is provided for testing the correct reception of the coded transport block and for sending a positive acknowledge command to the transmitting side over a back channel when there is correct reception and a negative acknowledge command when there is error-affected reception.

Fig. 3

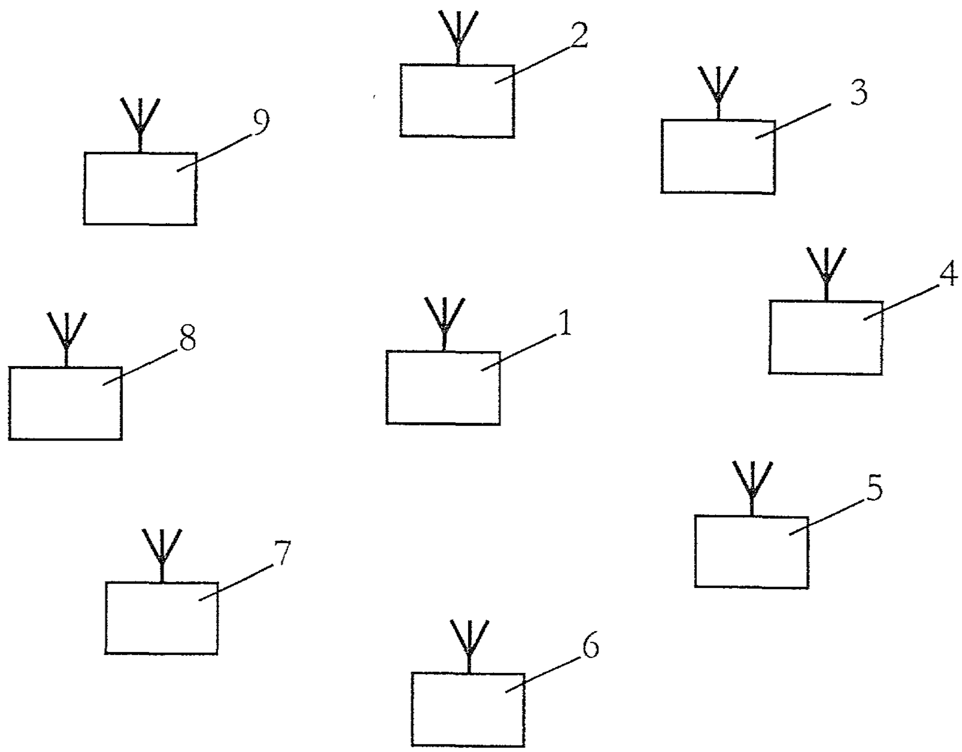

FIG. 1

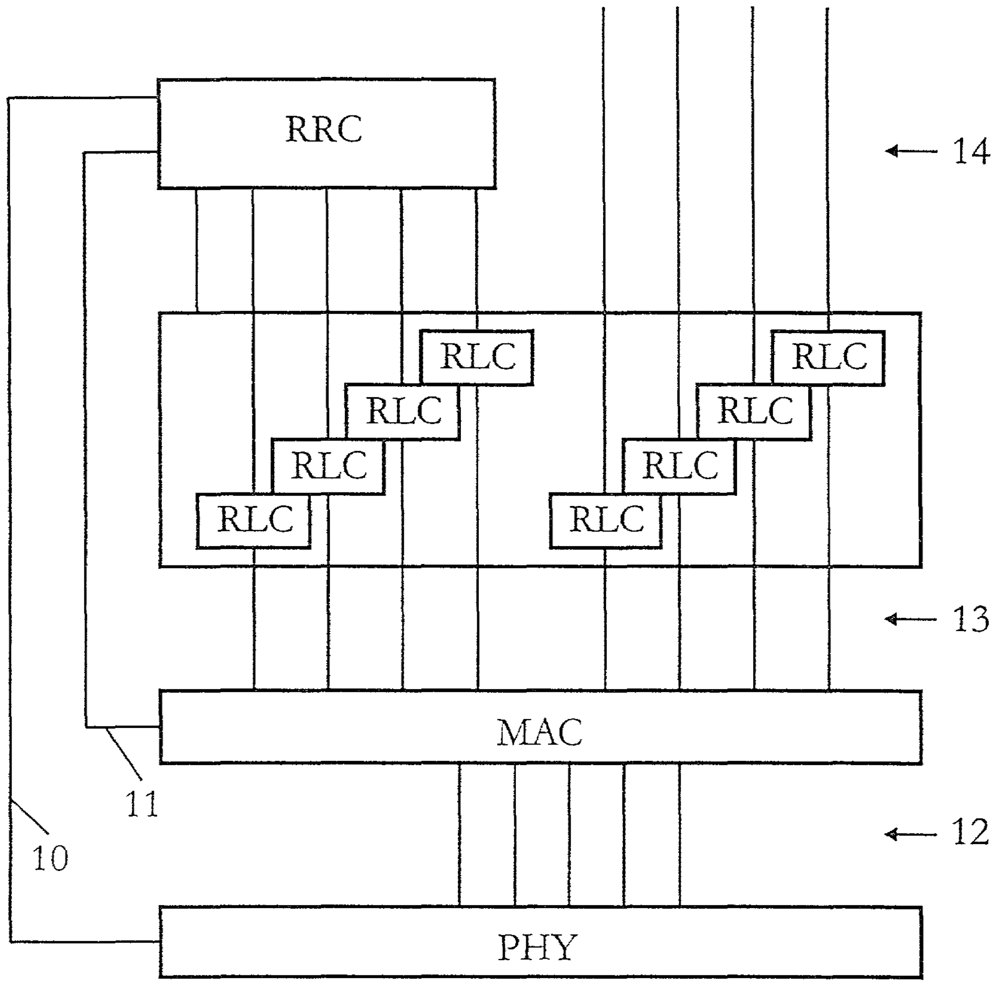

FIG. 2

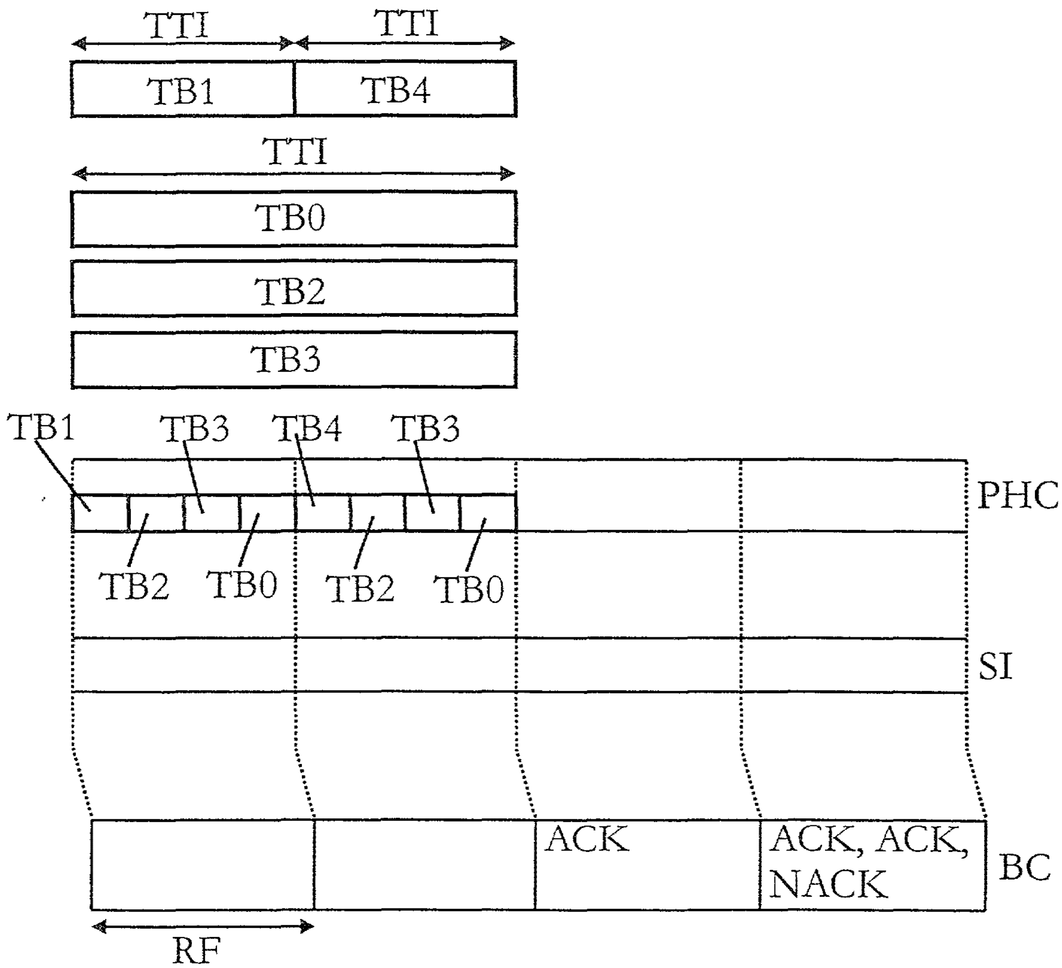
TTI
TTI
TB1
TB4
TTI
TB0
TB2
TB3
TB1
TB3
TB4
TB3
PHC
TB2
TB0
TB2
TB0
SI
ACK
ACK, ACK, NACK
BC
RF

FIG. 3

DECLARATION and POWER OF ATTORNEY

ATTORNEY'S DOCKET NO.:
PHDE000173

As a below named inventor, I hereby declare that:
My residence, post office address and citizenship are as stated below next to my name.
I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first 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
"Wireless network with a data exchange according to the ARQ method"
the specification of which (check one)
☐ is attached hereto.
☐ was filed on ______________________ as Application Serial No. ________________ and was amended on
____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by the amendment(s) referred to above.

I acknowledge the duty to disclose information which is material to patentability of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

COUNTRY	APP. NUMBER	DATE OF FILING (DATE, MONTH, YEAR)	PRIORITY CLAIMED UNDER 35 U.S.C. 119
Germany	**10050117.6**	**11 October 2000**	**YES**

I hereby claim the benefit under Title 35, United States Code, §120 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:

PRIOR UNITED STATES APPLICATION(S)

APPLICATION SERIAL NUMBER	FILING DATE	STATUS (PATENTED, PENDING, ABANDONED)

I hereby 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 issued thereon.

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. (list name and registration number)

Jack E. Haken, Reg. No. 26,902
Michael E. Marion, Reg. No. 32,266
Edward M. Blocker, Reg. No. 30,245

SEND CORRESPONDENCE TO: Corporate Patent Counsel; U.S. Philips Corporation; 580 White Plains Road; Tarrytown, NY 10591	DIRECT TELEPHONE CALLS TO: (name and telephone No.) (914) 332-0222

Dated:		Inventor's Signature:		
Full Name of Inventor	Last Name **HERRMANN**	First Name **Christoph**	Middle Name	
Residence & Citizenship	City **Aachen**	State or Foreign Country **Germany**	Country of Citizenship **Germany**	
Post Office Address	Street **Kasernenstrasse 6**	City **D-52064 Aachen**	State or Country **Germany**	Zip Code

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of | Atty. Docket
CHRISTOPH HERRMANN | DE 000173

Serial No. | Group Art Unit

Filed: CONCURRENTLY | Ex.

Title: WIRELESS NETWORK WITH A DATA EXCHANGE ACCORDING TO THE ARQ METHOD

Commissioner for Patents
Washington, D.C. 20231

APPOINTMENT OF ASSOCIATES

Sir:

The undersigned Attorney of Record hereby revokes all prior appointments (if any) of Associate Attorney(s) or Agent(s) in the above-captioned case and appoints:

JACK D. SLOBOD **(Registration No. 26,236)**

c/o PHILIPS ELECTRONICS CORPORATION NORTH AMERICA CORPORATION, Intellectual Property Department, 580 White Plains Road, Tarrytown, New York 10591, his Associate Attorney(s)/Agent(s) with all the usual powers to prosecute the above-identified application and any division or continuation thereof, to make alterations and amendments therein, and to transact all business in the Patent and Trademark Office connected therewith.

ALL CORRESPONDENCE CONCERNING THIS APPLICATION AND THE LETTERS PATENT WHEN GRANTED SHOULD BE ADDRESSED TO THE UNDERSIGNED ATTORNEY OF RECORD.

Respectfully,

Michael E. Marion, Reg. 32,266
Attorney of Record

Dated at Tarrytown, New York
this 9TH day of October, 2001.
C:\wp\appasoH.sl1.doc

Bib Data Sheet

CONFIRMATION NO. 8200

SERIAL NUMBER	FILING DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
09/973,312	10/09/2001 RULE	455	2681	DE 000173

APPLICANTS

Christoph Herrmann, Aachen, GERMANY;

** **CONTINUING DATA** **************************

** **FOREIGN APPLICATIONS** ********************

GERMANY 10050117.6 10/11/2000

IF REQUIRED, FOREIGN FILING LICENSE GRANTED
** 11/08/2001

		STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed	❑ yes ❑ no	GERMANY	3	10	3
35 USC 119 (a-d) conditions met	❑ yes ❑ no ❑ Met after Allowance				
Verified and Acknowledged	Examiner's Signature Initials				

ADDRESS

Philips Electronics North America Corporation
580 White Plains Road
Tarrytown ,NY 10591

TITLE

Wireless network with a data exchange according to the ARQ method

FILING FEE RECEIVED		
870	FEES: Authority has been given in Paper No. _________ to charge/credit DEPOSIT ACCOUNT No. _________ for following:	❑ All Fees ❑ 1.16 Fees (Filing) ❑ 1.17 Fees (Processing Ext. of time) ❑ 1.18 Fees (Issue) ❑ Other _________ ❑ Credit

PATENT APPLICATION SERIAL NO. ____________________

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

10/12/2001 GGEBREGI 00000059 141270 09973312

01 FC:101 740.00 CH

PTO-1556
(5/87)

*U.S. GPO: 2000-468-987/39595

PATENT APPLICATION FEE DETERMINATION RECORD
Effective October 1, 2001

Application or Docket Number: DE 000173

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)
TOTAL CLAIMS	10	
FOR	NUMBER FILED	NUMBER EXTRA
TOTAL CHARGEABLE CLAIMS	10 minus 20=	* 0
INDEPENDENT CLAIMS	3 minus 3 =	* 0
MULTIPLE DEPENDENT CLAIM PRESENT		☐

* If the difference in column 1 is less than zero, enter "0" in column 2

SMALL ENTITY TYPE ☐ RATE	FEE	OR	OTHER THAN SMALL ENTITY RATE	FEE
BASIC FEE	370.00	OR	BASIC FEE	740.00
X$ 9=		OR	X$18=	
X42=		OR	X84=	
+140=		OR	+280=	
TOTAL		OR	TOTAL	740

CLAIMS AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X42=		OR	X84=	
+140=		OR	+280=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE	OR	RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X42=		OR	X84=	
+140=		OR	+280=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE	OR	RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X42=		OR	X84=	
+140=		OR	+280=	
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."
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

CLAIMS ONLY

SERIAL NO.	FILING DATE
09973312	10-09-01
APPLICANT(S)	

CLAIMS

	AS FILED		AFTER 1st AMENDMENT		AFTER 2nd AMENDMENT	
	IND.	DEP.	IND.	DEP.	IND.	DEP.
1	/					
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TOTAL IND.	3					
TOTAL DEP.	7					
TOTAL CLAIMS	10					

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TOTAL IND.						
TOTAL DEP.						
TOTAL CLAIMS						

MAY BE USED FOR ADDITIONAL CLAIMS OR ADMENDMENTS

FORM PTO-2022 (1-96)

U.S.DEPARTMENT OF COMMERCE
Patent and Trademark Office

*U.S. Government Printing Office: 1996 - 433-214/70303

DE00173

BUNDESREPUBLIK DEUTSCHLAND

J1040 U.S. PTO
09/973312
10/09/01

Prioritätsbescheinigung über die Einreichung einer Patentanmeldung

Aktenzeichen:	100 50 117.6
Anmeldetag:	11. Oktober 2000
Anmelder/Inhaber:	Philips Corporate Intellectual Property GmbH, Hamburg/DE
Bezeichnung:	Drahtloses Netzwerk mit einem Datenaustausch nach der ARQ-Methode
IPC:	H 04 L, H 04 Q

Die angehefteten Stücke sind eine richtige und genaue Wiedergabe der ursprünglichen Unterlagen dieser Patentanmeldung.

CERTIFIED COPY OF PRIORITY DOCUMENT

München, den 13. Juni 2001
Deutsches Patent- und Markenamt
Der Präsident
Im Auftrag

A 9161

ZUSAMMENFASSUNG

Drahtloses Netzwerk mit einem Datenaustausch nach der ARQ-Methode

Die Erfindung bezieht sich auf ein drahtloses Netzwerk mit einer Funknetzwerk-Steuerung und mehreren zugeordneten Terminals, die jeweils zum Austausch von Daten nach der hybriden ARQ-Methode vom Typ II oder III vorgesehen sind und die jeweils eine Empfangs- und/oder Sendeseite bilden. Eine physikalische Schicht einer Sendeseite ist

- zur Speicherung von codierten Transportblöcken in einem Speicher, die wenigstens eine von der zugeordneten Funkverbindungssteuerungs-Schicht gelieferten Paketeinheit enthalten und die durch eine Paketeinheits-Folgenummer identifizierbar ist,
- zur Speicherung von Kurz-Folgenummern, deren Länge von der maximalen Anzahl von zu speichernden codierten Transportblöcken abhängt und die eindeutig auf eine Paketeinheits-Folgenummer abbildbar sind, und
- zur Übertragung von codierten Transportblöcken wenigstens mit der zugeordneten Kurz-Folgenummer vorgesehen.

Eine physikalische Schicht einer Empfangsseite ist zur Prüfung des korrekten Empfangs des codierten Transportblocks und zur Sendung eines positiven Bestätigungsbefehls bei korrektem Empfang und zur Sendung eines negativen Bestätigungsbefehls zur Sendeseite bei fehlerbehafteten Empfang über einen Rückkanal vorgesehen.

Fig. 3

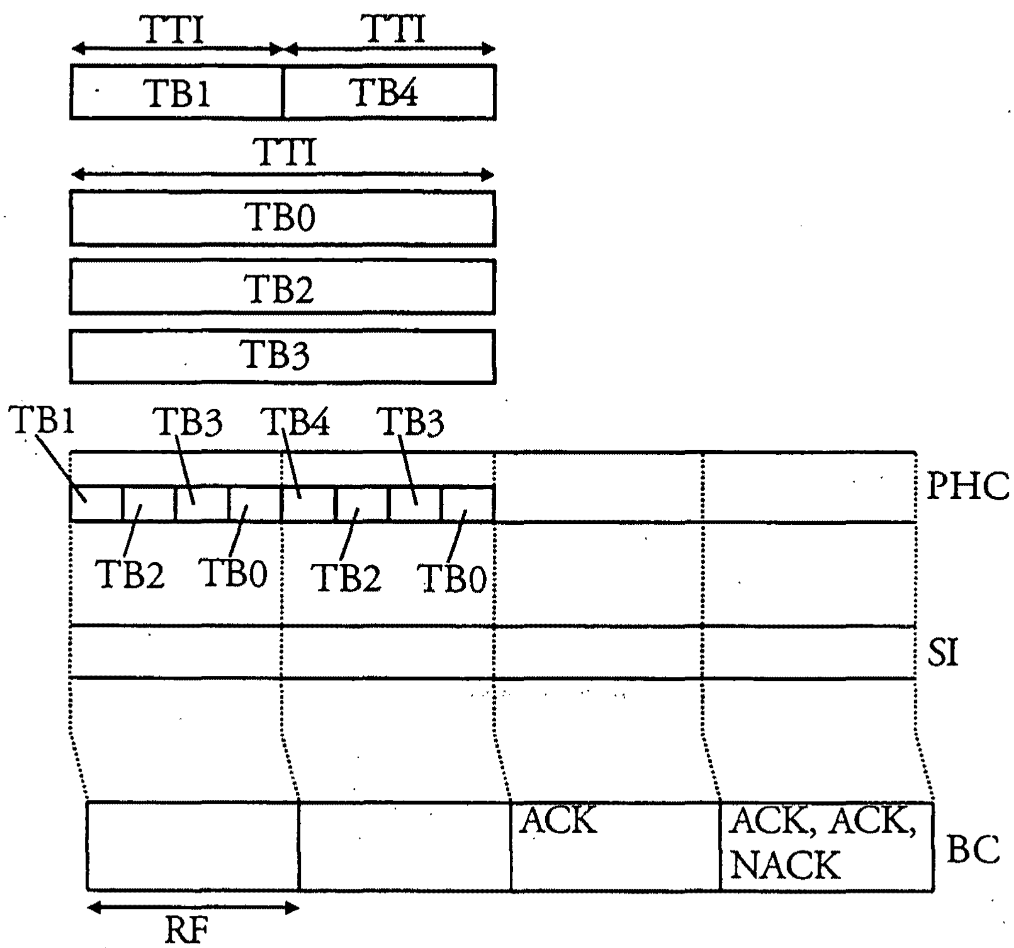

FIG. 3

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BESCHREIBUNG

Drahtloses Netzwerk mit einem Datenaustausch nach der ARQ-Methode

Die Erfindung bezieht sich auf ein drahtloses Netzwerk mit einer Funknetzwerk-Steuerung und mehreren zugeordneten Terminals, die jeweils zum Austausch von Daten nach der hybriden ARQ-Methode vorgesehen sind und die jeweils eine Empfangs- und/oder Sendeseite bilden.

Ein solches drahtloses Netzwerk ist aus dem Dokument „3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Report on Hybrid ARQ Type II/III (Release 2000), 3G TR 25.835 V0.0.2, TSG-RAN Working Group 2 (Radio L2 and Radio L3), Sophia Antipolis, France, 21-15 August 2000" bekannt. Hier wird zur gesicherten Übertragung von Daten eine Methode verwendet, die hybride ARQ-Methode Typ II oder III (ARQ = Automatic Repeat Request/ automatische Wiederholungsrückfrage) genannt wird. Die in Paketeinheiten (PDU = Packet Data Unit) von der Funkverbindungssteuerungs-Schicht (RLC-Schicht) gesendeten Daten sind zusätzlich zur fehlerkorrigierenden Codierung mit einer Fehlerkontrolle durch Übertragungswiederholung versehen. Das bedeutet, dass bei fehlerhaftem Empfang einer in einer von der zugeordneten physikalischen Schicht codierten Transportblock verpackten Paketeinheit ein erneutes Versenden der fehlerhaft empfangenen Paketeinheit erfolgt. Bei der hybriden ARQ-Methode Typ I wird die fehlerhaft empfangene Paketeinheit verworfen und eine identische Kopie erneut angefordert. Bei den hybriden ARQ-Methoden Typ II und III wird die fehlerhaft empfangene Paketeinheit zwischengespeichert und nach dem Empfang zusätzlicher auf die empfangene Paketeinheit bezogener inkrementeller Redundanz zusammen mit der fehlerhaft empfangenen Paketeinheit decodiert. Weil nur inkrementelle Redundanz und nicht die gesamte fehlerhafte Paketeinheit erneut übertragen wird, verringert sich die Datenmenge, die für Übertagungswiederholungen anfällt. Bei der ARQ-Methode Typ II ist die inkrementelle Redundanz ohne das zwischengespeicherte (fehlerhafte) Paket nutzlos, bei ARQ-Methode Typ III, ist die inkrementelle Redundanz auch ohne das zwischengespeicherte (fehlerhafte) Paket decodierbar. Die codierten Transportblöcke werden über wenigstens einen Transportkanal gesendet. Eine Meldung über den fehlerfreien Empfang erfolgt in oben genannten Dokument erst dann, wenn die empfangende RLC-Schicht an Hand von sogenannten RLC-Folgenummern feststellt, dass ihm Paketeinheiten fehlen, selbst wenn die physikalische Schicht die Paketeinheit schon als fehlerhaft erkannt hat. Das bedeutet, dass eine Paketeinheit über lange Zeiträume zwischengespeichert werden muss, bis eine inkrementelle Redundanz angefordert wird und dann nach erfolgreicher Decodierung der Empfang als korrekt bestätigt werden kann, insbesondere dann wenn die empfangende Seite die Netzseite ist, die physikalische Schicht und die RLC-Schicht in der Regel auf unterschiedlichen Hardwarekomponenten angesiedelt sind. Zusätzlich zu den in den Transportblöcken enthaltenen Paketeinheiten müssen für die Anwendung der hybriden ARQ-Methoden vom Typ II oder III synchron mit dem codierten Transportblock die RLC-Folgenummer der Paketeinheit und eine Redundanzversion übertragen werden. Dies geschieht in der Regel über einen deutlich besser geschützten Transportkanal, um sicherzustellen, dass diese Information schon beim ersten Empfang fehlerfrei ist. Sie ist entscheidend, wenn nach einer Übertragungswiederholung mit inkrementeller Redundanz die zwischengespeicherte (fehlerhafte) Paketeinheit zusammen mit der inkrementellen Redundanz decodiert werden soll, da die inkrementelle Redundanz über die Redundanzversion der jeweiligen Paketeinheit zugeordnet werden muss.

Der Erfindung liegt die Aufgabe zugrunde, ein drahtloses Netzwerk zu schaffen, bei dem fehlerbehaftete nach der ARQ-Methode vom Typ II oder III wiederholt zu übertragende Daten im Mittel geringere Zeit zwischengespeichert werden.

Die Aufgabe wird durch das eingangs genannte drahtlose Netzwerk, das eine Funknetzwerk-Steuerung und mehrere zugeordnete Terminals enthält, die jeweils zum Austausch von Daten nach der hybriden ARQ-Methode vom Typ II oder III vorgesehen sind und die jeweils eine Empfangs- und/oder Sendeseite bilden, durch folgende Merkmale gelöst:
Eine physikalische Schicht einer Sendeseite ist

- zur Speicherung von codierten Transportblöcken in einem Speicher, die wenigstens eine von der zugeordneten Funkverbindungssteuerungs-Schicht gelieferten Paketeinheit enthalten und die durch eine Paketeinheits-Folgenummer identifizierbar ist,
- zur Speicherung von Kurz-Folgenummern, deren Länge von der maximalen Anzahl

von zu speichernden codierten Transportblöcken abhängt und die eindeutig auf eine Paketeinheits-Folgenummer abbildbar sind, und

- zur Übertragung von codierten Transportblöcken wenigstens mit der zugeordneten Kurz-Folgenummer und

eine physikalische Schicht einer Empfangsseite ist zur Prüfung des korrekten Empfangs des codierten Transportblocks und zur Sendung eines positiven Bestätigungsbefehls bei korrektem Empfang und zur Sendung eines negativen Bestätigungsbefehls zur Sendeseite bei fehlerbehafteten Empfang über einen Rückkanal vorgesehen.

Das erfindungsgemäße drahtlose Netzwerk kann beispielsweise ein Funknetzwerk nach dem UMTS-Standard (UMTS = Universal Mobile Telecommunication System) sein. Hierbei wird durch die Übertragung eines Bestätigungsbefehls über einen bisher nicht bekannten Rückkanal direkt zwischen einer physikalischen Schicht einer Sendeseite (z.B. Funknetzwerk-Steuerung) und der physikalischen Schicht einer Empfangsseite (z.B. Terminal) bei der Übertragung von Daten nach der ARQ-Methode vom Typ II oder III eine korrekte oder fehlerbehaftete Übertragung eines Transportblocks schneller der Sendeseite mitgeteilt als bisher bekannt ist. Dadurch kann eine Übertragungswiederholung mit inkrementeller Redundanz schnell erfolgen. Das erlaubt der Empfangsseite, den fehlerhaft empfangenen codierten Transportblock deutlich kürzer zwischenzuspeichern, da die für die korrekte Decodierung erforderliche zusätzliche Redundanz früher vorliegt. Somit reduziert sich auch der im Mittel erforderliche Speicherbedarf bzw. Speicherbereich zur Zwischenspeicherung von fehlerhaft empfangenen codierten Transportblöcken.

Die Verwendung der Kurz-Folgenummern reduziert die Größe der zur Verwaltung der Transportblöcke und Paketeinheiten erforderlichen zusätzlich zu übertragenden Information und vereinfacht die Zuordnung eines empfangenen Bestätigungsbefehls zu den gespeicherten Transportblöcken. Hierbei ist die physikalische Schicht einer Empfangsseite zur Sendung eines positiven oder negativen Bestätigungsbefehls mit der Kurz-Folgenummer des korrekt oder fehlerhaft empfangenen Transportblocks über den Rückkanal vorgesehen.

Anstelle der Übertragung der Kurz-Folgenummer kann eine Kurz-Folgenummer eines

Transportblocks, auf den sich ein empfangener Bestätigungsbefehl bezieht, auch implizit anhand der Zeitdauer zwischen Übertragung des Transportblocks und Empfang des Bestätigungsbefehls und der Sendereihenfolge des Bestätigungsbefehls bei mehreren empfangenen Bestätigungsbefehlen ermittelt werden. Dies wird auf einfache Weise dadurch ermöglicht, dass eine Übertragung der Transportblöcke in Funkrahmen vorgesehen ist und dass die Übertragung eines Bestätigungsbefehls von der Sendeseite zur Empfangsseite frühestens im F-ten Funkrahmen nach dem Funkrahmen vorgesehen ist, der den entsprechenden Transportblock enthält (mit $F \geq 1$). Dabei entspricht die Reihenfolge mehrerer Bestätigungsbefehle der Reihenfolge der Übertragung von Transportblöcken in einem vorhergehenden Funkrahmen entspricht.

Wenn die physikalische Schicht einer Sendeseite einen negativen Bestätigungsbefehl erhalten hat, fordert die physikalische Schicht bei der Funkverbindungssteuerungs-Schicht diejenige Paketeinheit noch einmal an, die über den codierten Transportblock fehlerbehaftet übertragen worden ist. Nach Empfang einer Paketeinheit bildet die physikalische Schicht daraus einen codierten Transportblock, der eine inkrementelle Redundanz enthält.

Die Erfindung bezieht sich auch auf eine Funknetzwerk-Steuerung und ein Terminal in einem drahtlosen Netzwerk, die jeweils Daten nach der hybriden ARQ-Methode austauschen.

Ausführungsbeispiele der Erfindung werden nachstehend anhand der Fig. näher erläutert. Es zeigen:

Fig. 1	ein drahtloses Netzwerk mit einer Funknetzwerk-Steuerung und mehreren Terminals,
Fig. 2	ein Schichtenmodell zur Erläuterung verschiedener Funktionen eines Terminals oder einer Funknetzwerk-Steuerung und
Fig. 3	mehrere Funkrahmen, in denen über den Funkweg zu übertragende Daten zwischen Funknetzwerk-Steuerung und Terminals enthalten sind.

In Fig. 1 ist ein drahtloses Netzwerk, z.B. Funknetzwerk, mit einer Funknetzwerk-Steuerung (Radio Network Controller = RNC) 1 und mehreren Terminals 2 bis 9 dargestellt. Die Funknetzwerk-Steuerung 1 ist für Steuerung aller am Funkverkehr beteiligten Komponenten verantwortlich, wie z.B. der Terminals 2 bis 9. Ein Steuer- und Nutzdatenaustausch findet zumindest zwischen der Funknetzwerk-Steuerung 1 und den Terminals 2 bis 9 statt. Die Funknetzwerk-Steuerung 1 baut jeweils eine Verbindung zur Übertragung von Nutzdaten auf.

In der Regel sind die Terminals 2 bis 9 Mobilstationen und die Funknetzwerk-Steuerung 1 ist fest installiert. Eine Funknetzwerk-Steuerung 1 kann gegebenenfalls aber auch beweglich bzw. mobil sein.

In dem drahtlosen Netzwerk werden beispielsweise Funksignale nach dem FDMA-, TDMA- oder CDMA-Verfahren (FDMA = frequency division multiplex access, TDMA = time division multiplex access, CDMA = code division multiplex access) oder nach einer Kombination der Verfahren übertragen.

Beim CDMA-Verfahren, das ein spezielles Code-Spreiz-Verfahren (code spreading) ist, wird eine von einem Anwender stammende Binärinformation (Datensignal) mit jeweils einer unterschiedlichen Codesequenz moduliert. Eine solche Codesequenz besteht aus einem pseudo-zufälligen Rechtecksignal (pseudo noise code), dessen Rate, auch Chiprate genannt, in der Regel wesentlich höher als die der Binärinformation ist. Die Dauer eines Rechteckimpulses des pseudo-zufälligen Rechtecksignals wird als Chipintervall T_C bezeichnet. $1/T_C$ ist die Chiprate. Die Multiplikation bzw. Modulation des Datensignals mit dem pseudo-zufälligen Rechtecksignal hat eine Spreizung des Spektrums um den Spreizungsfaktor $N_C = T/T_C$ zur Folge, wobei T die Dauer eines Rechteckimpulses des Datensignals ist.

Nutzdaten und Steuerdaten zwischen wenigstens einem Terminal (2 bis 9) und der Funknetzwerk-Steuerung 1 werden über von der Funknetzwerk-Steuerung 1 vorgegebene Kanäle übertragen. Ein Kanal ist durch einen Frequenzbereich, einen Zeitbereich und z.B. beim CDMA-Verfahren durch einen Spreizungscode bestimmt. Die Funkverbindung von der Funknetzwerk-Steuerung 1 zu den Terminals 2 bis 9 wird als Downlink und von den Terminals zur Basisstation als Uplink bezeichnet. Somit werden über Downlink-Kanäle Daten von der Basisstation zu den Terminals und über Uplink-Kanäle Daten von Terminals zur Basisstation gesendet.

Beispielsweise kann ein Downlink-Steuerkanal vorgesehen sein, der benutzt wird, um von der Funknetzwerk-Steuerung 1 Steuerdaten vor einem Verbindungsaufbau an alle Terminals 2 bis 9 zu verteilen. Ein solcher Kanal wird als Downlink-Verteil-Steuerkanal (broadcast control channel) bezeichnet. Zur Übertragung von Steuerdaten vor einem Verbindungsaufbau von einem Terminal 2 bis 9 zur Funknetzwerk-Steuerung 1 kann beispielsweise ein von der Funknetzwerk-Steuerung 1 zugewiesener Uplink-Steuerkanal verwendet werden, auf den aber auch andere Terminals 2 bis 9 zugreifen können. Ein Uplink-Kanal, der von mehreren oder allen Terminals 2 bis 9 benutzt werden kann, wird als gemeinsamer Uplink-Kanal (common uplink channel) bezeichnet. Nach einem Verbindungsaufbau z.B. zwischen einem Terminal 2 bis 9 und der Funknetzwerk-Steuerung 1 werden Nutzdaten über einen Downlink- und ein Uplink-Nutzkanal übertragen. Kanäle, die nur zwischen einem Sender und einem Empfänger aufgebaut werden, werden als dedizierte Kanäle bezeichnet. In der Regel ist ein Nutzkanal ein dedizierter Kanal, der von einem dedizierten Steuerkanal zur Übertragung von verbindungsspezifischen Steuerdaten begleitet werden kann.

Damit Nutzdaten zwischen der Funknetzwerk-Steuerung 1 und einem Terminal ausgetauscht werden können, ist es erforderlich, dass ein Terminal 2 bis 9 mit der Funknetzwerk-Steuerung 1 synchronisiert wird. Beispielsweise ist aus dem GSM-System (GSM = Global System for Mobile communication) bekannt, in welchem eine Kombination aus FDMA- und TDMA-Verfahren benutzt wird, dass nach der Bestimmung eines geeigneten Frequenzbereichs anhand vorgegebener Parameter die zeitliche Position eines Rahmens bestimmt wird (Rahmensynchronisation), mit dessen Hilfe die zeitliche Abfolge zur Übertragung von Daten erfolgt. Ein solcher Rahmen ist immer für die Datensynchronisation von Terminals und Basisstation bei TDMA-, FDMA- und CDMA-Verfahren notwendig. Ein solcher Rahmen kann verschiedene Unter- oder Subrahmen enthalten oder mit mehreren anderen aufeinanderfolgenden Rahmen einen Superrahmen bilden.

Der Steuer- und Nutzdatenaustausch über die Funkschnittstelle zwischen der Funknetzwerk-Steuerung 1 und den Terminals 2 bis 9 kann mit dem in Fig. 2 dargestellten, beispielhaften Schichtenmodell oder Protokollarchitektur (vgl. z.B. 3rd Generation Partnership Project (3GPP); Technical Specification Group (TSG) RAN; Working Group 2 (WG2); Radio Interface Protocol Architecture; TS 25.301 V3.2.0 (1999-10)) erläutert werden. Das Schichtenmodell besteht aus drei Protokollschichten: der physikalischen Schicht PHY, der Datenverbindungsschicht mit den Unterschichten MAC und RLC (in Fig. 2 sind mehrere Ausprägungen der Unterschicht RLC dargestellt) und der Schicht RRC. Die Unterschicht MAC ist für die Medienzugriffssteuerung (Medium Access Control), die Unterschicht RLC für die Funkverbindungssteuerung (Radio Link Control) und die Schicht RRC für die Funkverwaltungssteuerung (Radio Resource Control) zuständig. Die Schicht RRC ist für die Signalisierung zwischen den Terminals 2 bis 9 und der Funknetzwerk-Steuerung 1 verantwortlich. Die Unterschicht RLC dient zur Steuerung einer Funkverbindung zwischen einem Terminal 2 bis 9 und der Funknetzwerk-Steuerung 1. Die Schicht RRC steuert die Schichten MAC und PHY über Steuerungsverbindungen 10 und 11. Hiermit kann die Schicht RRC die Konfiguration der Schichten MAC und PHY steuern. Die physikalische Schicht PHY bietet der MAC-Schicht Transportkanäle bzw. Transportverbindungen 12 an. Die MAC-Schicht stellt der RLC-Schicht logische Verbindungen 13 zur Verfügung. Die RLC-Schicht ist über Zugangspunkte 14 von Applikationen erreichbar.

In einem solchen Netzwerk wird eine Methode zur sicheren Übertragung von Daten verwendet, die hybride ARQ-Methode (ARQ = Automatic Repeat Request/ automatische Wiederholungsrückfrage) genannt wird. Die in Paketeinheiten (PDU = Packet Data Unit) gesendeten Daten sind zusätzlich zur fehlerkorrigierenden Codierung (Forward Error Correction) mit einer Fehlerkontrolle durch Übertragungswiederholungen versehen. Das bedeutet, dass bei einem fehlerhaften Empfang einer Paketeinheit ein erneutes Versenden der fehlerhaft empfangenen Paketeinheit erfolgt. Bei den hybriden ARQ-Methoden vom Typ II oder III ist es möglich, dass nur bestimmte Teile der Daten bei einer fehlerhaften Übertragung wiederholt gesendet werden. Dies wird auch als inkrementelle Redundanz (Incremental Redundancy) bezeichnet.

Die Paketeinheiten werden in der RLC-Schicht gebildet und in der MAC-Schicht in

Transportblöcke verpackt, die über die von der physikalischen Schicht zur Verfügung gestellten Transportkanäle von der Funknetzwerk-Steuerung zu einem Terminal oder umgekehrt übertragen werden. In der physikalischen Schicht werden die Transportblöcke mit einer zyklische Redundanzprüfungsbitfolge (CRC = Cyclic Redundancy Check) versehen und beides zusammen codiert. Das Ergebnis dieser Operation wird als codierter Transportblock bezeichnet. Die codierten Transportblöcke enthalten eine Paketeinheit und Steuerinformationen.

Codierte Transportblöcke, die fehlerhaft übertragen wurden, werden zur Umsetzung der hybriden ARQ-Methode vom Typ II oder III in der physikalischen Schicht der Empfangsseite so lange zwischengespeichert, bis die nachträglich angeforderte inkrementelle Redundanz eine fehlerfreie Decodierung ermöglicht. Bekannt ist, dass dazu als sogenannte Seiteninformation (side information) (vgl. „3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Report on Hybrid ARQ Type II/III (Release 2000), 3G TR 25.835 V0.0.2, TSG-RAN Working Group 2 (Radio L2 and Radio L3), Sophia Antipolis, France, 21-15 August 2000") wenigstens die RLC-Folgenummer oder Paketeinheits-Folgenummer, welche eine Paketeinheit kennzeichnet, und eine Redundanzversion parallel zum codierten Transportblock bzw. der nachträglich angeforderten inkrementellen Redundanz übertragen werden muss, damit die Empfangsseite bei Empfang eines fehlerhaften codierten Transportblockes bzw. zusätzlicher inkrementeller Redundanz erkennen kann, um welchen codierten Transportblock es sich handelt bzw. auf welchen zwischengespeicherten codierten Transportblock sich die zusätzlich übertragene Redundanz bezieht. Die Redundanzversion gibt an, ob es sich um eine erstmals gesendete inkrementelle Redundanz oder um welche nachfolgend unter Umständen mehrfach wiederholte inkrementelle Redundanz es sich handelt.

Erfindungsgemäß wird bei der Übertragung der Seiteninformation über die Funkschnittstelle anstelle der RLC-Folgenummer eine Kurz-Folgenummer verwendet, deren Länge deutlich kleiner als die RLC-Folgenummer ist. Diese Kurz -Folgenummer ist bestimmt durch die Anzahl M von codierten Transportblöcken, die empfangsseitig maximal gleichzeitig zwischengespeichert werden können, und besteht aus $\lceil \mathrm{ld}\, M \rceil$ Bits. ($\lceil \mathrm{ld}\, M \rceil$ bedeutet den auf die nächst größere natürliche Zahl aufgerundeten Logarithmus dualis)

Dazu erzeugt die sendende physikalische Schicht aus der von der RLC-Schicht als Seiteninformation lokal empfangenen RLC-Folgenummer eine Kurz-Folgenummer. Die physikalische Schicht enthält noch eine Tabelle oder einen Speicher, welche die Kurz-Folgenummer und die RLC-Folgenummer so speichert, dass eine Abbildung der RLC-Folgenummer auf die Kurz-Folgenummer erfolgt. Empfängt die physikalische Schicht von der RLC-Schicht einen Transportblock mit Seiteninformation, aber alle Kurz-Folgenummern sind schon vergeben, so kann dieser Transportblock nicht übertragen werden, und die RLC-Schicht muss über diese Stausituation informiert werden. Im anderen Fall wählt die physikalische Schicht eine nicht vergebene Kurz-Folgenummer aus, trägt den Zusammenhang zur RLC-Folgenummer in die Tabelle ein, und codiert den Transportblock und sendet ihn als codierten Transportblock mit der Seiteninformation über die Funkschnittstelle. Für eine nachträglich zu sendende inkrementelle Redundanz, die sich auf diesen codierten Transportblock bezieht, wird wiederum diese Kurz-Folgenummer aus der Tabelle entnommen und in der Seiteninformation parallel mit der inkrementellen Redundanz versendet.

Um der Sendeseite (sendendes Terminal oder Funknetzwerk-Steuerung) mitzuteilen, dass ein Transportblock nicht fehlerfrei übertragen worden ist, ist erfindungsgemäß ein schneller Rückkanal (Back Channel) vorgesehen, der direkt zwischen der empfangenden physikalischen Schicht und der sendenden physikalischen Schicht aufgebaut wird und nicht zwischen den beteiligten RLC-Schichten. Der Rückkanal wird jeweils dann aufgebaut, wenn zwischen einem Terminal und der Funknetzwerk-Steuerung vereinbart worden ist, Daten nach der hybriden ARQ-Methode vom Typ II oder III zu übertragen. Die empfangende physikalische Schicht prüft, ob der codierte Transportblock korrekt übertragen worden ist. Ist dies der Fall wird über den Rückkanal zur sendenden physikalischen Schicht ein positiver Bestätigungsbefehl ACK (Acknowledge) gesendet. Im umgekehrten Fall, wenn der codierte Transportblock nicht fehlerfrei empfangen worden ist, wird ein negativer Bestätigungsbefehl NACK (Negative Acknowledge) zur sendenden physikalischen Schicht geliefert.

Der positive und negative Bestätigungsbefehl ACK und NACK können jeweils die Kurz-Folgenummer des korrekt oder fehlerhaft empfangenen codierten Transportblocks enthalten. Die sendende Seite kann auch anhand der Nummer eines Funkrahmens, welcher den positiven oder negativen Bestätigungsbefehl enthält, den fehlerhaft übertragenen Transportblock identifizieren. Dabei beziehen sich die Bestätigungsbefehle in einem Funkrahmen des Rückkanals, auf codierte Transportblöcke, die in Übertragungszeitintervallen (TTI = Transmission Time Interval) übertragen wurden, die in einem Funkrahmen zu Ende gingen, der genau F Funkrahmen (mit F≥1) vor dem die Bestätigungsbefehle enthaltenden Funkrahmen lag. Aus der Fig. 3 lässt sich das entnehmen. Ein Transportzeitintervall TTI gibt die Zeitdauer eines Transportblocks an und entspricht mindestens der Dauer eines Funkrahmens RF, der den zeitlichen Verlauf der Übertragung der Transportblöcke über den Funkweg bzw. Funkschnittstelle bestimmt. Die Nummern der Funkrahmen wird in der Regel über einen Verteilkanal (Broadcast channel) den Mobilstationen mitgeteilt. In Fig. 3 sind verschiedene Transportblöcke TB0 bis TB4 dargestellt, die während der Dauer von zwei Funkrahmen RF übertragen werden sollen. Der Transportblock TB0 wird in diesem Beispiel nicht nach der hybriden ARQ-Methode vom Typ II oder III übertragen, während die anderen Transportblöcke nach den hybriden ARQ-Methoden vom Typ II oder III übertragen werden sollen. Die Mitteilung über eine korrekte oder fehlerbehaftete Übertragung erfolgt also nur für die Transportblöcke TB1 bis TB4 mit Hilfe eines positiven oder negativen Bestätigungsbefehls über den physikalischen Rückkanal.

Das Übertragungszeitintervall TTI der Transportblöcke TB1 und TB4 ist gleich der Dauer eines einzigen Funkrahmens RF und das der Transportblöcke TB0, TB2 und TB3 jeweils zwei Funkrahmen RF. Ein erster Teil der Transportblöcke TB2, TB3 und TB0 und der Transportblock TB1 werden während eines ersten Funkrahmens RF und der zweite Teil der Transportblöcke TB2, TB3 und TB0 und der Transportblock TB4 während eines zweiten, darauffolgenden Funkrahmens RF über den physikalischen Kanal PHC zur Übertragung der codierten Transportblöcke verwendet. Es sei vorausgesetzt, dass die Transportblöcke TB1, TB2 und TB4 korrekt und der Transportblock TB3 fehlerbehaftet von einem Terminal oder der Funknetzwerk-Steuerung empfangen worden sind. Der korrekte oder fehlerbehaftete Empfang wird in dem Funkrahmen RF geprüft, der auf das beendete Übertragungszeitintervall (TTI) folgt, und im nächsten Funkrahmen RF über den Rückkanal BC der sendenden Seite mitgeteilt (F=2). Die Fig. 3 zeigt im dritten Funkrahmen RF den positiven Bestätigungsbefehl ACK für den Transportblock TB1 und im vierten Funkrahmen RF den positiven Bestätigungsbefehl ACK für die Transportblöcke TB4 und TB2 und den negativen Bestätigungsbefehl NACK für den Transportblock TB3. Für den Transportblock TB0 wird kein Bestätigungsbefehl gesendet, da dieser nicht nach einer ARQ-Methode vom Typ II oder III übertragen worden ist. Die Bestätigungsbefehle sind dabei entsprechend der Reihenfolge sortiert, in der die Transportblöcke gesendet worden sind. Der Bestätigungsbefehl kann aber auch während eines späteren Funkrahmens RF gesendet werden. Die Anzahl F der Funkrahmen RF, die zwischen dem Empfang eines Transportblocks (d.h. nach Ablauf des Übertragungszeitintervalls) oder einer Anzahl von Transportblöcken (d.h. nach Ablauf ihrer Übertragungszeitintervalle, die alle an derselben Rahmengrenze enden) und der Sendung eines Bestätigungsbefehls liegen, sollte dabei so gewählt werden, dass die Empfangsseite genügend Zeit hat alle mitgesendeten Transportblöcke zu decodieren und auf Fehlerfreiheit zu untersuchen.

Die Übertragung der Transportblöcke TB0 bis TB4 wird von als Seiteninformationen (Side Information) genannten Daten begleitet, die wenigstens Auskunft über die Redundanzversion und über die Kurz-Folgenummer eines Transportsblocks enthält. Diese Seiteninformation ist in Fig. 3 mit SI bezeichnet.

Falls eine sendende Seite einen negativen Bestätigungsbefehl NACK erhält, wird das Versenden von zusätzlicher inkrementeller Redundanz veranlasst. Die physikalische Schicht, die den negativen Bestätigungsbefehl (NACK) für eine oder mehrere fehlerhaft empfangene codierte Transportblöcke empfangen hat, ermittelt die RLC-Folgenummer der Paketeinheit, auf die sich die negativen Bestätigungsbefehle beziehen und teilt der zugehörigen RLC-Schicht die RLC-Folgenummern der fehlerhaften Paketeinheiten mit. Gleichzeitig speichert die empfangende physikalische Schicht die RLC-Folgenummern der als fehlerhaft gemeldeten Paketeinheiten. Die RLC-Schicht sendet dann – wie in dem Fall, bei dem sie von der gegenüberliegenden RLC-Schicht zur erneuten Sendung einer Paketeinheit aufgefordert wird (hybride ARQ-Methode Typ I) – jede dieser Paketeinheiten erneut ab. Die MAC-Schicht erzeugt aus der Paketeinheit, einen Transportblock, der dann mit der Seiteninformation an die physikalische Schicht weitergegeben wird. Die physikalische Schicht vergleicht die in der Seiteninformation enthaltene RLC-Folgenummer mit der zwischengespeicherten, und erkennt, dass dieser Transportblock als Übertragungswiederholung gesendet werden muss. Die physikalische Schicht erzeugt einen codierten Transportblock, der - nach Maßgabe der hybriden ARQ-Methode Typ II oder III - die erforderliche inkrementelle Redundanz enthält und nicht mehr die gesamte codierte Paketeinheit.

Falls die physikalische Schicht einen positiven Bestätigungsbefehl ACK erhalten hat, löscht sie die gespeicherte RLC-Folgenummer. Die physikalische Schicht kann mittels dieser RLC-Folgenummer ebenfalls der zugehörigen RLC-Schicht den korrekten Empfang der Paketeinheit bestätigen, die dann die Paketeinheit mit dieser RLC-Folgenummer aus ihrem Puffer löscht. Dies ist insbesondere im Falle der Downlink-Richtung möglich, wenn physikalische Schicht und RLC-Schicht auf der empfangenen Mobilstation nicht auf getrennten Hardware-Komponenten angesiedelt sind.. Dagegen kann es günstiger sein, dass die sendende RLC-Schicht die Empfangsmeldung von der RLC-Schicht der Empfangsseite abwartet, da immer noch Übertragungsfehler bei der Weiterleitung von der empfangenden physikalischen Schicht zur empfangenen RLC-Schicht möglich sind (insbesondere in Uplink-Richtung, da hier die empfangende physikalische Schicht und die empfangende RLC-Schicht auf verschiedenen Hardware-Komponenten untergebracht sind).

PATENTANSPRÜCHE

1. Drahtloses Netzwerk mit einer Funknetzwerk-Steuerung und mehreren zugeordneten Terminals, die jeweils zum Austausch von Daten nach der hybriden ARQ-Methode vom Typ II oder III vorgesehen sind und die jeweils eine Empfangs- und/oder Sendeseite bilden, wobei

eine physikalische Schicht einer Sendeseite

- zur Speicherung von codierten Transportblöcken in einem Speicher, die wenigstens eine von der zugeordneten Funkverbindungssteuerungs-Schicht gelieferten Paketeinheit enthalten und die durch eine Paketeinheits-Folgenummer identifizierbar ist,
- zur Speicherung von Kurz-Folgenummern, deren Länge von der maximalen Anzahl von zu speichernden codierten Transportblöcken abhängt und die eindeutig auf eine Paketeinheits-Folgenummer abbildbar sind, und
- zur Übertragung von codierten Transportblöcken wenigstens mit der zugeordneten Kurz-Folgenummer vorgesehen ist und

eine physikalische Schicht einer Empfangsseite zur Prüfung des korrekten Empfangs des codierten Transportblocks und zur Sendung eines positiven Bestätigungsbefehls bei korrektem Empfang und zur Sendung eines negativen Bestätigungsbefehls zur Sendeseite bei fehlerbehafteten Empfang über einen Rückkanal vorgesehen ist.

2. Drahtloses Netzwerk nach Anspruch 1,

dadurch gekennzeichnet,

dass die physikalische Schicht einer Empfangsseite zur Sendung eines positiven oder negativen Bestätigungsbefehls mit der Kurz-Folgenummer des korrekt oder fehlerhaft empfangenen Transportblocks über den Rückkanal vorgesehen ist.

3. Drahtloses Netzwerk nach Anspruch 1,
dadurch gekennzeichnet,
dass die physikalische Schicht einer Sendeseite nach Empfang eines positiven oder negativen Bestätigungsbefehls zur Ermittlung der Kurz-Folgenummer des entsprechenden korrekt oder fehlerhaft übertragenen codierten Transportblocks anhand der Zeitdauer zwischen Übertragung des Transportblocks und Empfang des Bestätigungsbefehls und der Sendereihenfolge des Bestätigungsbefehls bei mehreren empfangenen Bestätigungsbefehlen vorgesehen ist.

4. Drahtloses Netzwerk nach Anspruch 3,
dadurch gekennzeichnet,
dass eine Übertragung der codierten Transportblöcke in Funkrahmen vorgesehen ist und dass die Übertragung eines Bestätigungsbefehls von der Sendeseite zur Empfangsseite in einem nachfolgenden Funkrahmen nach dem Funkrahmen vorgesehen ist, in dem die Übertragung des entsprechenden codierten Transportblocks endet.

5. Drahtloses Netzwerk nach Anspruch 4,
dadurch gekennzeichnet,
dass die Reihenfolge mehrerer Bestätigungsbefehle der Reihenfolge der Übertragung von letzten Teilen von Transportblöcken in einem vorhergehenden Funkrahmen entspricht.

6. Drahtloses Netzwerk nach Anspruch 1,
dadurch gekennzeichnet,
dass die physikalische Schicht einer Sendeseite nach Empfang eines positiven Bestätigungsbefehls zur Löschung des zugeordneten Transportblocks und der Kurz-Folgenummer und zur Meldung über den korrekten Empfang an die Funkverbindungssteuerungs-Schicht vorgesehen ist.

7. Drahtloses Netzwerk nach Anspruch 1,
dadurch gekennzeichnet,
dass die physikalische Schicht einer Sendeseite nach Empfang eines negativen Bestätigungsbefehls zur Sendeaufforderung einer Paketeinheit, die über den codierten Transportblock fehlerbehaftet übertragen worden ist, von der Funkverbindungssteuerungs-Schicht vorgesehen ist und
dass die physikalische Schicht nach Empfang einer wiederholt von der Funkverbindungssteuerungs-Schicht gesendeten Paketeinheit zur Bildung eines codierten Transportblocks vorgesehen ist, der eine inkrementelle Redundanz enthält.

8. Funknetzwerk-Steuerung in einem drahtlosen, mehrere Terminals enthaltenden Netzwerk, die zum Austausch von Daten nach der hybriden ARQ-Methode vom Typ II oder III mit den Terminals vorgesehen ist und die eine Empfangs- und/oder Sendeseite bildet, wobei
eine physikalische Schicht der Funknetzwerk-Steuerung als Sendeseite
- zur Speicherung von codierten Transportblöcken in einem Speicher, die wenigstens eine von der zugeordneten Funkverbindungssteuerungs-Schicht gelieferten Paketeinheit enthalten und die durch eine Paketeinheits-Folgenummer identifizierbar ist,
- zur Speicherung von Kurz-Folgenummern, deren Länge von der maximalen Anzahl von zu speichernden codierten Transportblöcken abhängt und die eindeutig auf eine Paketeinheits-Folgenummer abbildbar sind, und
- zur Übertragung von codierten Transportblöcken zu einem Terminal wenigstens mit der zugeordneten Kurz-Folgenummer vorgesehen ist und

eine physikalische Schicht der Funknetzwerk-Steuerung als Empfangsseite zur Prüfung des korrekten Empfangs eines codierten Transportblocks von einem Terminal und zur Sendung eines positiven Bestätigungsbefehls bei korrektem Empfang und zur Sendung eines negativen Bestätigungsbefehls zu einem Terminal bei fehlerbehafteten Empfang über einen Rückkanal vorgesehen ist.

9. Terminal in einem drahtlosen, weitere Terminals und eine Funknetzwerk-Steuerung enthaltenden Netzwerk, das zum Austausch von Daten nach der hybriden ARQ-Methode vom Typ II oder III mit den Terminals vorgesehen sind und das eine Empfangs- und/oder Sendeseite bildet, wobei

eine physikalische Schicht des Terminals als Sendeseite

- zur Speicherung von codierten Transportblöcken in einem Speicher, die wenigstens eine von der zugeordneten Funkverbindungssteuerungs-Schicht gelieferten Paketeinheit enthalten und die durch eine Paketeinheits-Folgenummer identifizierbar ist,
- zur Speicherung von Kurz-Folgenummern, deren Länge von der maximalen Anzahl von zu speichernden codierten Transportblöcken abhängt und die eindeutig auf eine Paketeinheits-Folgenummer abbildbar sind, und
- zur Übertragung von codierten Transportblöcken zu der Funknetzwerk-Steuerung wenigstens mit der zugeordneten Kurz-Folgenummer vorgesehen ist und

eine physikalische Schicht des Terminals als Empfangsseite zur Prüfung des korrekten Empfangs eines codierten Transportblocks von der Funknetzwerk-Steuerung und zur Sendung eines positiven Bestätigungsbefehls bei korrektem Empfang und zur Sendung eines negativen Bestätigungsbefehls zu der Funknetzwerk-Steuerung bei fehlerbehafteten Empfang über einen Rückkanal vorgesehen ist.

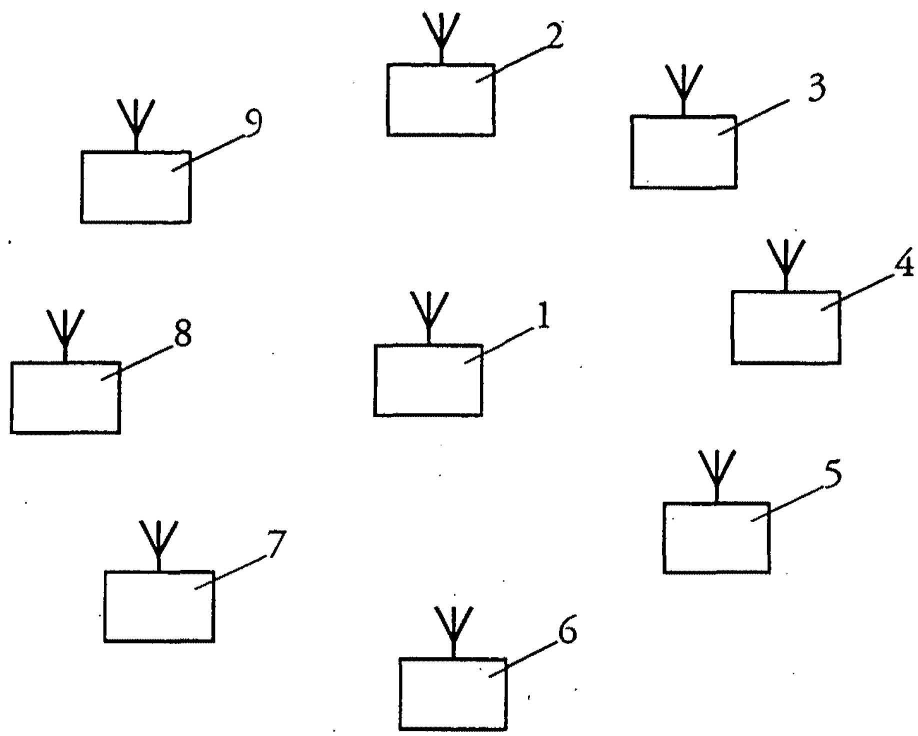

FIG. 1

1-III-PHDE000173

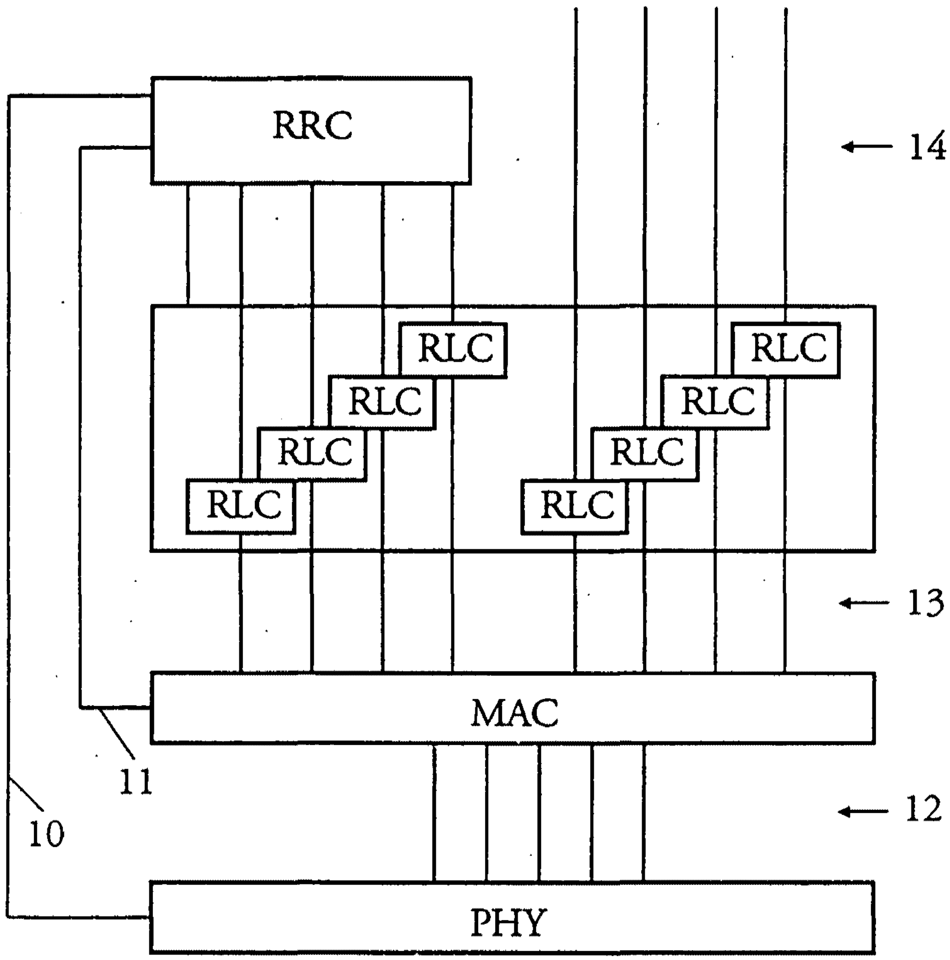

FIG. 2

2-III-PHDE000173

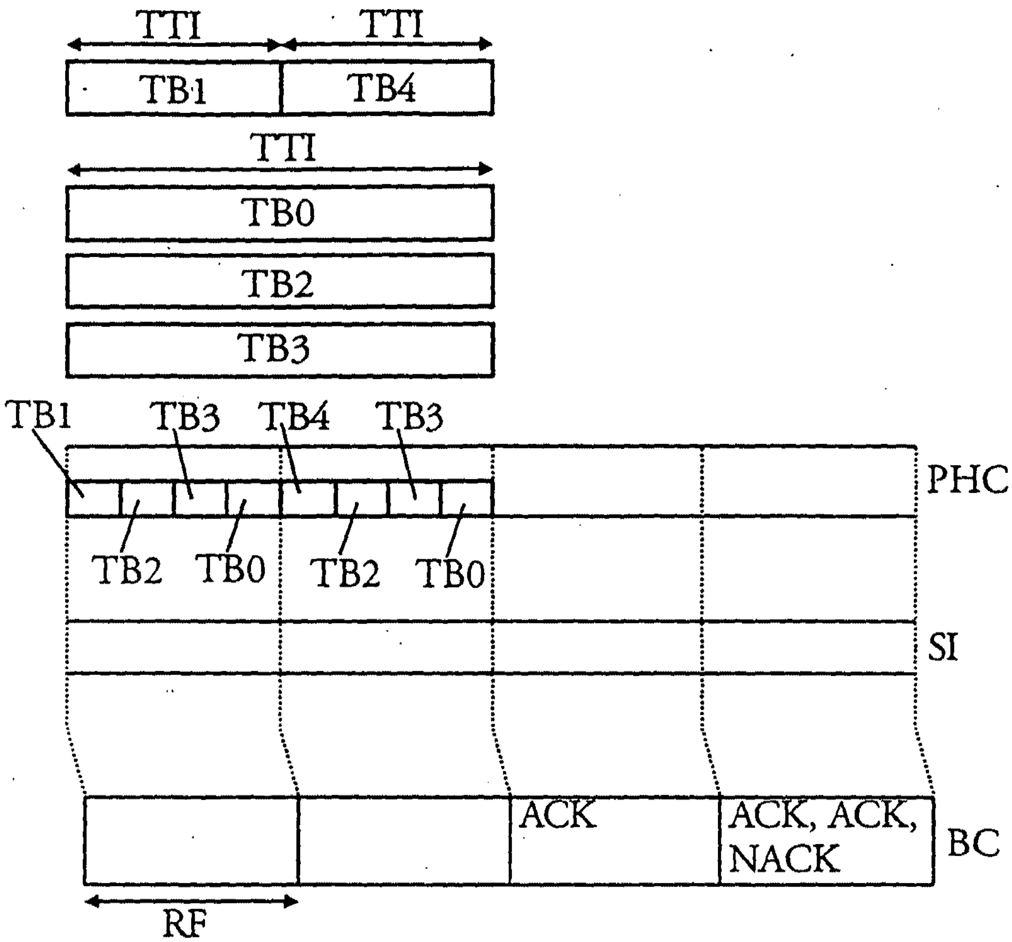

FIG. 3

3-III-PHDE000173

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APPLICATION NUMBER	FILING/RECEIPT DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
09/973,312	10/09/2001	Christoph Herrmann	DE 000173

CONFIRMATION NO. 8200

FORMALITIES LETTER

OC000000007052349

Philips Electronics North America Corporation
580 White Plains Road
Tarrytown, NY 10591

Date Mailed: 11/09/2001

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The oath or declaration is unsigned.
- To avoid abandonment, a late filing fee or oath or declaration surcharge as set forth in 37 CFR 1.16(l) of $130 for a non-small entity, must be submitted with the missing items identified in this letter.
- **The balance due by applicant is $ 130.**

A copy of this notice MUST be returned with the reply.

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of
CHRISTOPH HERRMANN

Atty. Docket
DE 000173

Serial No. 09/973,312

Group Art Unit: 2681

Filed: OCTOBER 9, 2001

Examiner

Title: WIRELESS NETWORK WITH A DATA EXCHANGE ACCORDING TO THE ARQ METHOD

Commissioner for Patents
Washington, D.C. 20231

ATTENTION: APPLICATION DIVISION

RESPONSE TO NOTICE TO FILE MISSING PARTS OF APPLICATION

Sir:

In response to the NOTICE TO FILE MISSING PARTS OF APPLICATION mailed on November 9, 2001, enclosed is a Declaration, properly signed by the Applicant and referring to the above case by its Serial Number and filing date, in compliance with 37 CFR 1.63, and a copy of the Notice. Accordingly, the above-identified patent application is now complete.

Please charge Deposit Account No. 14-1270 in the amount of $130.00 for the surcharge for filing the Declaration on a date later than the filing date of the application, as set forth in 37 CFR 1.16(e).

Respectfully submitted,

By Jack D. Slobod

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Attorney
(914) 333-9606

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited this date with the United States Postal Service as first-class mail in an envelope addressed to:
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On January 8, 2001
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By Natalie A. Manzo
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APPLICATION NUMBER	FILING/RECEIPT DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
09/973,312	10/09/2001	Christoph Herrmann	DE 000173

OIPE JAN 2 5 2002 PATENT & TRADEMARK OFFICE

CONFIRMATION NO. 8200

FORMALITIES LETTER

OC000000007052349

Philips Electronics North America Corporation
580 White Plains Road
Tarrytown, NY 10591

Date Mailed: 11/09/2001

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The oath or declaration is unsigned.
- To avoid abandonment, a late filing fee or oath or declaration surcharge as set forth in 37 CFR 1.16(l) of $130 for a non-small entity, must be submitted with the missing items identified in this letter.
- **The balance due by applicant is $ 130.**

A copy of this notice <u>MUST</u> be returned with the reply.

Customer Service Center
Initial Patent Examination Division (703) 308-1202

PART 2 - COPY TO BE RETURNED WITH RESPONSE

O I P E JC88 JAN 2 5 2002 PATENT & TRADEMARK OFFICE

(5)

DECLARATION and POWER OF ATTORNEY

ATTORNEY'S DOCKET NO.: **PHDE000173**

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first 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 **"Wireless network with a data exchange according to the ARQ method"**

the specification of which (check one)

☐ is attached hereto.

☒ was filed on 9 October 2001 as Application Serial No. 09/973,312 and was amended on ______ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by the amendment(s) referred to above.

I acknowledge the duty to disclose information which is material to patentability of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

COUNTRY	APP. NUMBER	DATE OF FILING (DATE, MONTH, YEAR)	PRIORITY CLAIMED UNDER 35 U.S.C. 119
Germany	**10050117.6**	**11 October 2000**	**YES**

I hereby claim the benefit under Title 35, United States Code, §120 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:

PRIOR UNITED STATES APPLICATION(S)

APPLICATION SERIAL NUMBER	FILING DATE	STATUS (PATENTED, PENDING, ABANDONED)

I hereby 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 issued thereon.

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. (list name and registration number)

Jack E. Haken, Reg. No. 26,902

Michael E. Marion, Reg. No. 32,266

Edward M. Blocker, Reg. No. 30,245

SEND CORRESPONDENCE TO:	DIRECT TELEPHONE CALLS TO:
Corporate Patent Counsel; U.S. Philips Corporation; 580 White Plains Road; Tarrytown, NY 10591	(name and telephone No.) (914) 332-0222

Dated: 5 November 2001		Inventor's Signature: Christoph Herrmann		
Full Name of Inventor	Last Name **HERRMANN**	First Name **Christoph**	Middle Name	
Residence & Citizenship	City **Aachen**	State or Foreign Country **Germany**	Country of Citizenship **Germany**	
Post Office Address	Street **Kasernenstrasse 6**	City **D-52064 Aachen**	State or Country **Germany**	Zip Code

AO

(4) 2681

INFORMATION DISCLOSURE STATEMENT TRANSMITTAL		
To Commissioner For Patents Enclosed herewith is a Form PTO-1449 and required copies of documents listed thereon and a concise explanation of their relevance is described below or enclosed herewith per 37 CFR 1.97.	*Application Number*	09/973,312
	Filing Date	October 9, 2001
	First Named Inventor	CHRISTOPH HERRMANN
	Group Art Unit	2681
	Examiner Name	
	Attorney Docket Number	DE 000173

These documents may be relevant in that they have been:

☐ considered in drafting the specification of the above-referenced application;

☒ cited in the specification of the above-referenced application;

☐ previously submitted or cited in U.S. patent application(s) ______________ which are relied on for an earlier effective filing date under 35 U.S.C. 120 (no copy required); or

☐ cited as an "X" or "Y" document in a foreign Patent Office search report on a foreign counter part application, a copy of which report is also enclosed;

☐ I hereby certify that these documents were first cited in any communication with a foreign Patent Office for a counterpart foreign application not more than three (3) months ago;

☐ otherwise a concise explanation of the relevance of each document is append hereto.

☐ I hereby certify that not one of these documents was cited in any communication with a foreign Patent Office nor was any known to any individual designated in §1.56(c) more than three (3) months ago.

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQURIED			
Name (Print Type)	Jack D. Slobod	*Registration No.26,236*	
Signature	Jack D. Slobod	*Date*	January 8, 2002

CERTIFICATE OF MAILING OR TRANSMISSION			
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Name (Print Type)	Natale A. Manzo		
Signature	Natale A. Manzo	*Date*	1/8/02

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Sheet 1 of 1

Form PTO-1449 U.S. DEPARTMENT OF COMMERCE (REV. 7-80) PATENT AND TRADEMARK OFFICE	Atty. Docket No. DE 000173	Serial No. 09/973,312
	Applicant CHRISTOPH HERRMANN	
INFORMATION DISCLOSURE CITATION (Use several sheets if necessary)	Filing Date October 9, 2001	Group 2681

U.S. PATENT DOCUMENTS

Ex. Int.		Document Number	Date	Name	Class	Sub-class	Filing Date If Approp.
	AA						
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	AD						
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FOREIGN PATENT DOCUMENTS

		Document Number	Date	Country	Class	Sub-class	Trans. Yes	Trans. No
	AG							
	AH							
	AI							
	AJ							
	AK							

OTHER (Including Author, Title, Date, Pertinent Pages, Etc.)

	AL	BY SOPHIA ANTIPOLIS, 3RD GENERATION PARTNERSHIP PROJECT; ENTITLED: TECHNICAL SPECIFICATION GROUP RADIO ACCESS NETWORK; REPORT ON HYBRID ARQ TYPE II/III (RELEASE 2000), 3G TR 25.835 VO.O.2, TSG-RAN WORKING GROUP 2 (RADIO L2 AND RADIO L3, FRANCE, AUGUST 15-21, 2000.

Examiner	Date Considered

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP Draw line through citation if not in conformance and not considered. Include a copy this form with next communication to applicant.

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OIPE JC41 SEP 24 2003 PATENT & TRADEMARK OFFICE

#6 S.I 10-07-03 2681

# INFORMATION DISCLOSURE STATEMENT TRANSMITTAL		
To Commissioner For Patents Enclosed herewith is a Form PTO-1449, required copies of documents listed thereon, and a concise explanation of their relevance is described below or enclosed herewith per 37 CFR 1.97.	Application Number	09/973,312
	Filing Date	October 9, 2001
	First Named Inventor	Christoph Herrmann
	Group Art Unit	2681
	Examiner Name	
	Attorney Docket Number	DE000173

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These documents may be relevant in that they have been (check one):

☐ considered in drafting the specification of the above referenced application;

☐ cited in the specification of the above-referenced application;

☐ previously submitted or cited in U.S. patent application(s) which are relied on for an earlier effective filing date under 35 U.S.C. 120 (no copies required);

☒ cited as an "X" or "Y" document in a foreign Patent Office search report in a foreign counterpart application, a copy of which report is also enclosed; or

☐ otherwise a concise explanation of the relevance of each document, as understood by the individual designated in §1.56(c) most knowledgeable about the contents, is append hereto.

if the date of this IDS may be after the date of a final Office Action - per §1.97(e) check one:

☐ I hereby certify that these documents were first cited in any communication with a foreign Patent Office for a counterpart foreign application not more than three (3) months ago; or

☐ I hereby certify that not one of these documents was cited in any communication with a foreign Patent Office in a counterpart foreign application, nor was any known to any individual designated in §1.56(c) more than three (3) months ago.

Please charge any required fee under § 1.17(p) or any other required fee (except the issue fee) to Account No. 14-1270.

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED			
Name (Print Type)	Jack D. Slobod	Registration No. (Attorney/Agent)	26,236
Signature	Jack D. Slobod	Date	September 11, 2003

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I hereby certify that this is being deposited with the U.S. Postal Service with sufficient postage as first class mail in an envelope addressed to: Commissioner For Patents, Box 1450, Alexandria, VA 22313-1450, , or facsimile transmitted to the U.S. Patent and Trademark Office tel# :_______________on the date below:			
Name (Print Type)	Natale A. Manzo		
Signature	Natale A. Manzo	Date	9/22/03

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Form PTO-1449 U.S. DEPARTMENT OF COMMERCE (REV. 7-80) PATENT AND TRADEMARK OFFICE	Atty. Docket No. DE000173	Serial No. 09/973,312
	Applicant CHRISTOPH HERRMANN	
INFORMATION DISCLOSURE CITATION (Use several sheets if necessary)	Filing Date OCTOBER 9, 2001	Group 2681

U.S. PATENT DOCUMENTS

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FOREIGN PATENT DOCUMENTS

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	AG							
	AH							
	AI							
	AJ							
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OTHER (Including Author, Title, Date, Pertinent Pages, Etc.)

	AL		BY BALACHANDRAN K. ET AL: ENTITLED: "GPRS-136: HIGH-RATE PACKET DATA SERVICE FOR NORTH AMERICAN TDMA DIGITAL CELLULAR SYSTEMS" IEEE PERSONAL COMMUNICATIONS SOCIETY, US BD. 6, JUNE 3 1999, PAGES 34-47.
	AM		BY LOCKITT J.A. ET AL. "A SELECTIVE REPEAT ARQ SYSTEMS" PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON DIGITAL SATELLITE COMMUNICATIONS. KYOTO, JAPAN, NOVEMBER 11-13, 1975, PAGES 189-195.
	AN		

Examiner	Date Considered

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP Draw line through citation if not in conformance and not considered. Include a copy this form with next communication to applicant.

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Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	2	("20020075867").PN.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2005/09/13 16:45
L2	1	1 and unambiguous$4	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2005/09/13 16:52
L3	1	1 and sending adj side$1	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2005/09/13 16:54
L4	1	1 and transmitting adj side$1	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2005/09/13 17:07
L5	1	1 and maximum	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2005/09/13 17:13
L6	3754	arq$1 or automatic adj repeat adj request$1	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2005/09/13 17:13
L7	183601	(sequence adj number$1) or sn or sns	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2005/09/13 17:14
L8	1862	7 near3 (short$6 or abbreviat$6 or reduc$3)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2005/09/13 17:15
L9	22	6 and 8	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2005/09/13 17:15

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/973,312	10/09/2001	Christoph Herrmann	DE 000173	8200

24737 7590 09/21/2005

PHILIPS INTELLECTUAL PROPERTY & STANDARDS
P.O. BOX 3001
BRIARCLIFF MANOR, NY 10510

EXAMINER	
MARCELO, MELVIN C	

ART UNIT	PAPER NUMBER
2662	

DATE MAILED: 09/21/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO 90C (Rev 10/03)

Office Action Summary	Application No. 09/973,312	Applicant(s) HERRMANN, CHRISTOPH	
	Examiner Melvin Marcelo	Art Unit 2662	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *09 October 2001*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-10* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *4-8* is/are rejected.

7)☒ Claim(s) *1-3,9 and 10* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *09 October 2001* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☒ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other: _____.

DETAILED ACTION

Claim Objections

1. Claims 1, 9 and 10 are objected to because of the following informalities:

Claim 1, line 6, "the assigned radio link control layer" should be --an assigned radio link control layer-- since there is no previous mention of an "assigning."

Claim 1, line 11, "the assigned abbreviated sequence number" should be --an assigned abbreviated sequence number-- since there is no previous mention of an "assigning."

Claim 9, line 6, "the assigned radio link control layer" should be --an assigned radio link control layer--.

Claim 9, line 11, "the assigned abbreviated sequence number" should be --an assigned abbreviated sequence number--.

Claim 10, line 6, "the assigned radio link control layer" should be --an assigned radio link control layer--.

Claim 10, line 12, "the assigned abbreviated sequence number" should be --an assigned abbreviated sequence number--.

Claim 10, line 13, "A physical layer" should be --a physical layer--.

Appropriate correction is required.

Claim Rejections - 35 USC § 112

2. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

3. Claims 4-8 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claim 4, lines 1-2, it is not clear whether "the physical layer of a sending side" should be --the physical layer of a transmitting side-- corresponding to claim 1, lines 3-4 or --the physical layer of a receiving side-- corresponding to claim 1, lines 13-14 since the term "send" is recited in conjunction with the "receiving side." Note: there appears to be only two sides to the physical layer-- the transmitting side and the receiving side--. It is not clear whether "the sending side" is equivalent to "the transmitting side."

Claim 5, line 3 recites "the sending side."

Claim 7, lines 1-2 recites "the physical layer of a sending side."

Claim 8, lines 1-2 recites "the physical layer of a sending side."

Allowable Subject Matter

4. Claims 1-3, 9 and 10 are allowed.

5. Claims 4-8 would be allowable if rewritten or amended to overcome the rejection(s) under 35 U.S.C. 112, 2nd paragraph, set forth in this Office action.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Melvin Marcelo whose telephone number is 571-272-3125. The examiner can normally be reached on Mon-Fri 8:30-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Hassan Kizou can be reached on 571-272-3088. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Melvin Marcelo
Primary Examiner
Art Unit 2662

September 19, 2005

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Sheet 1 of 1

Form PTO-1449 U.S. DEPARTMENT OF COMMERCE (REV. 7-80) PATENT AND TRADEMARK OFFICE	Atty. Docket No. DE000173	Serial No. 09/973,312
	Applicant CHRISTOPH HERRMANN	
INFORMATION DISCLOSURE CITATION (Use several sheets if necessary)	Filing Date OCTOBER 9, 2001	Group 2681

U.S. PATENT DOCUMENTS

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FOREIGN PATENT DOCUMENTS

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	AH							
	AI							
	AJ							
	AK							

OTHER (Including Author, Title, Date, Pertinent Pages, Etc.)

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MM	AM	BY LOCKITT J.A. ET AL. "A SELECTIVE REPEAT ARQ SYSTEMS" PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON DIGITAL SATELLITE COMMUNICATIONS. KYOTO, JAPAN, NOVEMBER 11-13, 1975, PAGES 189-195.
	AN	

Examiner Melvin Marcelo	Date Considered 9-13-2005

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP Draw line through citation if not in conformance and not considered. Include a copy this form with next communication to applicant.

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Sheet 1 of 1

Form PTO-1449 U.S. DEPARTMENT OF COMMERCE (REV. 7-80) PATENT AND TRADEMARK OFFICE	Atty. Docket No. DE 000173	Serial No. 09/973,312
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	AH							
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	AJ							
	AK							

OTHER (Including Author, Title, Date, Pertinent Pages, Etc.)

MM	AL	BY SOPHIA ANTIPOLIS, 3RD GENERATION PARTNERSHIP PROJECT; ENTITLED: TECHNICAL SPECIFICATION GROUP RADIO ACCESS NETWORK; REPORT ON HYBRID ARQ TYPE II/III (RELEASE 2000), 3G TR 25.835 VO.O.2, TSG-RAN WORKING GROUP 2 (RADIO L2 AND RADIO L3, FRANCE, AUGUST 15-21, 2000.

Examiner Melvin Marcelo	Date Considered 9-13-2005

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Notice of References Cited	Application/Control No. 09/973,312	Applicant(s)/Patent Under Reexamination HERRMANN, CHRISTOPH	
	Examiner Melvin Marcelo	Art Unit 2662	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-2001/0036169 A1	11-2001	Ratzel, David G.	370/338
	B	US-2003/0157927 A1	08-2003	Yi et al.	455/411
	C	US-2004/0246917 A1	12-2004	Cheng et al.	370/328
	D	US-			
	E	US-			
	F	US-			
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	P					
	Q					
	R					
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NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
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	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

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CONFIRMATION NO. 8200

SERIAL NUMBER	FILING DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
09/973,312	10/09/2001 RULE	370	2662	DE 000173

APPLICANTS

Christoph Herrmann, Aachen, GERMANY;

** CONTINUING DATA ************************* None mm

** FOREIGN APPLICATIONS ******************** 1-mm
GERMANY 10050117.6 10/11/2000

IF REQUIRED, FOREIGN FILING LICENSE GRANTED
** 11/08/2001

Foreign Priority claimed ☒ yes ☐ no 35 USC 119 (a-d) conditions met ☒ yes ☐ no ☐ Met after Allowance Verified and Acknowledged [signature] mm Examiner's Signature Initials	STATE OR COUNTRY GERMANY	SHEETS DRAWING 3	TOTAL CLAIMS 10	INDEPENDENT CLAIMS 3

ADDRESS
24737
PHILIPS INTELLECTUAL PROPERTY & STANDARDS
P.O. BOX 3001
BRIARCLIFF MANOR , NY
10510

TITLE
Wireless network with a data exchange according to the ARQ method

FILING FEE RECEIVED 870	FEES: Authority has been given in Paper No. _________ to charge/credit DEPOSIT ACCOUNT No. _________ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other ___________ ☐ Credit

Search Notes	Application/Control No. 09/973,312	Applicant(s)/Patent under Reexamination HERRMANN, CHRISTOPH
	Examiner Melvin Marcelo	Art Unit 2662

SEARCHED

Class	Subclass	Date	Examiner
370	349, 394, 471, 474	9/13/2005	MM

INTERFERENCE SEARCHED

Class	Subclass	Date	Examiner

SEARCH NOTES (INCLUDING SEARCH STRATEGY)

	DATE	EXMR
EAST (USPGPUB, USPAT, EPO, JPO, DERWENT, IBM_TDB)-See search history printout.	9/13/2005	MM
PALM- Inventor Name and Continuity Data checked.	9/13/2005	MM
IEEExplore-See search history printout.	9/13/2005	MM

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of — Atty. Docket

CHRISTOPH HERRMANN — DE 000173

Serial No. 09/973,312 — Group Art Unit: 2662

Filed: October 9, 2001 — Examiner: M. MARCELO

Title: WIRELESS NETWORK WITH A DATA EXCHANGE ACCORDING TO THE ARQ METHOD

Assistant Commissioner for Patents
Alexandria, VA 22313-1450

AMENDMENT
INTRODUCTORY COMMENTS

In response to the Office Action dated September 22, 2005, Applicant submits the following amendments and remarks.

IN THE CLAIMS

Please amend the Claims 1, 4-5, and 7-10 as follows:

1. (Currently Amended) A wireless network comprising a radio network controller and a plurality of assigned terminals, which are each provided for exchanging data according to the hybrid ARQ method and which form a receiving and/or transmitting side, in which a physical layer of a transmitting side is arranged for

- storing coded transport blocks in a memory, which blocks contain at least a packet data unit which is delivered by ~~the~~ an assigned radio link control layer and can be identified by a packet data unit sequence number,
- storing abbreviated sequence numbers whose length depends on the maximum number of coded transport blocks to be stored and which can be shown unambiguously in a packet data unit sequence number, and for
- transmitting coded transport blocks having at least ~~the~~ an assigned abbreviated sequence number and

a physical layer of a receiving side is provided for testing the correct reception of the coded transport block and for sending a positive acknowledge command to the transmitting side over a back channel when there is correct reception and a negative acknowledge command when there is error-affected reception.

2. (Original) A wireless network as claimed in claim 1, characterized in that the radio network controller and the assigned terminals are provided for exchanging data according to the hybrid ARQ method of type II or III.

3. (Original) A wireless network as claimed in claim 1, characterized in that the physical layer of a receiving side is provided for sending a positive or negative acknowledge command with the abbreviated sequence number of the transport block received correctly or affected by error.

4. (Currently Amended) A wireless network as claimed in claim 1, characterized in that the physical layer of one of a sending side or transmitting side, after the reception of a positive or negative acknowledge command, is provided for determining the abbreviated sequence number of the respective coded transport block transmitted correctly or affected by error based on the length of time between transmission of the transport block and reception of the acknowledge command and the sending sequence of the acknowledge command when there is a plurality of received acknowledge commands.

5. (Currently Amended) A wireless network as claimed in claim 3, characterized in that a transmission of the coded transport blocks is provided in radio frames and in that the transmission of an acknowledge command from either the sending side or the transmitting side to the receiving side is provided in a subsequent radio frame after the radio frame in which the transmission of the respective coded transport block ends.

6. (Original) A wireless network as claimed in claim 4, characterized in that the order of a plurality of acknowledge commands corresponds to the order of the transmission of last parts of transport blocks in a previous radio frame.

7. (Currently Amended) A wireless network as claimed in claim 1, characterized in that the physical layer of one of a sending side or transmitting side, upon reception of a positive acknowledge command, is provided for deleting the assigned transport block and the abbreviated sequence number and for announcing the correct reception to the radio link control layer.

8. (Currently Amended) A wireless network as claimed in claim 1, characterized in that the physical layer of one of a a sending side or transmitting side, upon reception of a negative acknowledge command, is provided for requesting the radio link control layer to transmit a packet data unit that has been transmitted affected by error via the coded transport block and in that the physical layer, upon reception of a packet data unit repeatedly sent by the radio link control layer is provided for forming a coded transport block which contains an incremental redundancy.

9. (Currently Amended) A radio network controller in a wireless network comprising a plurality of terminals, which radio network controller is provided for exchanging data with the terminals and which forms a receiving and/or transmitting side, in which a physical layer of the radio network controller is arranged as a transmitting side for

- storing coded transport blocks in a memory, which blocks contain at least a packet data unit which is delivered by ~~the~~ an assigned radio link control layer and can be identified by a packet data unit sequence number,

- storing abbreviated sequence numbers whose length depends on the maximum number of coded transport blocks to be stored and which can be shown unambiguously in a packet data unit sequence number, and for

- transmitting coded transport blocks having at least ~~the~~ an assigned abbreviated sequence number and

a physical layer of the radio network controller is arranged as a receiving side for testing the correct reception of a coded transport block from a terminal and for sending a positive acknowledge command to a terminal over a back channel when there is correct reception and a negative acknowledge command when there is error-affected reception.

10. (Currently Amended) A terminal in a wireless network comprising further terminals and a radio network controller, which terminal is provided for exchanging data with the terminals and which forms a receiving and/or transmitting side, in which a physical layer of the terminal is arranged as a transmitting side for

- storing coded transport blocks in a memory, which blocks contain at least a packet data unit which is delivered by ~~the~~ an assigned radio link control layer and can be identified by a packet data unit sequence number,

- storing abbreviated sequence numbers whose length depends on the maximum number of coded transport blocks to be stored and which can be shown unambiguously in a packet data unit sequence number, and for

- transmitting coded transport blocks to the radio network controller having at least ~~the~~ an assigned abbreviated sequence number and

A physical layer of the terminal is arranged as a receiving side for testing the correct reception of a coded transport block from the radio network controller and for sending a positive acknowledge command to the radio network controller over a back channel when there is correct reception and a negative acknowledge command when there is error-affected reception.

REMARKS

This application has been carefully reviewed in light of the Office Action dated September 21, 2005. Claims 1-10 remain pending in this application. Claims 1, 9, and 10 are the independent claims.

Applicant notes with appreciation the indication that Claims 1-3, 9 and 10 are allowed. Applicant further notes with appreciation the indication that Claims 4-8 would be allowable if rewritten in independent form to overcome the rejections under 35 U.S.C. § 112 second paragraph. Applicant has so amended Claims 4-8, rendering any objections and § 112, second paragraph objections moot, and respectfully believes all claims in condition for allowance at this time.

In view of the foregoing remarks, Applicant respectfully requests favorable reconsideration and early passage to issue of the present application. Applicant's undersigned attorney may be reached by telephone at the number given below.

Respectfully submitted,

By ____________

Aaron Waxler
Reg. 48,027
(914) 333-9608
January 23, 2006

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TO THE UNITED STATES PATENT AND TRADEMARK OFFICE

(571) 273-8300

TO: **EXAMINER: Marcelo Melvin**

EXAMINER'S TELEPHONE NUMBER: (571) 272-3125

ART UNIT: 2662

SERIAL NO.: 09/973,312

FROM: **Aaron Waxler**

REGISTRATION NUMBER: 48,027

PHILIPS ELECTRONICS NORTH AMERICA CORPORATION
345 SCARBOROUGH ROAD
P.O. BOX 3001
BRIARCLIFF MANOR, NEW YORK 10510
TELEPHONE: (914) 333-9608

I certify that these documents consisting of 8 pages (including this cover sheet, a petition for an extension of One (1) month's time, and an amendment) is being transmitted via facsimile to the United States Patent and Trademark Office at the telephone number set forth above on January 23, 2006.

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In re Application of — Atty. Docket

CHRISTOPH HERRMANN — DE 000173

Serial No. 09/973,312 — Group Art Unit: 2662

Filed: October 9, 2001 — Examiner: M. MARCELO

Title: WIRELESS NETWORK WITH A DATA EXCHANGE ACCORDING TO THE ARQ METHOD

Commissioner for Patents
Washington, D.C. 20231

PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)

Sir:

Applicants hereby petition for an extension of (1) ONE month to respond to the Office Action mailed on September 21, 2005; because of this extension the time period for response will expire on January 21, 2006. January 21, 2006 falls on a Saturday when the USPTO is not open, therefore a response filed on January 23, 2006 will be considered timely as per 37 CFR § 1.7. Filed herewith is a complete response to said Office Action.

Please charge Deposit Account No. 14-1270 in the amount of $120.00, the fee for this extension; and charge any additional fees except for the Issue Fee, and credit any overpayment, to Deposit Account No. 14-1270.

01/25/2006 EFLORES 00000115 141270 09973312
01 FC:1251 120.00 DA

Respectfully submitted,

By ____________
Aaron Waxler
Reg. 48,027
914-333-9608

N:\UserPublic\WX\Templates\EXT.DOC

PTO/SB/06 (12-04)
Approved for use through 7/31/2006. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 09733172

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))							
SEARCH FEE (37 CFR 1.16(k), (i), or (m))							
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))							
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X =		OR	X =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X =			X =	
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due 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).						
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
			TOTAL			TOTAL	

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED – PART II

1-23-06

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 10	Minus	** 20	= 0	X =		OR	X =	
Independent (37 CFR 1.16(h))	* 3	Minus	*** 3	= 0	X =		OR	X =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X =		OR	X =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X =		OR	X =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L 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".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	4215	arq$1 or automatic adj repeat adj request$1	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2006/02/21 08:20
L2	191250	(sequence adj number$1) or sn or sns	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2006/02/21 08:20
L3	1957	L2 near3 (short$6 or abbreviat$6 or reduc$3)	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2006/02/21 08:20
L4	23	L1 and L3	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2006/02/21 08:22
L5	1	((arq) same (sn or sns or sequence adj1 number$1) same (short$4 or abbrev$)).clm.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2006/02/21 08:24
L6	5	((ack or acknowledg$6) same (sn or sns or sequence adj1 number$1) same (short$4 or abbrev$)).clm.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2006/02/21 08:24

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NOTICE OF ALLOWANCE AND FEE(S) DUE

24737 7590 02/27/2006

PHILIPS INTELLECTUAL PROPERTY & STANDARDS
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BRIARCLIFF MANOR, NY 10510

EXAMINER	
MARCELO, MELVIN C	
ART UNIT	PAPER NUMBER
2662	

DATE MAILED: 02/27/2006

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/973,312	10/09/2001	Christoph Herrmann	DE 000173	8200

TITLE OF INVENTION: WIRELESS NETWORK WITH A DATA EXCHANGE ACCORDING TO THE ARQ METHOD

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1400	$300	$1700	05/30/2006

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE REFLECTS A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE APPLIED IN THIS APPLICATION. THE PTOL-85B (OR AN EQUIVALENT) MUST BE RETURNED WITHIN THIS PERIOD EVEN IF NO FEE IS DUE OR THE APPLICATION WILL BE REGARDED AS ABANDONED.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL should be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). Even if the fee(s) have already been paid, Part B - Fee(s) Transmittal should be completed and returned. If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: **Mail** **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

24737 7590 02/27/2006

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Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/973,312	10/09/2001	Christoph Herrmann	DE 000173	8200

TITLE OF INVENTION: WIRELESS NETWORK WITH A DATA EXCHANGE ACCORDING TO THE ARQ METHOD

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1400	$300	$1700	05/30/2006

EXAMINER	ART UNIT	CLASS-SUBCLASS
MARCELO, MELVIN C	2662	370-349000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
   - ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
   - ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
   (1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
   (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
   1 ____________
   2 ____________
   3 ____________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. The following fee(s) are enclosed:
- ☐ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies ____________

4b. Payment of Fee(s):
- ☐ A check in the amount of the fee(s) is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☐ The Director is hereby authorized by charge the required fee(s), or credit any overpayment, to Deposit Account Number ____________ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
- ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.
NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature ____________ Date ____________

Typed or printed name ____________ Registration No. ____________

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/973,312	10/09/2001	Christoph Herrmann	DE 000173	8200

24737 7590 02/27/2006

PHILIPS INTELLECTUAL PROPERTY & STANDARDS
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BRIARCLIFF MANOR, NY 10510

EXAMINER	
MARCELO, MELVIN C	
ART UNIT	**PAPER NUMBER**
2662	

DATE MAILED: 02/27/2006

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 984 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 984 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 01/06) Approved for use through 04/30/2007.

Notice of Allowability	Application No. 09/973,312	Applicant(s) HERRMANN, CHRISTOPH	
	Examiner Melvin Marcelo	Art Unit 2662	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to amendment filed 01-23-2006.
2. ☒ The allowed claim(s) is/are 1-10.
3. ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☒ All b) ☐ Some* c) ☐ None of the:
   1. ☒ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
   1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
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CONFIRMATION NO. 8200

SERIAL NUMBER	FILING DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
09/973,312	10/09/2001 RULE	370	2662	DE 000173

APPLICANTS

Christoph Herrmann, Aachen, GERMANY;

** CONTINUING DATA ************************* None

** FOREIGN APPLICATIONS ******************** 1-mr
GERMANY 10050117.6 10/11/2000

IF REQUIRED, FOREIGN FILING LICENSE GRANTED
** 11/08/2001

Foreign Priority claimed / 35 USC 119 (a-d) conditions met / Verified and Acknowledged	STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed: ☒ yes ☐ no 35 USC 119 (a-d) conditions met: ☒ yes ☐ no ☐ Met after Allowance Verified and Acknowledged: Examiner's Signature [signature] Initials nm	GERMANY	3	10	3

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TITLE
Wireless network with a data exchange according to the ARQ method

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Issue Classification	Application/Control No.	Applicant(s)/Patent under Reexamination
	09/973,312	HERRMANN, CHRISTOPH
	Examiner: Melvin Marcelo	Art Unit: 2662

ISSUE CLASSIFICATION

ORIGINAL		CROSS REFERENCE(S)							
CLASS	SUBCLASS	CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)						
370	349	370	394	471					

INTERNATIONAL CLASSIFICATION				
H	0	4	L	12/28
H	0	4	L	12/56
H	0	4	L	1/18
				/
				/

(Assistant Examiner) (Date)

2/23/06
(Legal Instruments Examiner) (Date)

MELVIN MARCELO
PRIMARY EXAMINER

(Primary Examiner) (Date)

Total Claims Allowed: 10

O.G. Print Claim(s)	O.G. Print Fig.
1	3

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1		31		61		91		121		151		181
2	2		32		62		92		122		152		182
3	3		33		63		93		123		153		183
4	4		34		64		94		124		154		184
5	5		35		65		95		125		155		185
6	6		36		66		96		126		156		186
7	7		37		67		97		127		157		187
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	29		59		89		119		149		179		209
	30		60		90		120		150		180		210

Search Notes	Application/Control No. 09/973,312	Applicant(s)/Patent under Reexamination HERRMANN, CHRISTOPH	
	Examiner Melvin Marcelo	Art Unit 2662	

SEARCHED

Class	Subclass	Date	Examiner
370	349, 394, 471, 474	2/21/2006	MM

INTERFERENCE SEARCHED

Class	Subclass	Date	Examiner
See Interference Search History Printout.		2/21/2006	MM

SEARCH NOTES (INCLUDING SEARCH STRATEGY)

	DATE	EXMR
EAST (USPGPUB, USPAT, EPO, JPO, DERWENT, IBM_TDB)-See search history printout.	2/21/2006	MM
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May 24 2006 (Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/973,312	10/09/2001	Christoph Herrmann	DE 000173	8200

TITLE OF INVENTION: WIRELESS NETWORK WITH A DATA EXCHANGE ACCORDING TO THE ARQ METHOD

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1400	$300	$1700	05/30/2006

EXAMINER	ART UNIT	CLASS-SUBCLASS
MARCELO, MELVIN C	2662	370-349000

05/24/2006 CNGUYEN1 00000024 141270 09973312
~~01 FC:1501 1400.00 DA~~
02 FC:1504 300.00 DA

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Typed or printed name Aaron Waxler Registration No. 48,027

US007075917B2

(12) **United States Patent**
Herrmann

(10) **Patent No.: US 7,075,917 B2**
(45) **Date of Patent: Jul. 11, 2006**

(54) **WIRELESS NETWORK WITH A DATA EXCHANGE ACCORDING TO THE ARQ METHOD**

(75) Inventor: **Christoph Herrmann**, Aachen (DE)

(73) Assignee: **Koninklijke Philips Electronics N.V.**, Eindhoven (NL)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 984 days.

(21) Appl. No.: **09/973,312**

(22) Filed: **Oct. 9, 2001**

(65) **Prior Publication Data**

US 2002/0075867 A1 Jun. 20, 2002

(30) **Foreign Application Priority Data**

Oct. 11, 2000 (DE) 100 50 117

(51) **Int. Cl.**
H04L 12/28 (2006.01)
H04L 12/56 (2006.01)
H04L 1/18 (2006.01)

(52) **U.S. Cl.** **370/349**; 370/394; 370/471

(58) **Field of Classification Search** 370/349, 370/394, 471, 474
See application file for complete search history.

(56) **References Cited**

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* cited by examiner

Primary Examiner—Melvin Marcelo

(57) **ABSTRACT**

The invention relates to a wireless network comprising a radio network controller and a plurality of assigned terminals, which are provided for exchanging data according to the hybrid ARQ method of type II or III and each form a receiving and/or transmitting side. A physical layer of a transmitting side is arranged for

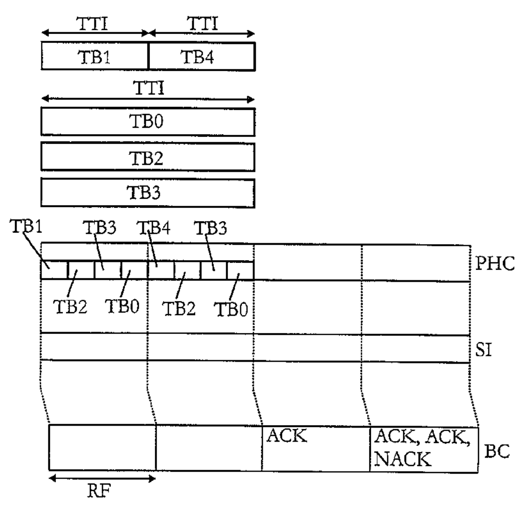
storing coded transport blocks in a memory, which blocks contain at least a packet data unit delivered by the assigned radio link control layer and can be identified by a packet data unit sequence number,

storing abbreviated sequence numbers whose length depends on the maximum number of coded transport blocks to be stored and which can be shown unambiguously shown in a packet data unit sequence number, and for

transmitting coded transport blocks having at least the assigned abbreviated sequence numbers.

a physical layer of a receiving side is provided for testing the correct reception of the coded transport block and for sending a positive acknowledge command to the transmitting side over a back channel when there is correct reception and a negative acknowledge command when there is error-affected reception.

10 Claims, 3 Drawing Sheets



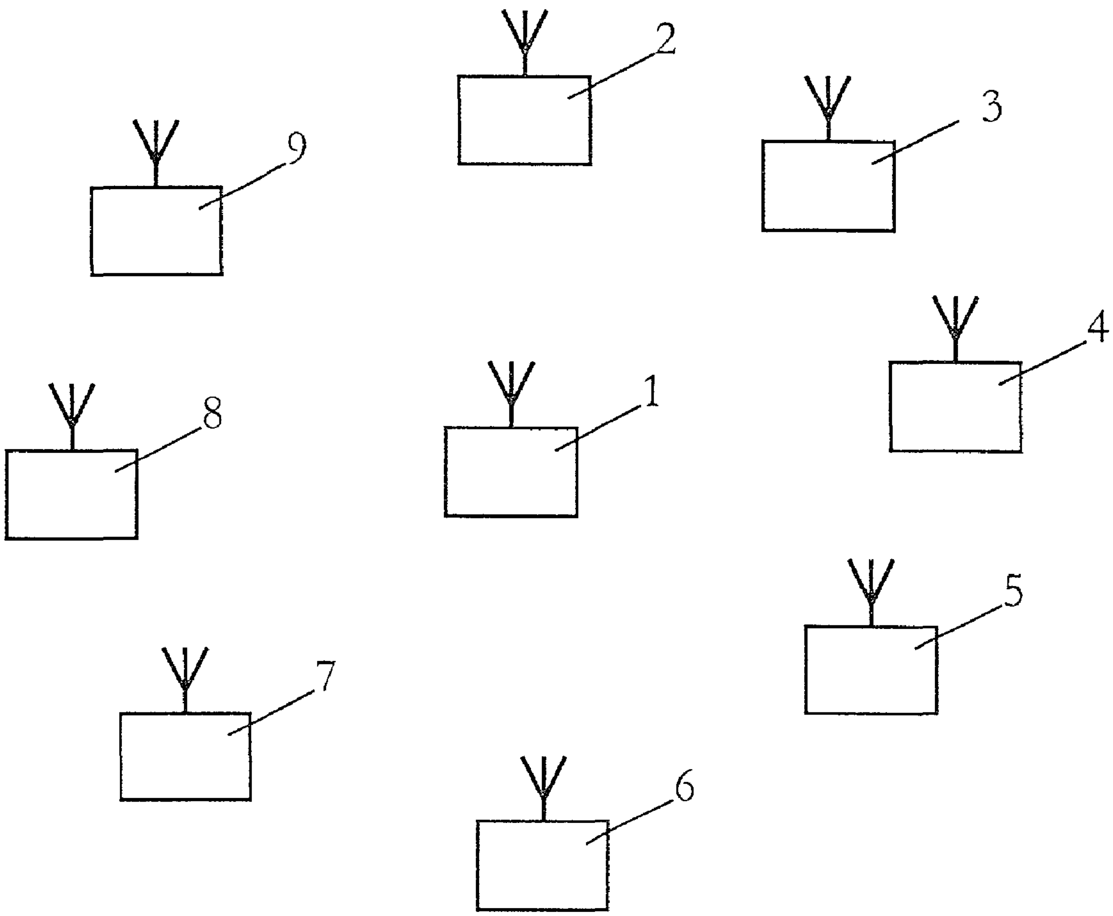


FIG. 1

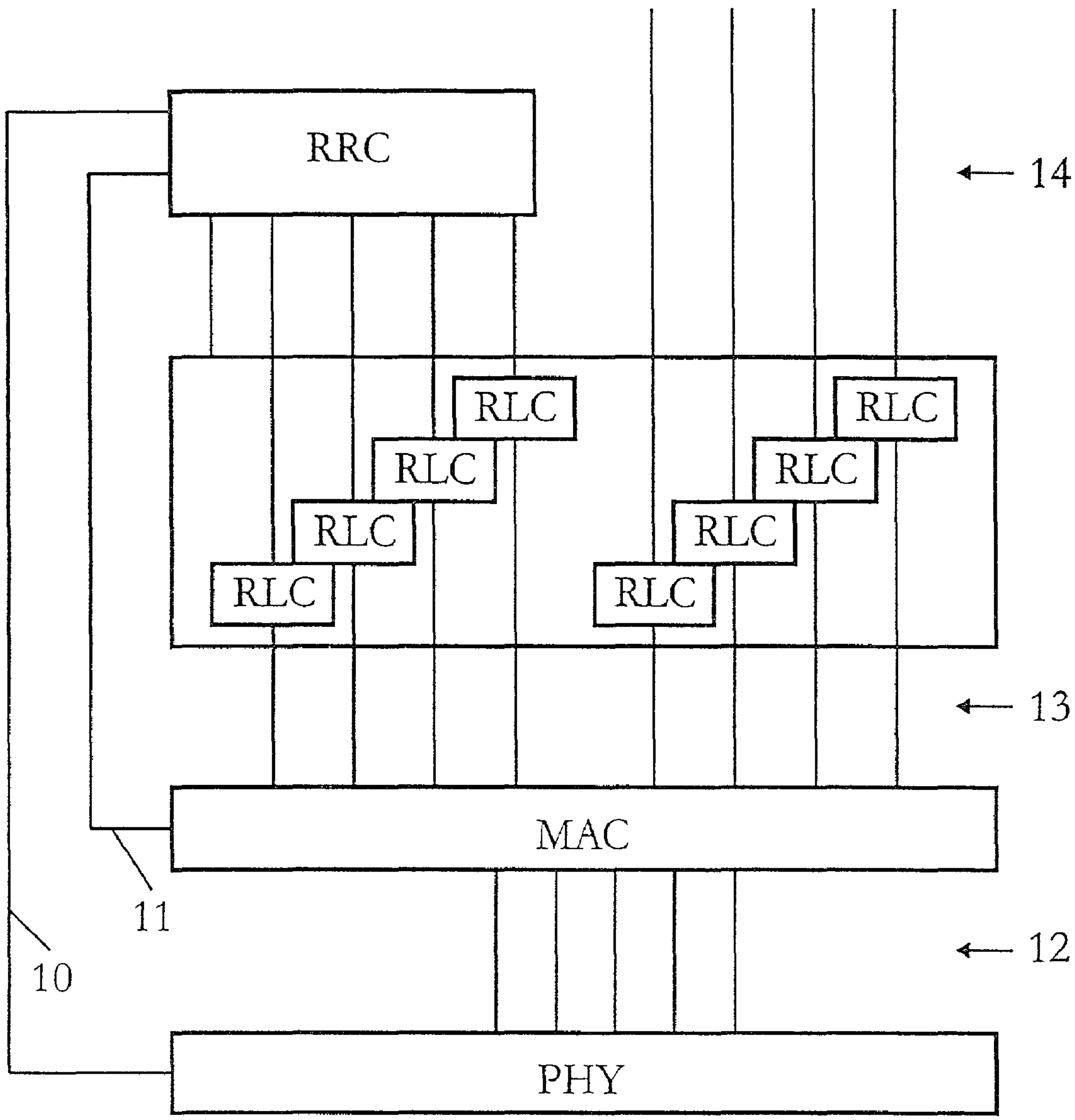
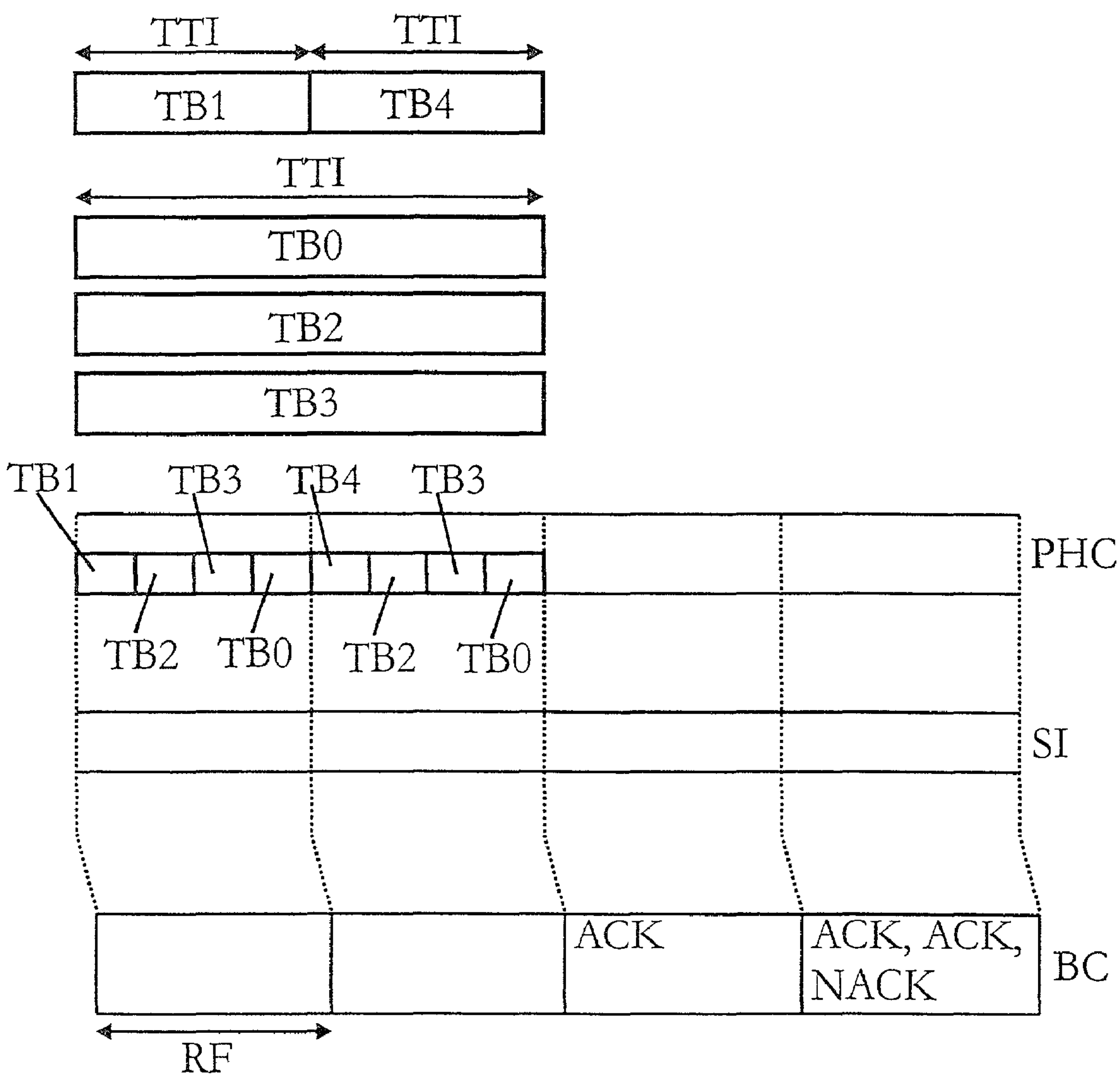


FIG. 2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TB4
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TB2
TB0
TB2
TB0
SI
ACK
ACK, ACK, NACK
BC
RF

FIG. 3

WIRELESS NETWORK WITH A DATA EXCHANGE ACCORDING TO THE ARQ METHOD

The invention relates to a wireless network comprising a radio network controller and a plurality of assigned terminals, which are each provided for exchanging data and which form a receiving and/or transmitting side.

Such a wireless network is known from the document "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Report on Hybrid ARQ Type II/III (Release 2000), 3G TR 25.835 V0.0.2, TSG-RAN Working Group 2 (Radio L2 and Radio L3), Sophia Antipolis, France, 21–15 August 2000". For the secured transmission of data a method is used here which is called the hybrid ARQ-method type II or III (ARQ=Automatic Repeat Request). The data sent in Packet Data Units (PDU) by the Radio Link Control layer (RLC layer) are additionally provided for the error correcting coding with an error control through repetition of transmission. This means that in the case of an error-affected reception of a packet data unit packed in a transport block coded by one of the assigned physical layers, the received packet data unit affected by error is sent anew. With the hybrid ARQ method type I the received packet data unit affected by error is rejected and an identical copy is requested anew. With the hybrid ARQ methods types II and III the received packet data unit affected by error is buffered and, after additional incremental redundancy relating to the received packet data unit, decoded together with the received packet data unit affected by error. Since only incremental redundancy and not the whole error-affected packet data unit is transmitted anew, the amount of data to be transmitted anew is reduced. With the ARQ method type II the incremental redundancy is useless without the buffered (error-affected) packet, with the ARQ method type III the incremental redundancy can be decoded also without the buffered (error-affected) packet. The coded transport blocks are sent over at least one transport channel. A message about the error-free reception in said document is sent only when the receiving RLC layer establishes on the basis of the so-called RLC sequence number that packet data units are lacking, even if the physical layer has already recognized the packet data unit as being error-affected. This means that the packet data unit is to be buffered over long time spaces until an incremental redundancy is requested and then, after a successful decoding, the reception may be acknowledged as correct, especially when the receiving side is the network side, while the physical layer and the RLC layer are usually located on different hardware components. In addition to the packet data units contained in the transport blocks, the RLC sequence numbers of the packet data unit and a redundancy version are to be transmitted in synchronism with the coded transport block when the hybrid ARQ methods of type II or III are implemented. This transmission is generally effected over a clearly better protected transport channel to safeguard that this information is error-free already at first reception. The information is decisive if after a repetition of transmission with incremental redundancy the buffered (error-affected) packet data unit is decoded together with the incremental redundancy, because the incremental redundancy is to be assigned to the respective packet data unit via the redundancy version.

It is an object of the invention to provide a wireless network in which error-affected data repeatedly to be transmitted according to the ARQ method of the type II or III are buffered for a shorter period of time on average.

The object is achieved by the following features by the wireless network mentioned in the opening paragraph which comprises a radio network controller and a plurality of assigned terminals which are each provided for exchanging data and which form each a receiving and/or transmitting side:

A physical layer of a transmitting side is provided for

storing coded transport blocks in a memory, which blocks contain at least a packet data unit which is delivered by the assigned radio link control layer and can be identified by a packet data unit sequence number,

storing abbreviated sequence numbers whose length depends on the maximum number of coded transport blocks to be stored and which can be shown unambiguously in a packet data unit sequence number, and for

transmitting coded transport blocks having at least the assigned abbreviated sequence number and

a physical layer of a receiving side is provided for testing the correct reception of the coded transport block and for sending a positive acknowledge command to the transmitting side over a back channel when there is correct reception and a negative acknowledge command when there is error-affected reception.

The wireless network according to the invention may be, for example, a radio network according to the UMTS standard (UMTS=Universal Mobile Telecommunication System). With this system, when, for example, data are transmitted according to the ARQ method of type II or III, the transmission of an acknowledge command over a back channel unknown thus far between a physical layer of a transmitting side (for example, a radio network controller) and the physical layer of a receiving side (for example, a terminal) provides that a correct or error-affected transmission of a transport block is announced to the transmitting side much more rapidly than known until now. As a result, a repetition of transmission with incremental redundancy may be effected rapidly. This enables the receiving side to buffer the received coded transport block affected by error clearly more briefly, because the additional redundancy necessary for the correct decoding is available at an earlier instant. In this manner, the memory capacity or memory area needed on average for buffering received coded transport blocks affected by error is also reduced.

The use of abbreviated sequence numbers reduces the extent of information that is required to be additionally transmitted for managing the transport blocks and packet data units and simplifies the assignment of the received acknowledge command to the stored transport blocks. The physical layer of a receiving side is provided here for sending a positive or negative acknowledge command with the abbreviated sequence number of the correctly or received transport block affected by error over the return channel.

In lieu of transmitting the abbreviated sequence number, an abbreviated sequence number of a transport block which a received acknowledge command relates to can also implicitly be determined based on the length of time between the transmission of the transport block and the reception of the acknowledge command and on the transmission sequence of the acknowledge command in case of a plurality of received acknowledge commands. This is made possible in a simple manner in that a transmission of the transport blocks is provided in radio frames and in that the transmission of an acknowledge command from the transmitting side to the receiving side is provided in the F^{th} radio frame at the earliest after the radio frame that contains the respective transport block (with F≧1). The order of a plurality of acknowledge commands corresponds to the order of the transmission of transport blocks in a preceding radio frame.

If the physical layer of a transmitting side has received a negative acknowledge command, the physical layer once again requests the radio link control layer to transmit the packet data unit that has been transmitted affected by error via the coded transport block. After a packet data unit has been received, the physical layer forms therefrom a coded transport block which contains an incremental redundancy.

The invention also relates to a radio network controller and a terminal in a wireless network which exchange data according to the hybrid ARQ method.

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

In the drawings:

FIG. **1** shows a wireless network comprising a radio network controller and a plurality of terminals,

FIG. **2** shows a layer model for explaining different functions of a terminal or of a radio network controller and

FIG. **3** shows a plurality of radio frames which contain data to be transmitted over the radio path between radio network controller and terminals.

FIG. **1** shows a wireless network, for example, radio network, including a radio network controller (RNC) **1** and a plurality of terminals **2** to **9**. The radio network controller **1** is responsible for controlling all the components taking part in the radio traffic such as, for example, the terminals **2** to **9**. An exchange of control and useful data takes place at least between the radio network controller **1** and the terminals **2** to **9**. The radio network controller **1** sets up a respective link for the transmission of useful data.

As a rule, the terminals **2** to **9** are mobile stations and the radio network controller **1** is fixedly installed. A radio network controller **1** may, however, also be movable or mobile, as appropriate.

In the wireless network are transmitted, for example, radio signals in accordance with the FDMA, TDMA or CDMA method (FDMA=frequency division multiple access, TDMA=time division multiple access, CDMA=code division multiple access), or in accordance with a combination of the methods.

In the CDMA method, which is a special code-spreading method, binary information (a data signal) coming from a user is modulated with a respective code sequence. Such a code sequence includes a pseudo-random square-wave signal (pseudo-noise code), whose rate, also called chip rate, is generally considerably higher than that of the binary data. The length of time of a square-wave pulse of the pseudo-random square-wave signal is referred to as a chip interval T_C. $1/T_C$ is the chip rate. The multiplication or modulation respectively, of the data signal by the pseudo-random square-wave signal has a spreading of the spectrum by the spreading factor $N_C=T/T_C$ as a result, where T is the length of time of the square-wave pulse of the data signal.

Useful data and control data are transmitted between at least one terminal (**2** to **9**) and the radio network controller **1** over channels predefined by the radio network controller **1**. A channel is determined by a frequency range, a time range and, for example, in the CDMA method, by a spreading code. The radio link from the radio network controller **1** to the terminals **2** to **9** is referred to as the downlink and from the terminals to the base station as the uplink. Thus data are sent over downlink channels from the base station to the terminals and over uplink channels from the terminals to the base station.

For example, a downlink control channel may be provided which is used for broadcasting, prior to a connection setup, control data coming from the radio network controller **1** to all the terminals **2** to **9**. Such a channel is referred to as downlink broadcast control channel. For transmitting control data from a terminal **2** to **9** to the radio network controller **1** prior to a connection setup, for example, an uplink control channel assigned by the radio network controller **1** can be used which, however, may also be accessed by other terminals **2** to **9**. An uplink channel that can be used by various terminals or all the terminals **2** to **9** is referred to as a common uplink channel. After a connection setup, for example, between a terminal **2** to **9** and the radio network controller **1**, useful data are transmitted by a downlink and an uplink user channel. Channels that are set up between only one transmitter and one receiver are referred to as dedicated channels. As a rule, a user channel is a dedicated channel which may be accompanied by a dedicated control channel for transmitting link-specific control data.

For exchanging useful data between the radio network controller **1** and a terminal, it is necessary for a terminal **2** to **9** to be synchronized with the radio network controller **1**. For example, it is known from the GSM system (GSM=Global System for Mobile communication), in which a combination of FDMA and TDMA methods is used, that after a suitable frequency range is determined based on predefined parameters, the position in time of a frame is determined (frame synchronization), with the aid of which frame the order in time for transmitting data is determined. Such a frame is always necessary for the data synchronization of terminals and base station in TDMA, FDMA and CDMA methods. Such a frame may contain several sub-frames, or together with various other successive frames, form a superframe.

The exchange of control and useful data via the radio interface between the radio network controller **1** and the terminals **2** to **9** can be explained with the layer model or protocol architecture shown by way of example in FIG. **2** (compare for example 3rd Generation Partnership Project (3GPP); Technical Specification Group (TSG) RAN; Working Group 2 (WG2); Radio Interface Protocol Architecture; TS 25.301 V3.2.0 (1999-10)). The layer model comprises three protocol layers: the physical layer PHY, the data link layer having the sub-layers MAC and RLC (in FIG. **2** various objects of the sub-layer RLC are shown) and the layer RRC. The sub-layer MAC is equipped for Medium Access Control, the sub-layer RLC for Radio Link Control and the layer RRC for Radio Resource Control. The layer RRC is responsible for the signaling between the terminals **2** to **9** and the radio network controller **1**. The sub-layer RLC is used for controlling a radio link between a terminal **2** to **9** and a radio network controller **1**. The layer RRC controls the layers MAC and PHY via control links **10** and **11**. By doing this, the layer RRC can control the configuration of the layers MAC and PHY. The physical layer PHY offers transport links **12** to the layer MAC. The layer MAC renders logic connections **13** available to the layer RLC. The layer RLC can be reached by applications via access points **4**.

In such a network a method of securely transmitting data is used, which is called the hybrid ARQ (ARQ=Automatic Repeat Request) method. The data sent in packet data units PDU are additionally provided for a forward error correction by means of an error control via repetitions of transmissions. This means that in case a packet data unit is received affected by error, the received packet data unit affected by error is sent anew. With the hybrid ARQ methods of type II or III it is possible to send only certain parts of the data of an error-affected transmission once again. This is referred to as incremental redundancy.

The packet data units are formed in the RLC layer and packed to transport blocks in the MAC layer, which transport blocks are transmitted by the physical layer from the radio network controller to a terminal or vice versa over the available transport channels. In the physical layer the transport blocks are provided with a cyclic redundancy check (CRC) and coded together. The result of this operation is referred to as a coded transport block. The coded transport blocks contain a packet data unit and control information.

Coded transport blocks affected by error that were transmitted are buffered in the physical layer of the receiving side for the conversion according to the hybrid ARQ method of type II or III until the incremental redundancy required afterwards makes an error-free decoding possible. It is known that at least the RLC sequence number or packet data unit sequence number, which features a packet data unit, and a redundancy version is to be transmitted, in parallel with the coded transport block or the incremental redundancy required afterwards, as so-called side information (compare: "3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Report on Hybrid ARQ Type II/III (Release 2000), 3G TR 25.835 V0.0.2, TSG-RAN Working Group 2 (Radio L2 and Radio L3), Sophia Antipolis, France, 21–15 August 2000"), so that the receiving side can detect which coded transport block is concerned or which buffered coded transport block the additionally transmitted redundancy refers to when a coded transport block affected by error or additional incremental redundancy affected by error is received. The redundancy version indicates whether it is a first-time sent incremental redundancy or which next incremental redundancy possibly repeated several times is concerned.

According to the invention, an abbreviated sequence number in lieu of the RLC sequence number is used for the transmission of the side information over the radio interface, the length of which abbreviated sequence number is clearly shorter than the RLC sequence number. This abbreviated sequence number is determined by the number of M coded transport blocks which, on the receiving side, can at most be buffered simultaneously, and consists of $\lceil 1d\ M \rceil$ bits. ($\lceil 1d\ M \rceil$ means the logarithm to the base of 2 rounded to the next higher natural number).

For this purpose, the transmitting physical layer generates an abbreviated sequence number from the RLC sequence number locally received as side information from the RLC layer. The physical layer contains another table or a memory which stores the abbreviated sequence number and the RLC sequence number, so that an image of the RLC sequence number follows the abbreviated sequence number. If the physical layer receives from the RLC layer a transport block containing side information, but all the abbreviated sequence numbers have already been issued, this transport block cannot be transmitted and the RLC layer is to be informed of this queue situation. In another case the physical layer selects a non-issued abbreviated sequence number, writes the relation to the RLC sequence number in the table and codes the transport block and sends it as a coded transport block with the side information via the radio interface. For an incremental redundancy to be sent afterwards, which relates to this coded transport block, again this abbreviated sequence number is taken from the table and sent in the side information in parallel with the incremental redundancy.

To inform the transmitting side (transmitting terminal or radio network controller) of the fact that a transport block has not been transmitted error-free, according to the invention a fast back channel is provided which is inserted directly between the receiving physical layer and the sending physical layer and not between the RLC layers concerned. The back channel is built up if a terminal and the radio network controller have agreed that data are transmitted according to the hybrid ARQ method of type II or III. The receiving physical layer checks whether the coded transport block has been transmitted correctly. If it has, a positive acknowledge signal ACK is sent to the sending physical layer over the back channel. Conversely, if the coded transport block has not been received error-free, a negative acknowledge command NACK is sent to the sending physical layer.

The positive and negative acknowledge commands ACK and NACK may each contain the abbreviated sequence number of the correctly or erroneously received coded transport block. The sending side can also identify the transmitted transport block affected by error on account of the number of a radio frame, which contains the positive or negative acknowledge command. The acknowledge commands in a radio frame of the back channel relate to coded transport blocks which were transmitted in transmission time intervals TTI which ended in a radio frame that preceded by exactly F radio frames (with $F \geqq 1$) the radio frame containing the acknowledge commands. FIG. **3** shows this. A transport time interval TTI indicates the time which a transport block lasts and corresponds at least to the length of time of one radio frame RF which determines the time necessary for the transport blocks to be sent over the radio link or radio interface. The numbers of the radio frames are generally broadcast to the mobile stations via a broadcast channel. In FIG. **3** are shown various transport blocks TB**0** to TB**4** which are to be transmitted for the length of time of two radio frames RF. The transport block TB**0** in this example is not transmitted according to the hybrid ARQ method of type II or III, whereas the other transport blocks are to be transmitted indeed according to the hybrid ARQ methods of type II or III. The announcement about a correct or error-affected transmission thus only occurs for the transport blocks TB**1** to TB**4** via a positive or negative acknowledge command over the physical back channel.

The transmission time interval TTI of the transport blocks TB**1** and TB**4** is equal to the length of time of a single radio frame RF and the transmission time interval TTI of the transport blocks TB**0**, TB**2** and TB**3** is equal to two radio frames RF. A first part of the transport blocks TB**2**, TB**3** and TB**0** and transport block TB**1** are used for transmitting coded transport blocks during a first radio frame RF and a second part of the transport blocks TB**2**, TB**3** and TB**0** and transport block TB**4** during a second subsequent radio frame RF over the physical channel PHC. It is assumed that the transport blocks TB**1**, TB**2** and TB**4** have been received correctly and the transport block TB**3** from a terminal or from the network controller. The correct or error-affected reception is checked in a radio frame RF which comes after the ended Transmission Time Interval (TTI) and is announced to the sending side (F=2) in the next radio frame RF via the back channel BC. FIG. **3** shows in the third radio frame RF the positive acknowledge command ACK for the transport block TB**1** and in the fourth radio frame RF the positive acknowledge command ACK for the transport blocks TB**4** and TB**2** and the negative acknowledge command NACK for the transport block TB**3**. No acknowledge command is sent for the transport block TB**0**, because this command is not transmitted according to an ARQ method of type II or III. The acknowledge commands are sorted in the sequence in which the transport blocks have been sent. The acknowledge command can, however, also be sent during a later radio frame RF. The number F of radio frames RF which occur between the reception of a transport block (i.e. after the transmission time interval has ended) or a number of transport blocks (i.e. after their transmission time intervals have ended, ending all at the same frame boundary) and the sending of an acknowledge command should be selected so that the receiving side has enough time to decode all co-transmitted transport blocks and check them for errors.

The transmission of the transport blocks TB**0** to TB**4** is accompanied with data called side information, which contain at least information about the redundancy version and about the abbreviated sequence number of a transport block. This side information is referred to as SI in FIG. **3**.

If a sending side receives a negative acknowledge command NACK, additional incremental redundancy is prompted to be sent. The physical layer that has received the negative acknowledge command (NACK) for one or more received coded transport blocks affected by errors, determines the RLC sequence number of the packet data unit which the negative acknowledge commands relate to and announces to the associated RLC layer the RLC sequence numbers of the error-affected packet data units. At the same time, the receiving physical layer stores the RLC sequence numbers of the packet data units that have been announced to be error-affected. The RLC layer then sends each one of these packet data units again, as in the case where the opposite RLC layer requests to send a packet data unit again (hybrid ARQ method type I). The MAC layer generates a transport block from the packet data unit, which transport block is then transferred with the side information to the physical layer. The physical layer compares the RLC sequence number contained in the side information with the buffered sequence number and recognizes that this transport block is to be sent as a repetition of transmission. The physical layer generates a coded transport block which contains the necessary incremental redundancy and no longer the whole coded packet data unit—as defined by the hybrid ARQ method type II or III.

If the physical layer has received a positive acknowledge command ACK, it deletes the stored RLC sequence number. Via this RLC sequence number the physical layer can also acknowledge the correct reception of the packet data unit to the associated RLC layer, which RLC layer then deletes the packet data unit that has this RLC sequence number from its buffer. This is particularly possible in the case of the downlink direction, when physical layer and RLC layer are not accommodated on separate hardware components in the receiving mobile station. On the other hand, it may be more favorable for the sending RLC layer to wait for the acknowledgement of receipt from the RLC layer on the receiving side, because it is still possible for transmission errors to occur when the transport block is transferred from the receiving physical layer to the receiving RLC layer (more particularly in the uplink direction, because here the receiving physical layer and the receiving RLC layer are accommodated on different hardware components).

The invention claimed is:

1. A wireless network comprising a radio network controller and a plurality of assigned to signals, which are each provided for exchanging data according to the hybrid ARQ method an which form a receiving and/or transmitting side, in which a physical layer of a transmitting side is arranged for

storing coded transport blocks in a memory, which blocks contain at least a packet data unit which is delivered by an assigned radio link control layer and can be identified by a packet data unit sequence number,

storing abbreviated sequence numbers whose length depends on the maximum number of coded transport blocks to be stored and which can be shown unambiguously in a packet data unit sequence number, and for

transmitting coded transport blocks having at least an assigned abbreviated sequence number and

a physical layer of a receiving side is provided for testing the correct reception of the coded transport block and for sending a positive acknowledge command to the transmitting side over a back channel when there is correct reception and a negative acknowledge command when there is error-affected reception.

2. A wireless network as claimed in claim **1**, characterized in that the radio network controller and the assigned terminals are provided for exchanging data according to the hybrid ARQ method of type II or III.

3. A wireless network as claimed in claim **1**, characterized in that the physical layer of a receiving side is provided for sending a positive or negative acknowledge command with the abbreviate sequence number of the transport block received correctly or affected by error.

4. A wireless network as claimed in claim **1**, characterized in tat the physical layer of one of a sending side or transmitting side, after the reception of a positive or negative acknowledge command, is provided for determining the abbreviated sequence number of the respective coded transport block transmitted correctly or affected by error based on the length of time between transmission of the transport block and reception of the acknowledge command and the sending sequence of the acknowledge command when there is a plurality of received acknowledge commands.

5. A wireless network as claimed in claim **3**, characterized in that a transmission of the coded transport blocks is provided in radio frames and in that the transmission of an acknowledge command from either the sending side or the transmitting side to the receiving side is provided in a subsequent radio frame after the radio frame in which the transmission of the respective coded transport block ends.

6. A wireless network as claimed in claim **4**, characterized in that the order of a plurality of acknowledge commands corresponds to the order of the transmission of last parts of transport blocks in previous radio frame.

7. A wireless network as claimed in claim **1**, characterized in that the physical layer of one of a sending side or transmitting side, upon reception of a positive acknowledge command, is provided for deleting the assigned transport block and the abbreviated sequence number and for announcing the correct reception to the radio link control layer.

8. A wireless network as claimed in claim **1**, characterized in that the physical layer of one of a sending side or transmitting side, upon reception of a negative acknowledge command, is provided for requesting the radio link control layer to transmit a packet data unit that has been transmitted affected by error via the coded transport block and in that the physical layer, upon reception of a packet data unit repeatedly sent by the radio link control layer is provided for forming a coded transport block which contains an incremental redundancy.

9. A radio network controller in a wireless network comprising a plurality of terminals, which radio network controller is provided for exchanging data with the terminals and which forms a receiving and/or transmitting side, in which a physical layer of the radio network controller arranged as a transmitting side for

storing coded transport blocks in a memory, which blocks contain at least a packet data unit which is delivered by an assigned radio link control layer and can be identified by a packet data unit sequence number,

storing abbreviated sequence numbers whose length depends on the maximum number of coded transport blocks to be stored and which can be shown unambiguously in a packet data unit a sequence number, and for

transmitting coded transport blocks having at least an assigned abbreviated sequence number and

a physical layer of the radio network controller is arranged as a receiving side for testing the correct reception of a coded transport block from a terminal and for sending a positive acknowledge command to a terminal over a back channel when there is correct reception and a negative knowledge command when there is error-affected reception.

10. A terminal in a wireless network comprising further terminals and a radio network controller, which terminal is provided for exchanging data with the terminals and which forms a receiving and/or transmitting side, in which a physical layer of the terminal is arranged as a transmitting side for

storing coded transport blocks in a memory, which blocks contain at least a packet data unit which is delivered by an assigned radio link control layer and can be identified by a packet data unit sequence number,

storing abbreviated sequence numbers whose length depends on the maximum number of coded transport blocks to be stored and which can be shown unambiguously in a packet data unit a sequence number, and for

transmitting coded transport blocks to the radio network controller having at least an assigned abbreviated sequence number and

A physical layer of the terminal is arranged as a receiving side for testing the correct reception of a coded transport block from the radio network controller and for sending a positive acknowledge command to the radio network controller over a back channel when there is correct reception and a negative acknowledge command when there is error-affected reception.

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US 20010036169A1

(19) United States
(12) Patent Application Publication
Ratzel
(10) Pub. No.: US 2001/0036169 A1
(43) Pub. Date: Nov. 1, 2001

(54) METHOD AND SYSTEM FOR DATA TRANSMISSION IN A WIRELESS NETWORK

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(21) Appl. No.: 09/815,471

(22) Filed: Mar. 23, 2001

Related U.S. Application Data

(63) Non-provisional of provisional application No. 60/191,723, filed on Mar. 24, 2000.

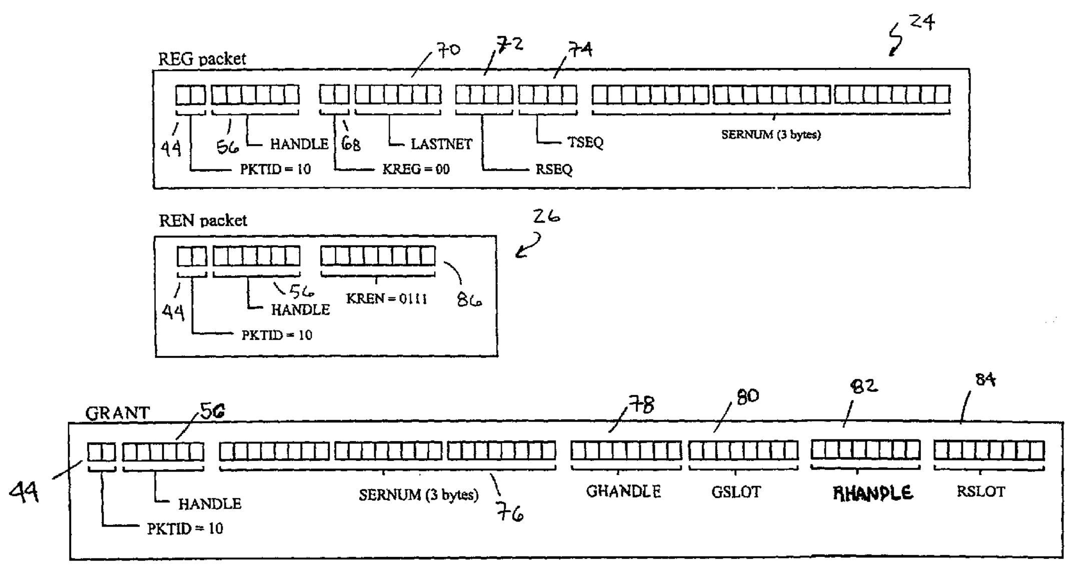
Publication Classification

(51) Int. Cl.^{7} H04Q 7/24

(52) U.S. Cl. 370/338; 370/349; 370/394

(57) ABSTRACT

A method and apparatus for a wireless communication network. The network utilizing time-division-multiple-access (TDMA) and being configured in a star layout having a base station and at least one remote station. A packet frame having a header, a trailer and a packet is transmitted and received throughout the communication network. The packet is defined to support a registration mechanism for controlling access of remote stations into and out of the network and supporting retransmission of defective or lost packets.



REG, REN and GRANT packet formats.

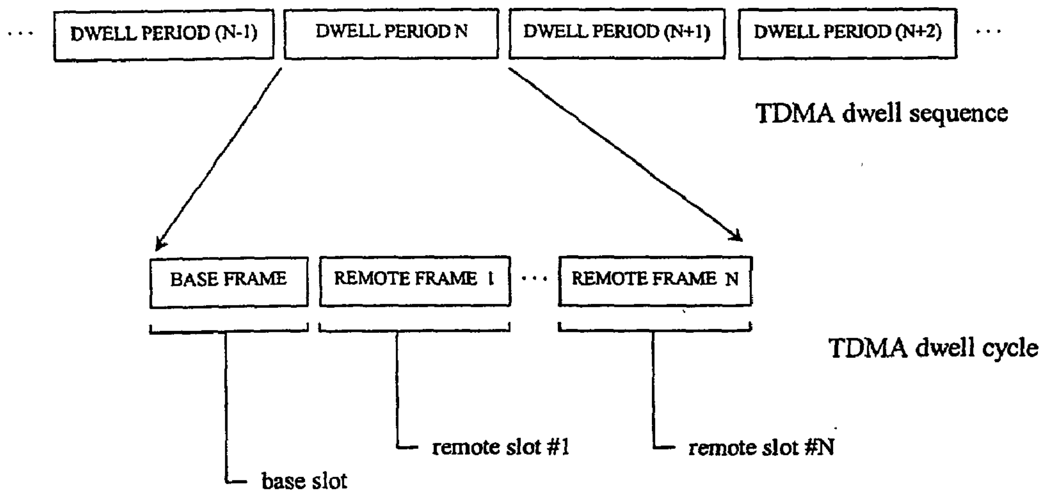


FIG 1

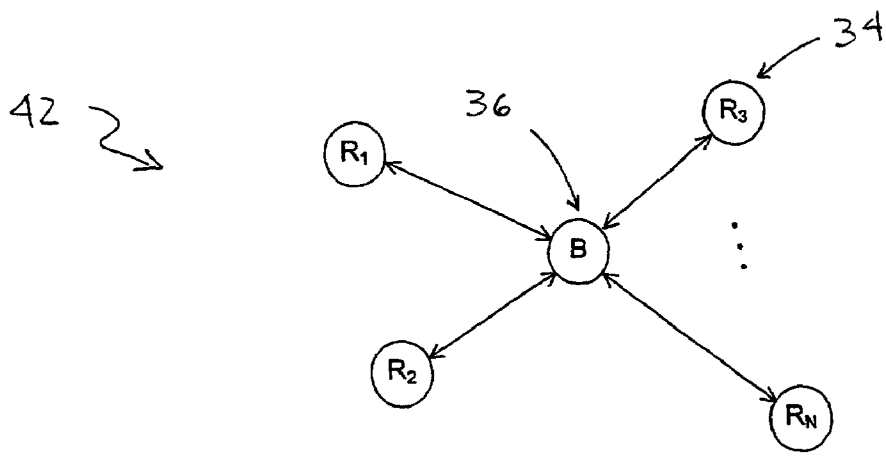


FIG 2 Star configuration radio network (base and N remotes)

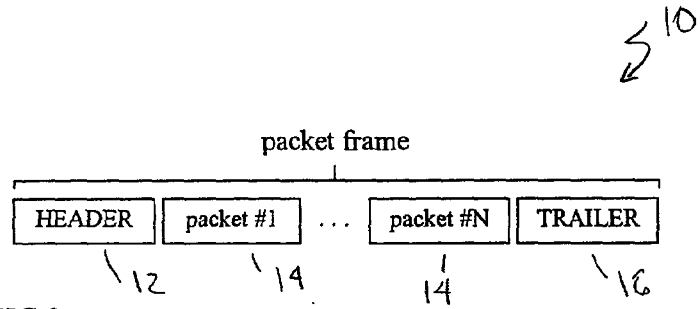

10
packet frame
HEADER
packet #1
. . .
packet #N
TRAILER
12
14
14
16

FIG 3

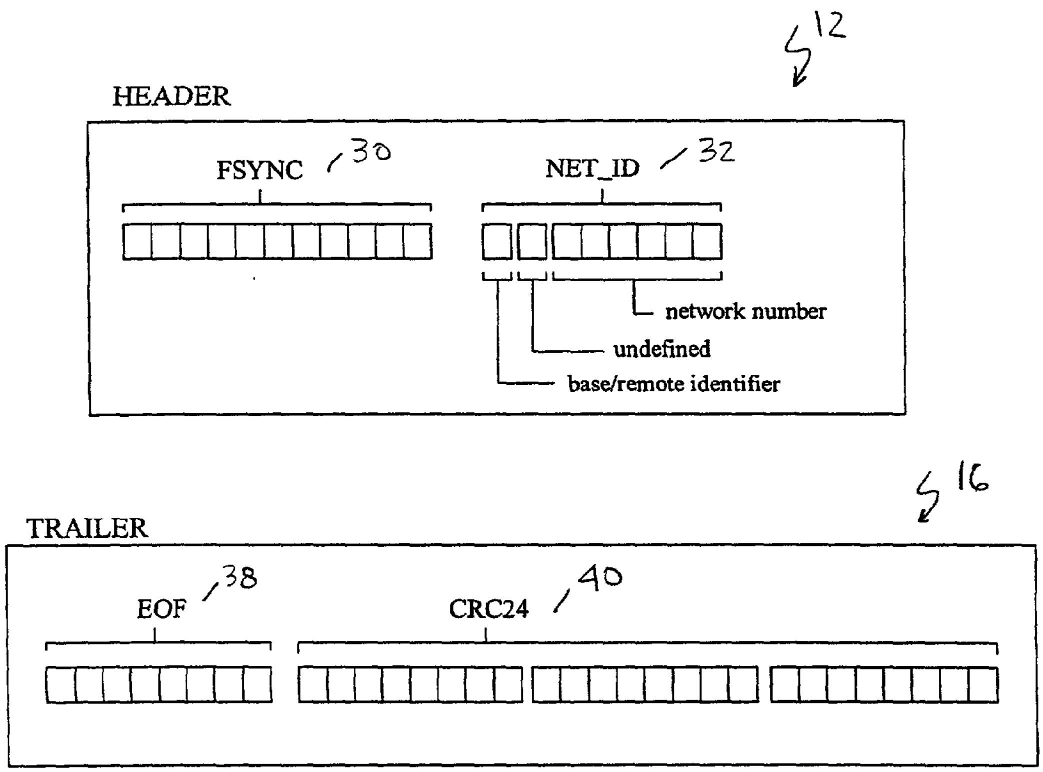

12
HEADER
FSYNC
30
NET_ID
32
network number
undefined
base/remote identifier
16
TRAILER
EOF
38
CRC24
40

FIG 4

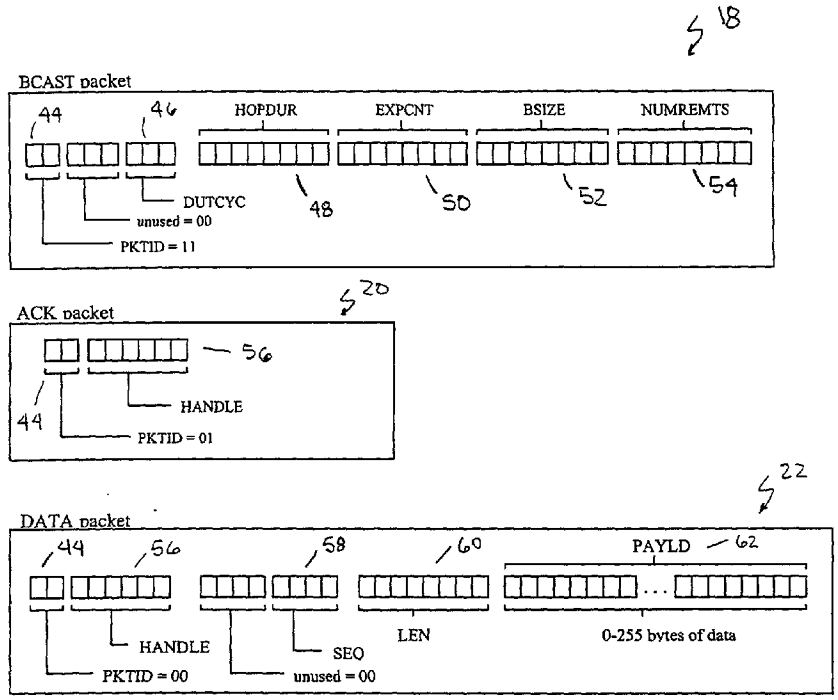


FIG 5. BCAST, ACK and DATA packet formats.

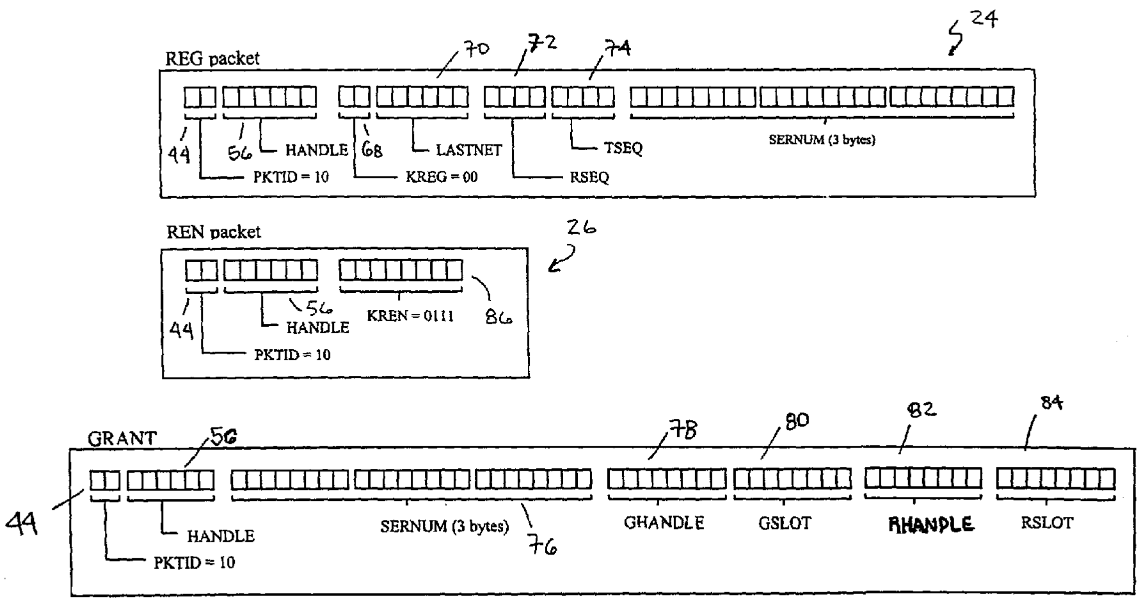


FIG 6. REG, REN and GRANT packet formats.

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METHOD AND SYSTEM FOR DATA TRANSMISSION IN A WIRELESS NETWORK

RELATED APPLICATIONS

[0001] This patent application claims the benefit of U.S. Provisional Patent application, entitled "Modulation Systems and Techniques," serial number 60/191,723, filed Mar. 24, 2000.

TECHNICAL FIELD

[0002] The present invention is generally related to communication system protocols. More specifically, the present invention is directed to a radio protocol for a wireless network.

BACKGROUND OF INVENTION

[0003] In digital packet radio transceiver networks, there are several schemes for coordinating multiple radios to access a shared radio channel. One such scheme is time-division-multiple-access (TDMA). **FIG. 1**. In TDMA, each transmitting station is assigned a time slot within a repeating time frame, called a dwell period, during which only that station is allowed to transmit. In a star configured wireless network, a central base station is surrounded by one or more remote stations. As opposed to a peer-to-peer network configuration, remote stations are only allowed to communicate with the base station and not to each other. The sequence of transmission slots begins with a transmission by the base station which is received by all remote stations and followed by an individual transmission slot for each remote station. **FIG. 2**.

[0004] Digital communications networks often provide a facility for retransmitting defective or errant data messages. One common form of such error handling is automatic repeat-request, or ARQ. In ARQ, the transmitting station listens after every transmitted message for an acknowledgment (ACK) message from its recipient. If the originating station fails to receive the ACK message, the originally transmitted message is sent again, repeating until either the ACK is received or a predetermined number of attempts have been made, in which case the message is discarded.

SUMMARY OF THE INVENTION

[0005] The present invention includes various forms of messaging protocols or methods of transmitting and receiving data between radio stations in a multipoint TDMA digital wireless network that are optimized for use in a star configuration. A hierarchical messaging protocol is defined comprising of a number of different control and messaging packet formats. Packet types are defined that support a registration mechanism for controlling access of remote stations into and out of the network and support retransmission of defective or errant packets.

[0006] Accommodation is made for network control functions including both access control and retransmission of defective or lost packets. The present invention provides a TDMA protocol implementation having superior efficiency when used in small multipoint data networks. The implementation provides a compact method of handle assignment capable of mapping a 24-bit address into a 6-bit handle space. In addition, an ARQ is provided in which a very short sequence number is utilized for space efficiency. The various packet types are distinguishable from one another with minimal decoding effort.

[0007] One embodiment of the present invention is directed to a method for attaining access to a wireless communication network configured in a star layout utilizing a base station and a remote station wherein a packet frame is transmitted and received throughout the network. The remote station discovers the network and requests access to the network by transmitting a packet frame comprising a registration packet. The remote station is granted access to the network by the base station transmitting a packet frame comprising a grant packet. A temporary identifier is assigned to the remote station. The temporary identifier being a handle associated with the remote station for a predetermined number of dwell periods. The duration of the dwell period is monitored by the network during transmission of a broadcast packet. The remote station can request to extend its utilization of the temporary identifier within the network by transmitting a renewal request packet. If the remote station does not request an extension, the temporary identifier will be removed after a predetermined amount of time has passed.

[0008] Another embodiment of the present invention is directed to a protocol for a wireless communication network having a base station and a remote station. The network being configured in a star layout for transmitting and receiving a packet frame having a header, a trailer and a packet throughout the network. The protocol comprises a broadcast message, an acknowledge message, a data message, a registration request message, a renewal message and a grant message.

[0009] An object of the present invention is to provide an access control procedure defined by which a base station can both grant entry to a remote station and detect when the remote station exits the network. Each remote station has a unique factory-assigned identifier. To improve data transmission efficiency, a short identifier called a handle is assigned to each remote station when it enters the network for the purpose of distinguishing messages intended for or originating from that remote station.

[0010] Another object of the present invention is to provide an automatic repeat-request error control mechanism wherein each packet carries a sequence number that allows a remote receiving station to distinguish repeated packets from ones it may have already received. Each new data packet is assigned a distinct sequence number that is used when that packet is transmitted, however many times as may be required. Sequence numbers are not infinite in extent and must be recycled by the transmitting station for reuse.

[0011] Other advantages and aspects of the present invention will become apparent upon reading the following description of the drawings and detailed description of the invention.

BRIEF DESCRIPTION OF DRAWINGS

[0012] **FIG. 1** depicts a TDMA transmission sequence showing a repeating slot structure to accommodate transmissions from a base station and remote stations;

[0013] **FIG. 2** depicts a star configuration TDMA network with a base station and a plurality of remote stations;

[0014] **FIG. 3** depicts a structure for a packet frame transmitted by a radio, one packet frame is sent per time slot;

[0015] **FIG. 4** depicts the data format of the HEADER and TRAILER portions of the packet frame depicted in **FIG. 3**;

[0016] **FIG. 5** depicts individual data formats for the BCAST, ACK and DATA packet types; and,

[0017] **FIG. 6** shows individual data formats for the registration, renewal and grant packet types.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

[0018] While this invention is susceptible of embodiments in many different forms, there is shown in the drawings and will herein be described in detail a preferred embodiment of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the broad aspect of the invention to the embodiment illustrated.

[0019] The largest element of transmission is the packet frame **10**. As shown in **FIG. 3**, the packet frame **10** comprises a HEADER block **12**, an individual data packet **14** and a TRAILER block **16**. **FIG. 3**. Packets **14** may be of one of the following types: BCAST **18**, ACK **20**, DATA **22**, REG **24**, REN **26** or GRANT **28**.

[0020] As shown in **FIG. 4**, the HEADER portion **12** of the packet frame **10** is comprised of a synchronization word **30** (FSYNC) and a network identifier **32** (NET_ID). Detection of the FSYNC **30** by a remote receiving station **34** is used to establish the byte boundaries within the serial data stream. The NET_ID **32** consists of a bit field specifying whether the sending station is a base station **36** or a remote station **34** and a network number that is used as a means of distinguishing traffic from other networks that may happen to be deployed within radio range of one another.

[0021] The TRAILER portion **16** of the packet frame **10** has an end-of-frame flag **38** (EOF) and a 24-bit checksum **40** (CRC**24**).

[0022] The middle of the packet frame **10** includes one or more individual packets **14**, that are described below.

[0023] As shown in **FIG. 5**, the BCAST packet **18** is a packet type sent only by the base station **36** and includes global information describing the system configuration and status of the network **42**. The first byte consists of a packet identifier field **44** (PKT_ID), (for this packet type, the packet identifier field is set equal to eleven), to distinguish it from other kinds of packets **14**, and a duty cycle-field **46** (DUTCYC) that specifies a duty cycle parameter for remote stations **34** that may wish to power down for some dwell periods in order to conserve power. The remaining four bytes constitute one field each. A HOPDUR field **48** specifies the length of the dwell period to be observed by all radios. An EXPCNT field **50** is a counter used for timing registration events. A BSIZE field **52** informs the remote stations **34** of the size of the time slot allocated to the base station **36**, and a NUMRENTS field **54** declares how many remote stations **34** are currently in the network **42**. After the base station **36** transmits, the remainder of the dwell period is divided equally among the remote stations and the NUMREMTS field **54** is used by the remote stations **34** to determine how many segments the dwell period should be divided.

[0024] Also as shown in **FIG. 5, a** DATA packet **22** is used to carry higher-level application data. A HANDLE field **56** specifies which remote station **34** the data is intended for, or which remote station **34** the data originated with, depending on whether the base station **36** or one of the remote stations **34** is the station transmitting the data. A SEQ field **58** is an ARQ sequence number. A LEN field **60** specifies the number of bytes in the payload portion **62** of the packet. The payload **62** (PAYLD) itself consists of 0-255 bytes of application data as specified by the LEN field **60**.

[0025] As further shown in **FIG. 5**, the ACK packet **20** is an ARQ acknowledgment used to inform an originating station that a DATA packet **22** was successfully received. As in the data packet **22**, the HANDLE field **56** specifies which remote the DATA packet **22** originated with or was intended for, depending on whether the base station **36** or one of the remote stations **34** was the originating station.

[0026] The REG **22**, REN **26** and GRANT **28** packet types, **FIG. 6**, pertain to the access control mechanism. The process begins when a remote station **26** discovers the network **42** and requests permission to enter from the base station **34** in the form of a REG packet **22**. If the base station **34** decides to admit the remote station **36**, it transmits a GRANT packet **28** which assigns the remote station **34** a temporary identifier called a HANDLE **56**. The HANDLE **56** is provided to the remote station **34** for a time period equal to 256 dwell periods, that is kept track of through the EXPCNT field **50** broadcast by the base station **36** in a BCAST packet **18** during every dwell period. During this period the remote station **34** must at some point request permission to continue using the handle **56** in the form of a renewal request **26** (REN packet). The base station **34** responds to this request with a GRANT packet **28** to renew the handle **56** for another 256 dwell periods. If a remote station **34** should fail to renew its registration, it is considered to have left the network **42** and its handle **56** is retired by the base station **36**.

[0027] The REG packet type **24** is a registration packet from a remote station **34** requesting access to the network **42** from the base station **36**. **FIG. 6**. The HANDLE field **56** in this case is a requested handle that the remote station **34** would like assigned if it is not already in use by another remote station. A KREG field **68** is a placeholder and is always zeros. A LASTNET field **70** informs the base station **36** what previous network **42** the remote station **34** requesting access may have belonged. A RSEQ **72** field and a TSEQ **74** field are initial values for receive and transmit ARQ sequence numbers to be used when communicating with that remote station **34**. The last field, SERNUM, **76** includes the remote station's factory-assigned unique identifier.

[0028] The GRANT packet type **28** is sent by the base station **36** to grant permission to a remote station **34** to enter the network **42** and to renew registration for an existing remote station, both of which operations may take place concurrently, if necessary. A GHANDLE **78** field specifies the handle that is being assigned to a new remote station **34**. The SERNUM field **76** specifies the unique serial number of the new remote station **34** that is being granted permission. A GSLOT field **80** specifies which time slot the remote station **34** is allowed to use. A RHANDLE field **82** specifies a remote station **34** whose handle has been renewed by the base station **36**, and RSLOT **84** specifies the time slot that is assigned to that renewing remote station **34**.

[0029] REN packets 26 are renewal requests sent by a remote station 34 to the base station 36 requesting permission to continue using its handle. The HANDLE field is the handle of the remote station 34 making the request. A KREN 86 field is a constant used by the base station 36 to distinguish REN packets 26 from REG packets 24, since both packets can share the same PKT_ID 44, e.g., shown to be ten for exemplification purposes.

[0030] The foregoing formats may be transmitted using conventional star network system components that may be adapted in conventional fashion to accommodate these formats. The formats may be modified and changed to accommodate the purposes of this invention without departing from its scope or spirit.

[0031] While the specific embodiment has been illustrated and described, numerous modifications come to mind without significantly departing from the spirit of the invention, and the scope of protection is only limited by the scope of the accompanying claims.

I claim:

1. A method for attaining access to a wireless communication network configured in a star layout utilizing a base station and a remote station wherein a packet frame is transmitted and received throughout the network, the method comprising the steps of:

discovering the network;

requesting access to the network by transmitting a registration packet;

granting access to the network by transmitting a grant packet;

assigning a temporary identifier to the remote station, the temporary identifier being associated with the remote station for a predetermined number of dwell periods;

monitoring the dwell periods during a transmission of a broadcast packet;

requesting to extend the use of the temporary identifier by transmitting a renewal request packet from the remote station, the requesting to extend the use of the temporary identifier further comprising:

providing a handle field populated with the temporary identifier of the remote station requesting renewal of its temporary identifier; and,

providing a renewal constant, the renewal constant being utilized by the base station to distinguish the renewal packet from the registration packet;

granting the request to extend the use of the temporary identifier; and,

removing the temporary identifier.

2. The method of claim 1 wherein the registration packet comprises:

a packet identifier;

a request handle;

a serial number field including a factory assigned identifier;

a previous network identifier representing a previous network accessed by the remote station;

a receive sequence number for cooperating with an automatic-repeat request message utilized to ensure delivery of the registration packet during network communication with the remote station; and,

a transmit sequence number for cooperating with the automatic-repeat request message utilized to ensure delivery of the registration packet during network communication with the remote station.

3. The method of claim 2 wherein the granting access to the remote station to enter the network comprises:

assigning a new handle to the remote station;

assigning a serial number field to the remote station, the serial number field comprising a unique serial number to the remote station; and,

assigning a time slot to be utilized by the remote station during network communication.

4. A protocol for a wireless communication network having a plurality of stations including a base station and a plurality of remote stations, the network being configured in a star layout for transmitting and receiving a plurality of packets of information throughout the network, the protocol comprising:

a broadcast message packet for providing global information of a network's configuration and status, the broadcast message packet being exclusively transmitted from the base station;

an acknowledge message packet for informing a transmitting station that a one of a plurality of packets of information was successfully received;

a data message packet for providing a higher-level application data;

a registration request message packet for requesting access to the network, the registration packet being sent from a one of the plurality of remote stations;

a grant message packet for granting access to the network, the grant packet being transmitted from the base station to the one of the plurality of remote stations; and,

a renewal message packet for requesting renewal of access to the network.

5. The protocol of claim 4 wherein the broadcast message packet comprising:

a packet identifier field for distinguishing the broadcast message packet from the plurality of packets of information;

a duty cycle field for specifying a duty cycle parameter for the plurality of remote stations to power down during a dwell period;

a dwell length field for specifying a length of the dwell period to be utilized by the plurality of remote stations;

a timing field for timing registration events;

a time slot field for communicating a size of a time slot to the plurality of remote stations; and,

a partition field for determining an amount of sections the dwell period should be partitioned.

6. The protocol of claim 4 wherein the data message packet comprises;

a handle field for specifying a one of the plurality of remote stations the data message packet is received from or destined for;

a sequence field having an automatic repeat-request sequence number;

a payload field; and,

a length field for specifying a number of bits in the payload field, the payload field ranging from 0-255 bytes as specified by the length field.

7. The protocol of claim 4 further comprising an access control packet selected from the group consisting of registration, renewal and grant packets.

8. The protocol of claim 7 wherein the registration packet comprises:

a packet identifier field;

a handle field for requesting a handle preferred by a one of the plurality of remote stations;

a previous network field for informing the base station of the previous network to which the one of the plurality of remote stations requesting access may have belonged;

a receive sequence field being set to an initial value for a receive automatic repeat-request sequence number to be utilized for communication with the one of the plurality of remote stations;

a transmit sequence field being set to an initial value for a transmit automatic repeat-request sequence number to be utilized for communication with the one of the plurality of remote stations; and,

a serial number field comprising a factory assigned unique identifier for the one of the plurality of remote stations.

9. The protocol of claim 7 wherein the grant packet comprising:

a packet identifier;

a serial number field for specifying a unique serial number associated with the one of the plurality of remote stations being granted permission to access the network;

a grant handle field for specifying a handle being assigned to the one of a plurality of remote stations;

a grant slot field for specifying a time slot utilized by the one of a plurality of remote stations;

a renewal handle field for specifying the one of the plurality of remote stations renewed by the base station; and,

a renewal slot field for specifying a renewal time slot assigned to the renewed one of the plurality of remote stations.

10. The protocol of claim 7 wherein the renewal packet comprises:

a handle field comprising a handle identifier of a one of the plurality of remote stations transmitting the renewal request; and,

a constant field having a constant utilized by the base station to distinguish the renewal packet from the registration packet.

11. The protocol of claim 4 wherein each of the plurality of packets of information comprises:

a header having a first byte and a second byte, the second byte further including a station identifier and a network number; and,

a trailer having an end-of-file (EOF) byte and a 24 bit checksum.

12. A method of communicating on a wireless network configured in a star layout having a base station and a plurality of remote stations wherein a packet frame is transmitted and received throughout the wireless network, the method comprising the steps of:

providing a plurality of control packets for network control wherein the base station utilizes the plurality of control packets to regulate access to the wireless network;

providing a plurality of message packets for transmitting information throughout the wireless network;

assigning a sequence number to a first message packet;

transmitting the first message packet;

receiving the first message packet;

transmitting the first message packet in response to a failure to receive an acknowledgment message packet; and,

transmitting the acknowledgment message packet.

13. The method of claim 12 further including:

requesting access to the wireless network by transmitting a registration packet from a one of the plurality of remote stations;

granting access to the wireless network by transmitting a grant packet from the base station;

assigning a temporary identifier to the one of the plurality of remote stations, the temporary identifier being a handle associated with the one of the plurality of remote stations for a predetermined number of dwell periods; and,

monitoring the dwell periods during transmission of a broadcast packet.

14. The method of claim 13 further comprising:

transmitting a renewal request packet requesting to extend the use of the temporary identifier;

granting the request to extend the use of the temporary identifier; and,

removing the temporary identifier.

* * * * *

US 20030157927A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2003/0157927 A1**

Yi et al.

(43) **Pub. Date: Aug. 21, 2003**

(54) **METHOD FOR RELOCATING SRNS IN A MOBILE COMMUNICATION SYSTEM**

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(21) Appl. No.: **10/365,655**

(22) Filed: **Feb. 13, 2003**

(30) **Foreign Application Priority Data**

Feb. 16, 2002 (KR) 8341/2002

Publication Classification

(51) **Int. Cl.**[7] **H04M 3/16**

(52) **U.S. Cl.** **455/411**; 455/414

(57) **ABSTRACT**

A system and method for performing SRNS relocation in a communications system transmits radio resource information including a ciphering parameter from a source RNC to a target RNC, modifies the ciphering parameter to coincide with a deciphering parameter which a user terminal uses when out-of-sequence data is received, ciphers a data unit based on the modified ciphering parameter, and transmits the ciphered data unit from the target RNC to the user terminal. The method may be modified to operate in UM mode or AM mode and to transmit data over one of several radio bearers. In accordance with another embodiment, the system and method transmits radio resource information from a source RNC to a target RNC and then transmits a data unit from the target RNC to a user terminal. In this case, the data unit including a transmission sequence number which consecutively follows a transmission sequence number of a data unit last transmitted from the source RNC to the user terminal. In accordance with another embodiment, the system and method resets ciphering and state variables in a target RNC and then transmits a message instructing a user terminal to reset a deciphering and state variables to the same or similar values. All the embodiments are advantageous because they ensure successful communications will take place between the target RNC and user terminal after a serving radio network sub-system relocation procedure is performed.

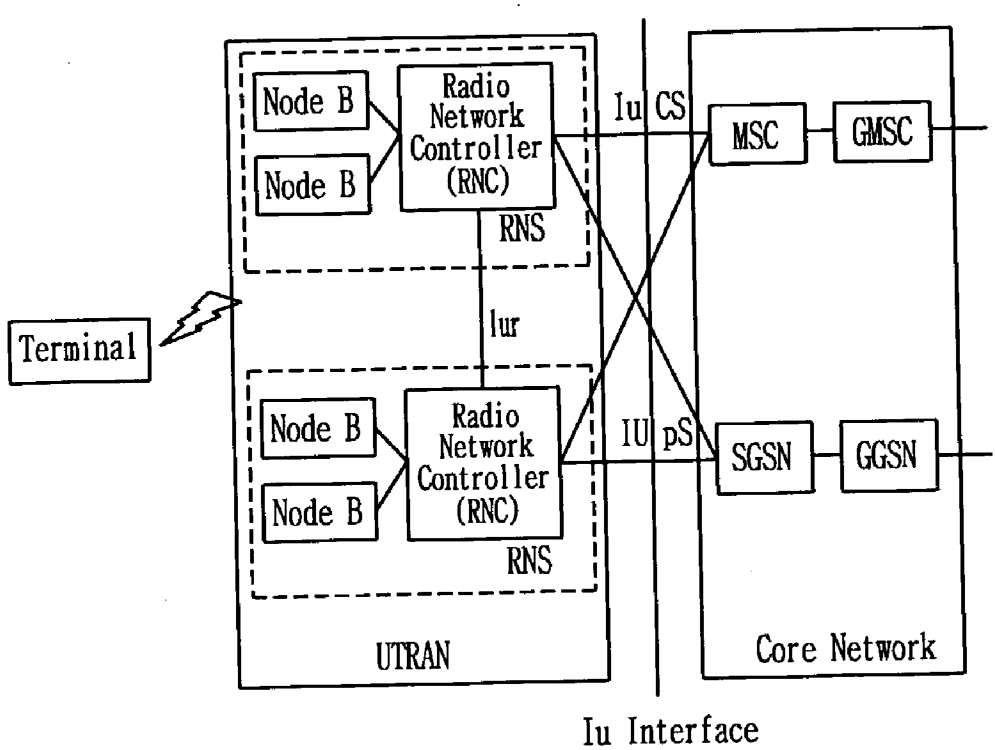


FIG. 1

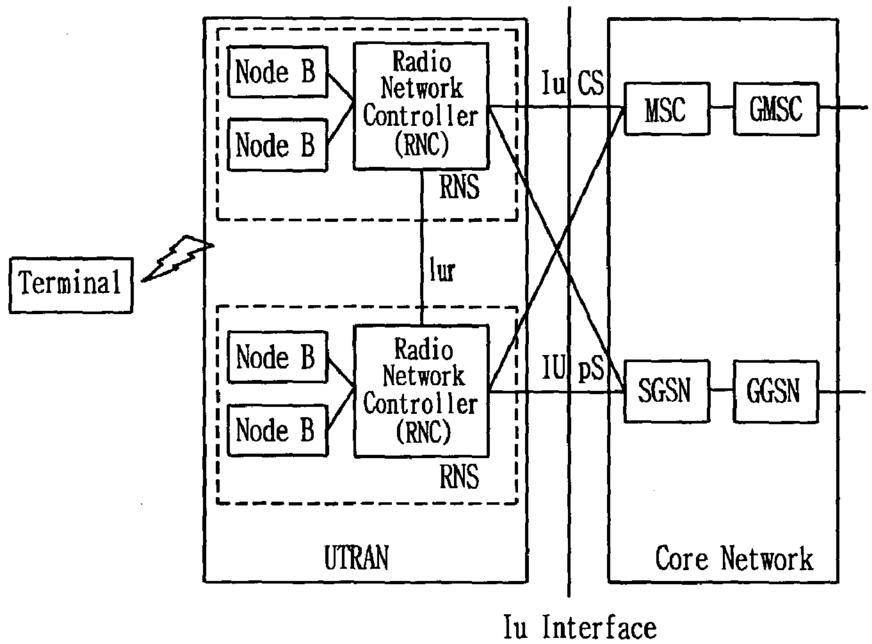

Node B
Node B
Radio Network Controller (RNC)
RNS
Iu CS
MSC
GMSC
Iur
Terminal
Node B
Node B
Radio Network Controller (RNC)
RNS
IU pS
SGSN
GGSN
UTRAN
Core Network
Iu Interface

FIG. 2

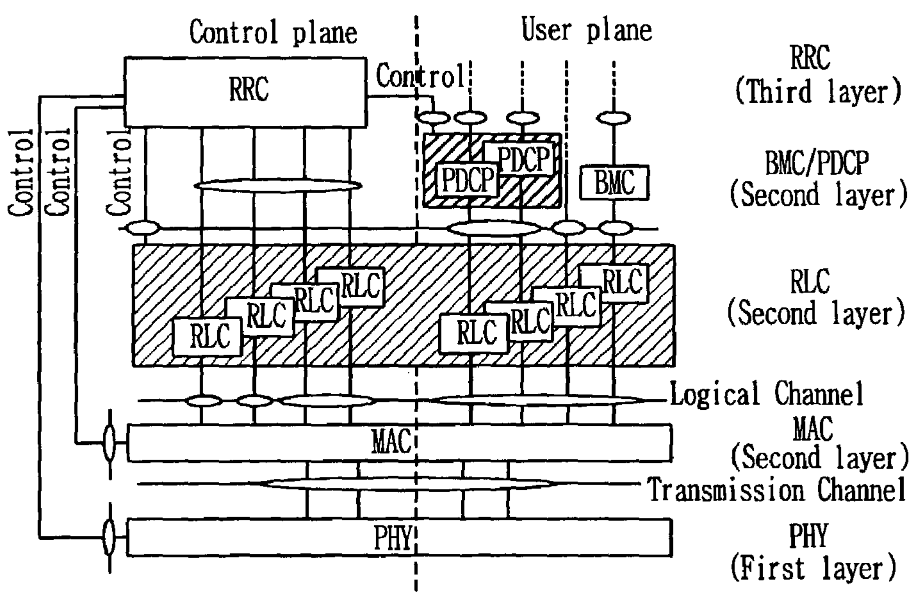

Control plane
User plane
RRC
Control
RRC
(Third layer)
Control
Control
Control
PDCP
PDCP
BMC
BMC/PDCP
(Second layer)
RLC
RLC
RLC
RLC
RLC
RLC
RLC
RLC
RLC
(Second layer)
Logical Channel
MAC
MAC
(Second layer)
Transmission Channel
PHY
PHY
(First layer)

FIG.3

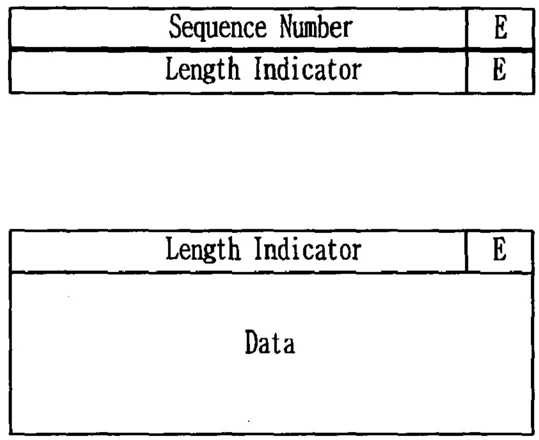

Sequence Number
E
Length Indicator
E
Length Indicator
E
Data

FIG.4

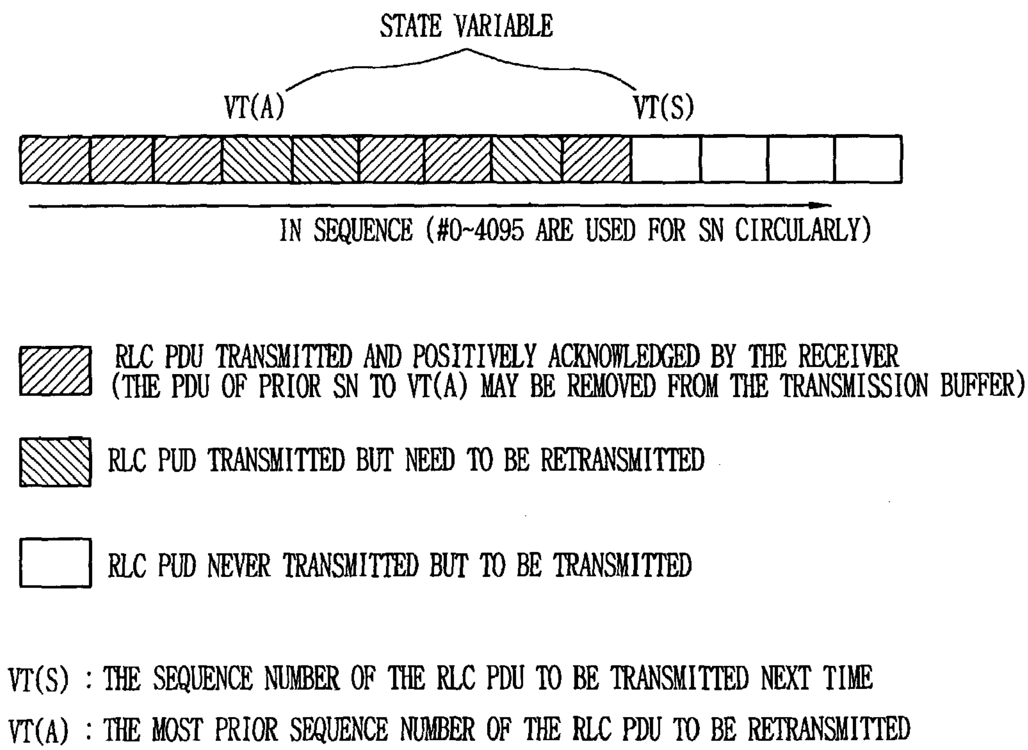

STATE VARIABLE
VT(A)
VT(S)
IN SEQUENCE (#0~4095 ARE USED FOR SN CIRCULARLY)
RLC PDU TRANSMITTED AND POSITIVELY ACKNOWLEDGED BY THE RECEIVER
(THE PDU OF PRIOR SN TO VT(A) MAY BE REMOVED FROM THE TRANSMISSION BUFFER)
RLC PUD TRANSMITTED BUT NEED TO BE RETRANSMITTED
RLC PUD NEVER TRANSMITTED BUT TO BE TRANSMITTED
VT(S) : THE SEQUENCE NUMBER OF THE RLC PDU TO BE TRANSMITTED NEXT TIME
VT(A) : THE MOST PRIOR SEQUENCE NUMBER OF THE RLC PDU TO BE RETRANSMITTED

FIG.5

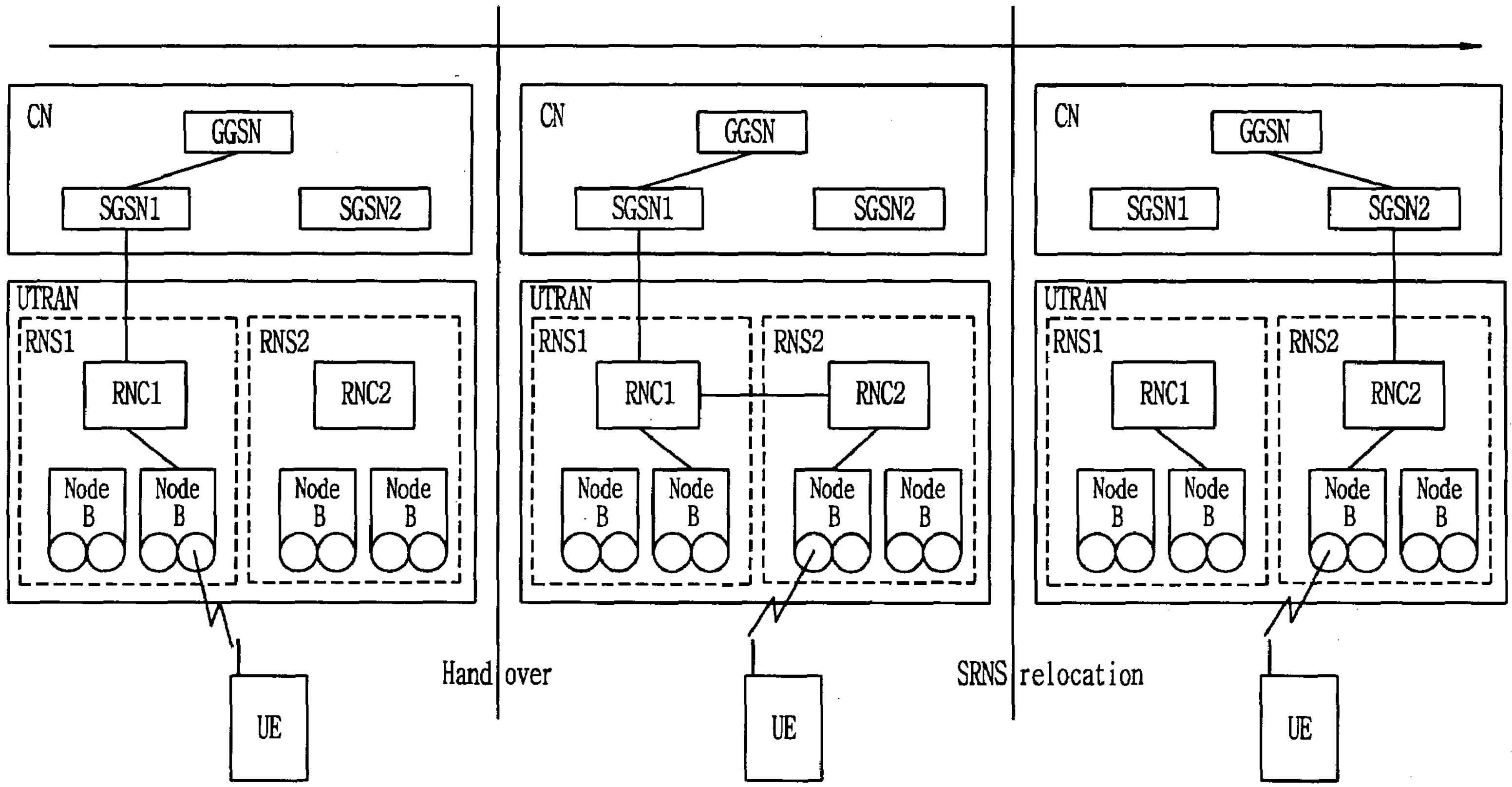

CN
GGSN
SGSN1
SGSN2
UTRAN
RNS1
RNS2
RNC1
RNC2
Node B
UE
Hand over
SRNS relocation

FIG.6

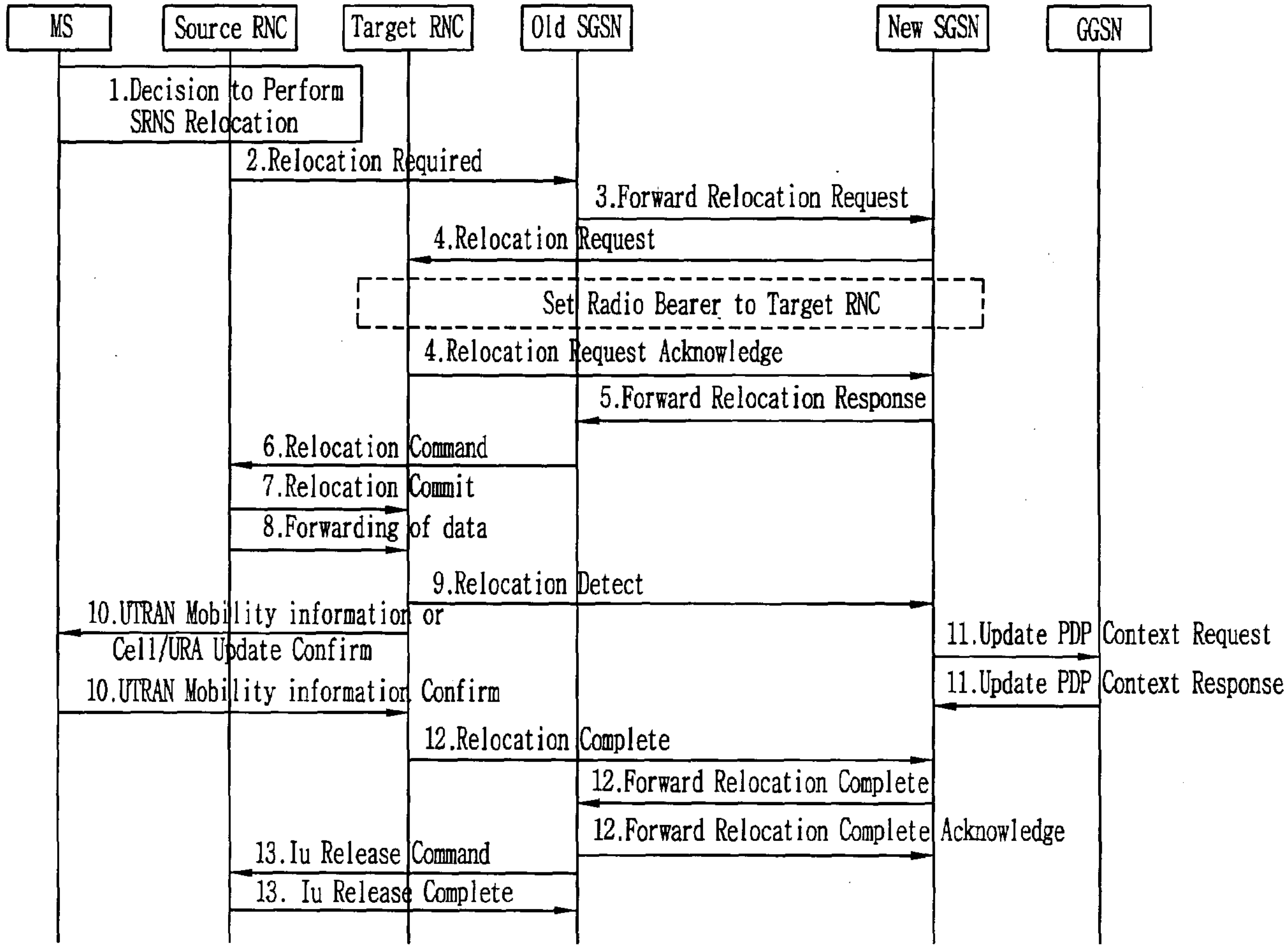

MS
Source RNC
Target RNC
Old SGSN
New SGSN
GGSN
1.Decision to Perform SRNS Relocation
2.Relocation Required
3.Forward Relocation Request
4.Relocation Request
Set Radio Bearer to Target RNC
4.Relocation Request Acknowledge
5.Forward Relocation Response
6.Relocation Command
7.Relocation Commit
8.Forwarding of data
9.Relocation Detect
10.UTRAN Mobility information or Cell/URA Update Confirm
11.Update PDP Context Request
11.Update PDP Context Response
10.UTRAN Mobility information Confirm
12.Relocation Complete
12.Forward Relocation Complete
12.Forward Relocation Complete Acknowledge
13.Iu Release Command
13. Iu Release Complete

FIG.7

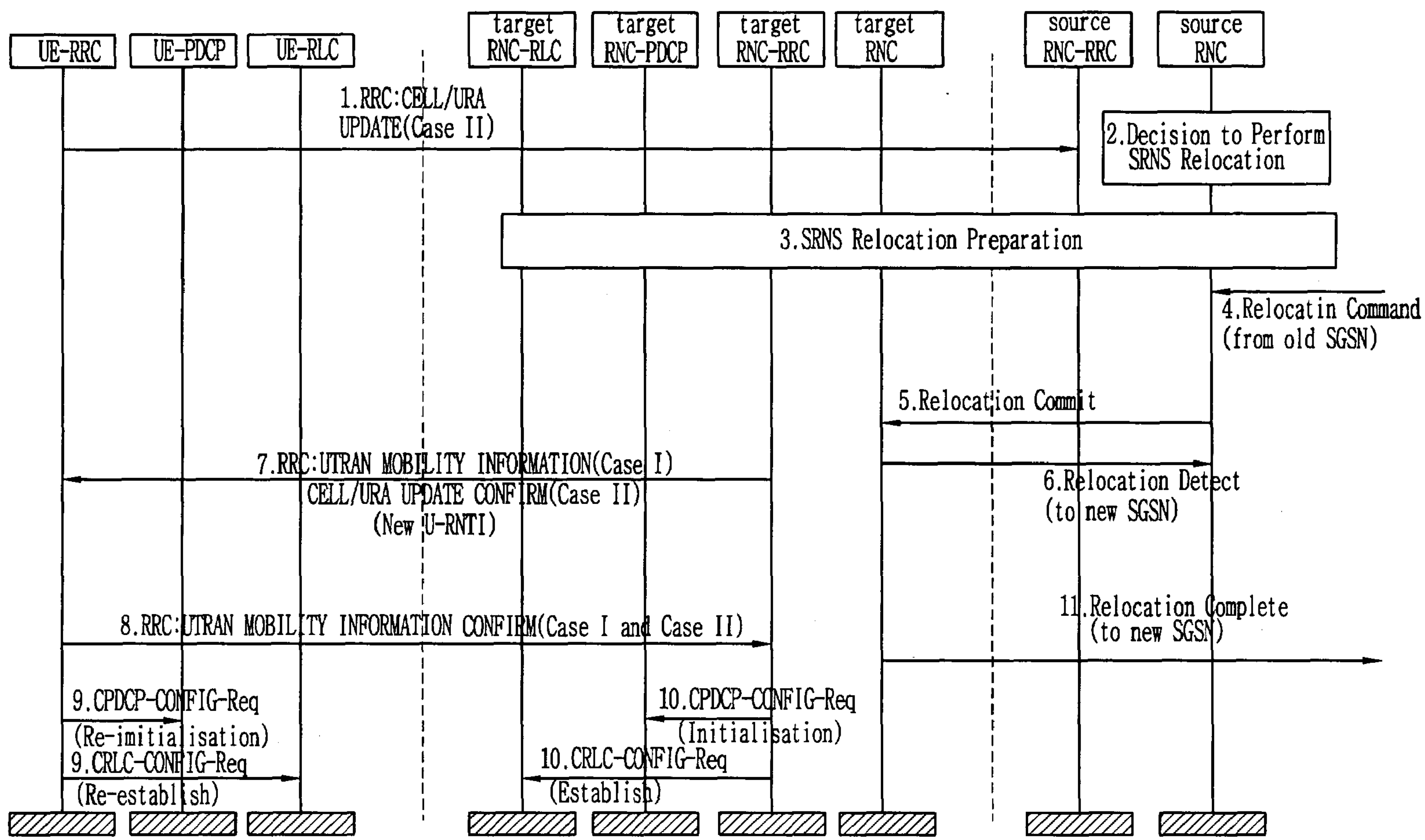

UE-RRC
UE-PDCP
UE-RLC
target RNC-RLC
target RNC-PDCP
target RNC-RRC
target RNC
source RNC-RRC
source RNC
1.RRC:CELL/URA UPDATE(Case II)
2.Decision to Perform SRNS Relocation
3.SRNS Relocation Preparation
4.Relocatin Command (from old SGSN)
5.Relocation Commit
6.Relocation Detect (to new SGSN)
7.RRC:UTRAN MOBILITY INFORMATION(Case I)
CELL/URA UPDATE CONFIRM(Case II)
(New U-RNTI)
8.RRC:UTRAN MOBILITY INFORMATION CONFIRM(Case I and Case II)
11.Relocation Complete (to new SGSN)
9.CPDCP-CONFIG-Req
(Re-imitialisation)
9.CRLC-CONFIG-Req
(Re-establish)
10.CPDCP-CONFIG-Req
(Initialisation)
10.CRLC-CONFIG-Req
(Establish)

FIG.8

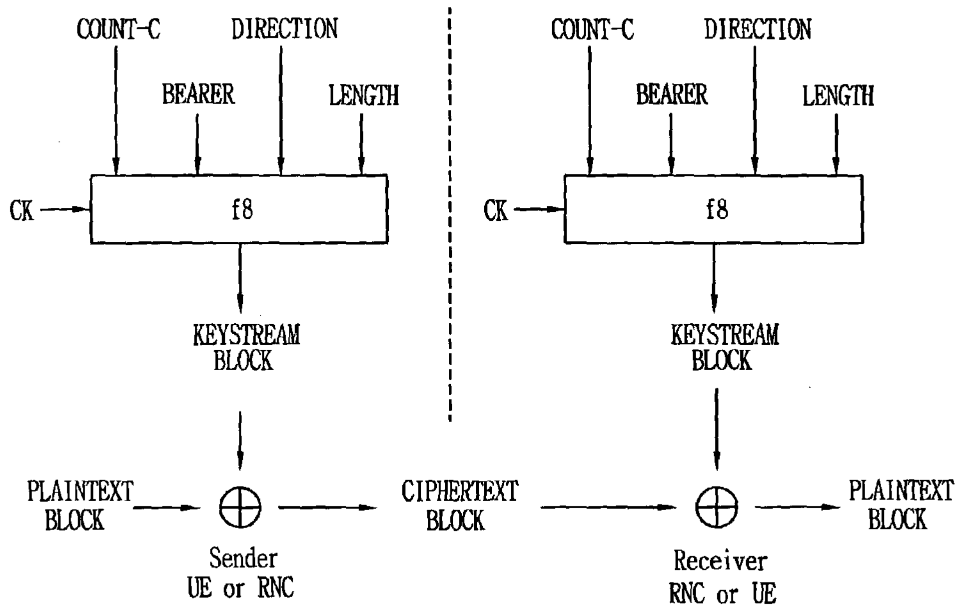

COUNT-C
DIRECTION
BEARER
LENGTH
CK
f8
KEYSTREAM BLOCK
PLAINTEXT BLOCK
Sender
UE or RNC
CIPHERTEXT BLOCK
COUNT-C
DIRECTION
BEARER
LENGTH
CK
f8
KEYSTREAM BLOCK
Receiver
RNC or UE
PLAINTEXT BLOCK

FIG.9

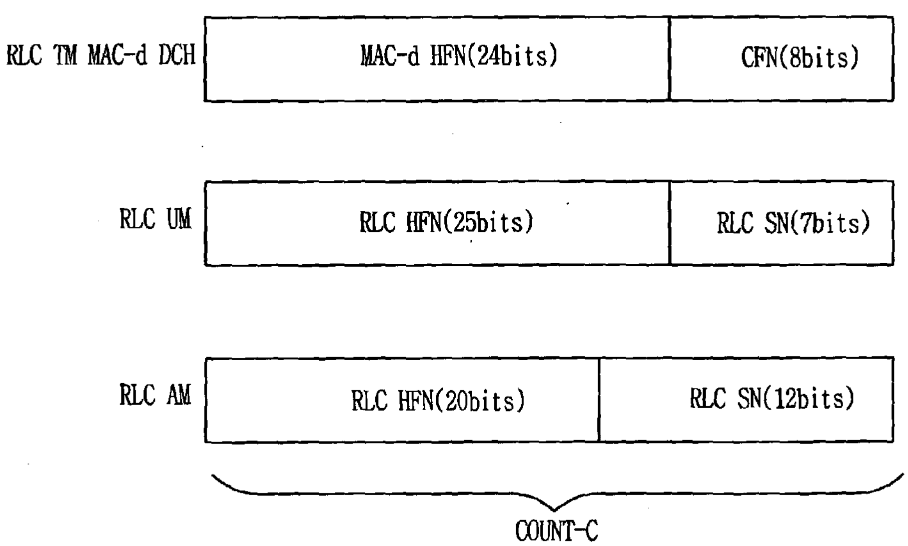

RLC TM MAC-d DCH
MAC-d HFN(24bits)
CFN(8bits)
RLC UM
RLC HFN(25bits)
RLC SN(7bits)
RLC AM
RLC HFN(20bits)
RLC SN(12bits)
COUNT-C

FIG.10

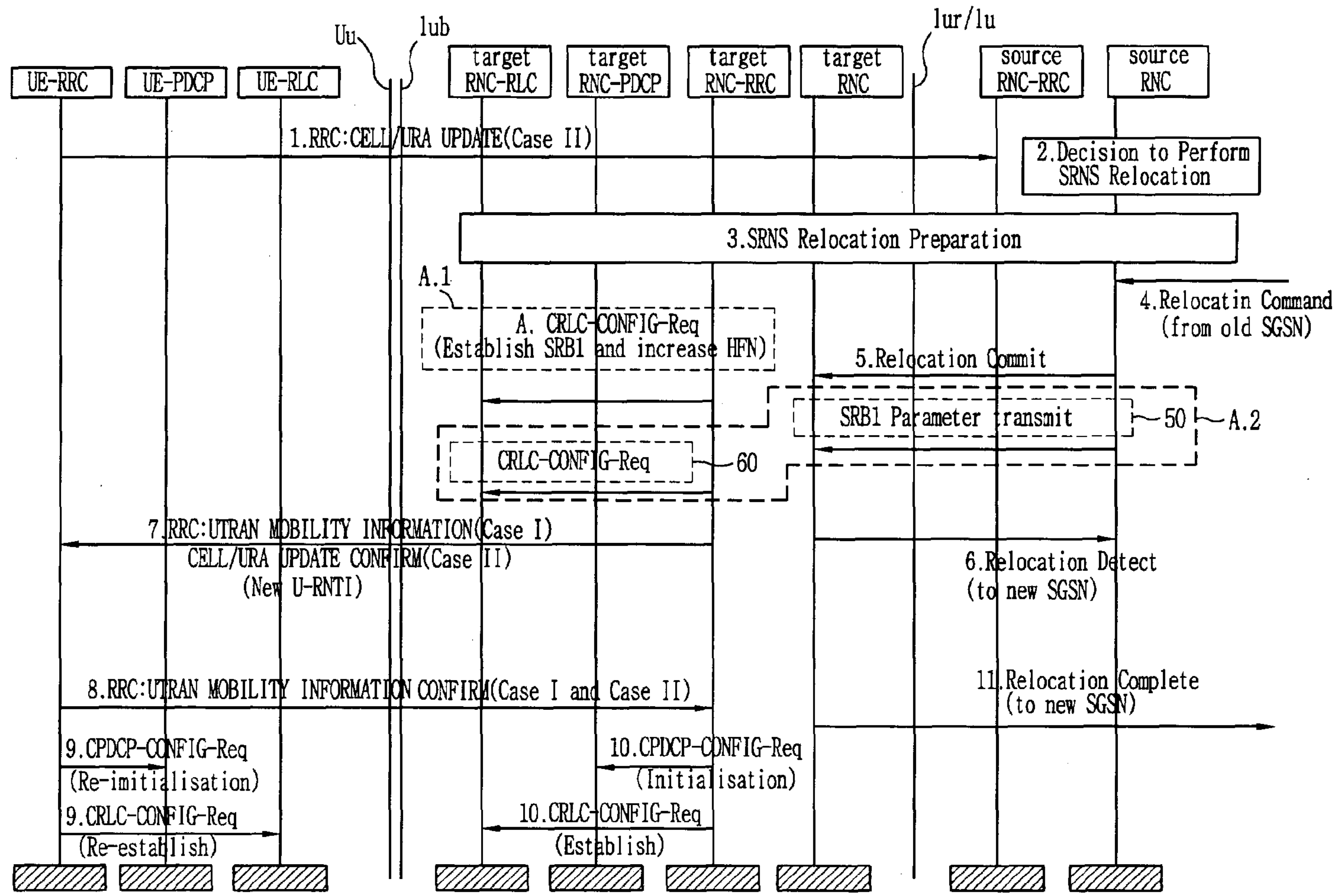

Uu
Iub
Iur/Iu
UE-RRC
UE-PDCP
UE-RLC
target RNC-RLC
target RNC-PDCP
target RNC-RRC
target RNC
source RNC-RRC
source RNC
1.RRC:CELL/URA UPDATE(Case II)
2.Decision to Perform SRNS Relocation
3.SRNS Relocation Preparation
4.Relocatin Command (from old SGSN)
A.1
A. CRLC-CONFIG-Req (Establish SRB1 and increase HFN)
5.Relocation Commit
SRB1 Parameter transmit
50
A.2
CRLC-CONFIG-Req
60
7.RRC:UTRAN MOBILITY INFORMATION(Case I)
CELL/URA UPDATE CONFIRM(Case II)
(New U-RNTI)
6.Relocation Detect (to new SGSN)
8.RRC:UTRAN MOBILITY INFORMATION CONFIRM(Case I and Case II)
11.Relocation Complete (to new SGSN)
9.CPDCP-CONFIG-Req (Re-imitialisation)
10.CPDCP-CONFIG-Req (Initialisation)
9.CRLC-CONFIG-Req (Re-establish)
10.CRLC-CONFIG-Req (Establish)

FIG. 11

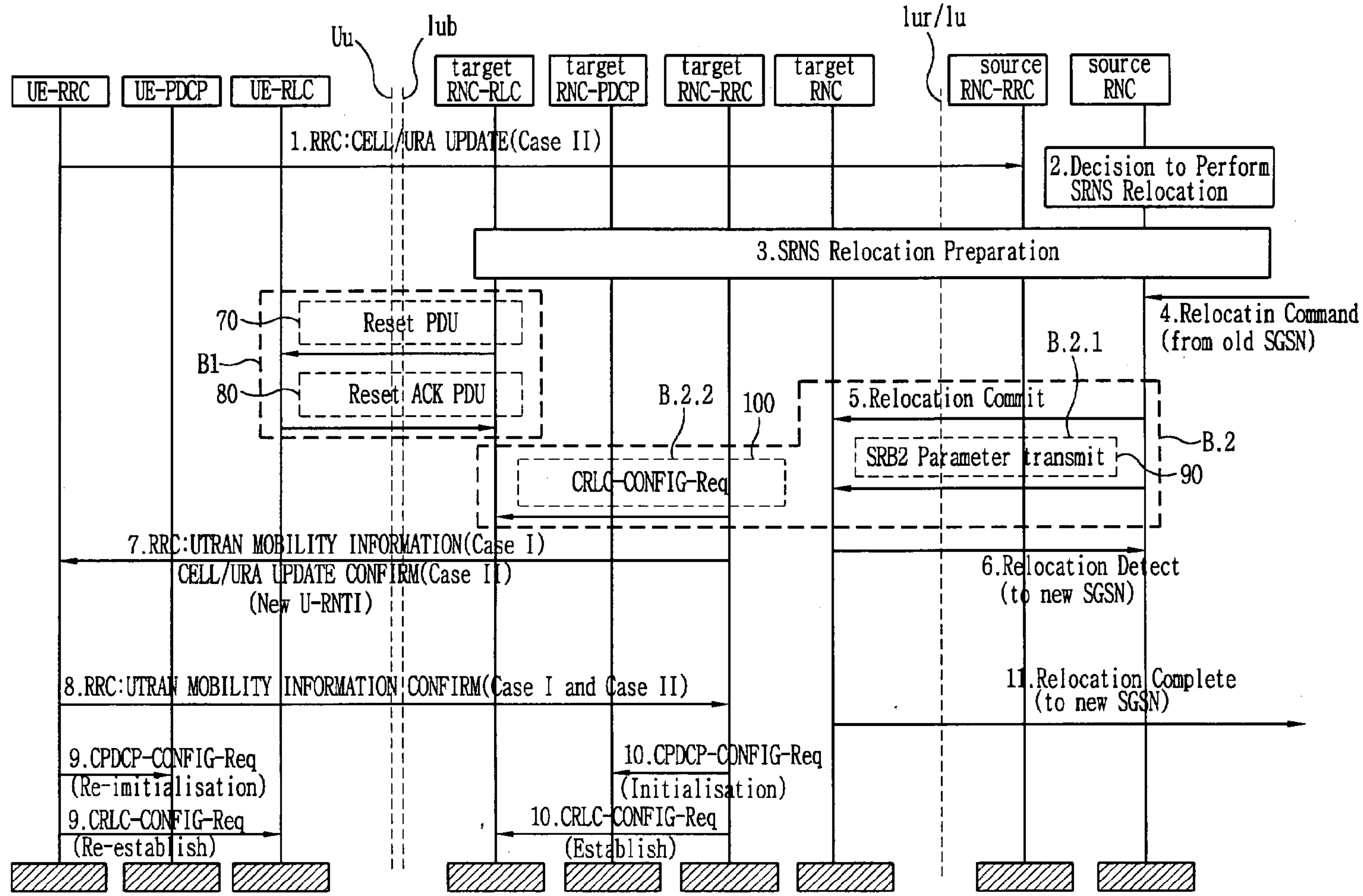

Uu
Iub
Iur/Iu
UE-RRC
UE-PDCP
UE-RLC
target RNC-RLC
target RNC-PDCP
target RNC-RRC
target RNC
source RNC-RRC
source RNC
1.RRC:CELL/URA UPDATE(Case II)
2.Decision to Perform SRNS Relocation
3.SRNS Relocation Preparation
4.Relocatin Command (from old SGSN)
70
Reset PDU
B1
80
Reset ACK PDU
B.2.1
B.2.2
100
5.Relocation Commit
B.2
SRB2 Parameter transmit
90
CRLC-CONFIG-Req
7.RRC:UTRAN MOBILITY INFORMATION(Case I)
CELL/URA UPDATE CONFIRM(Case II)
(New U-RNTI)
6.Relocation Detect (to new SGSN)
8.RRC:UTRAN MOBILITY INFORMATION CONFIRM(Case I and Case II)
11.Relocation Complete (to new SGSN)
9.CPDCP-CONFIG-Req (Re-initialisation)
9.CRLC-CONFIG-Req (Re-establish)
10.CPDCP-CONFIG-Req (Initialisation)
10.CRLC-CONFIG-Req (Establish)

FIG.12

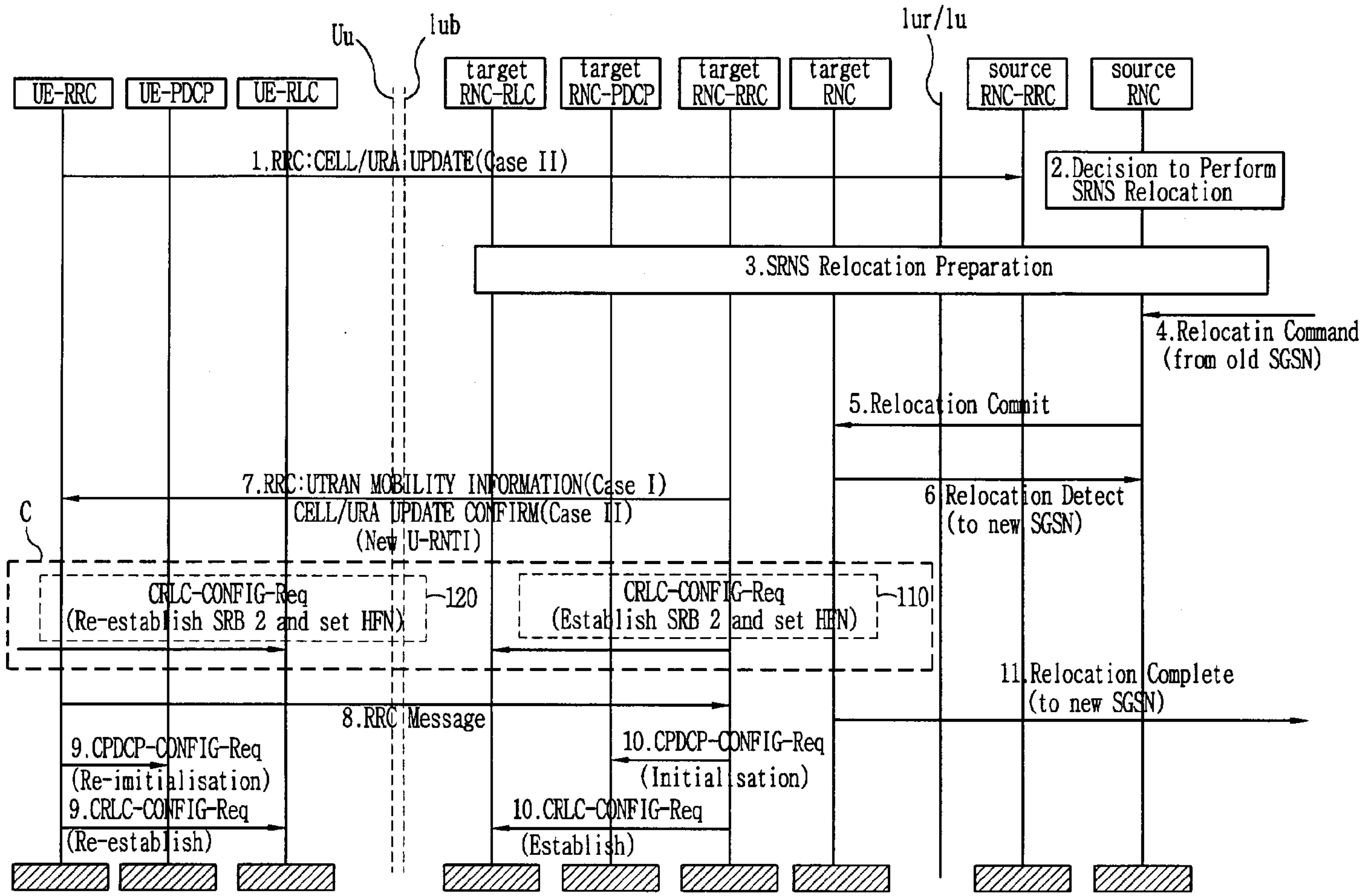
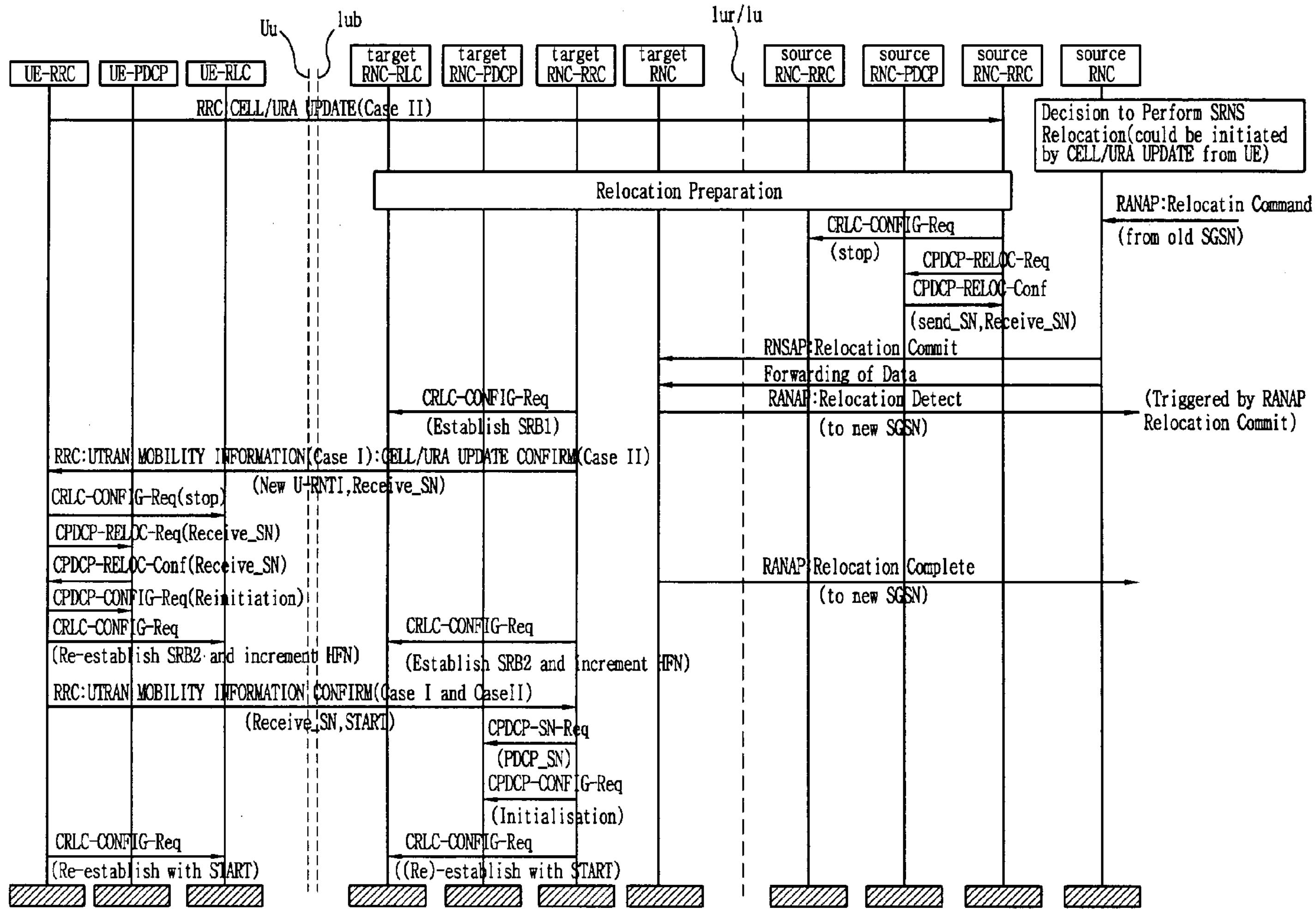
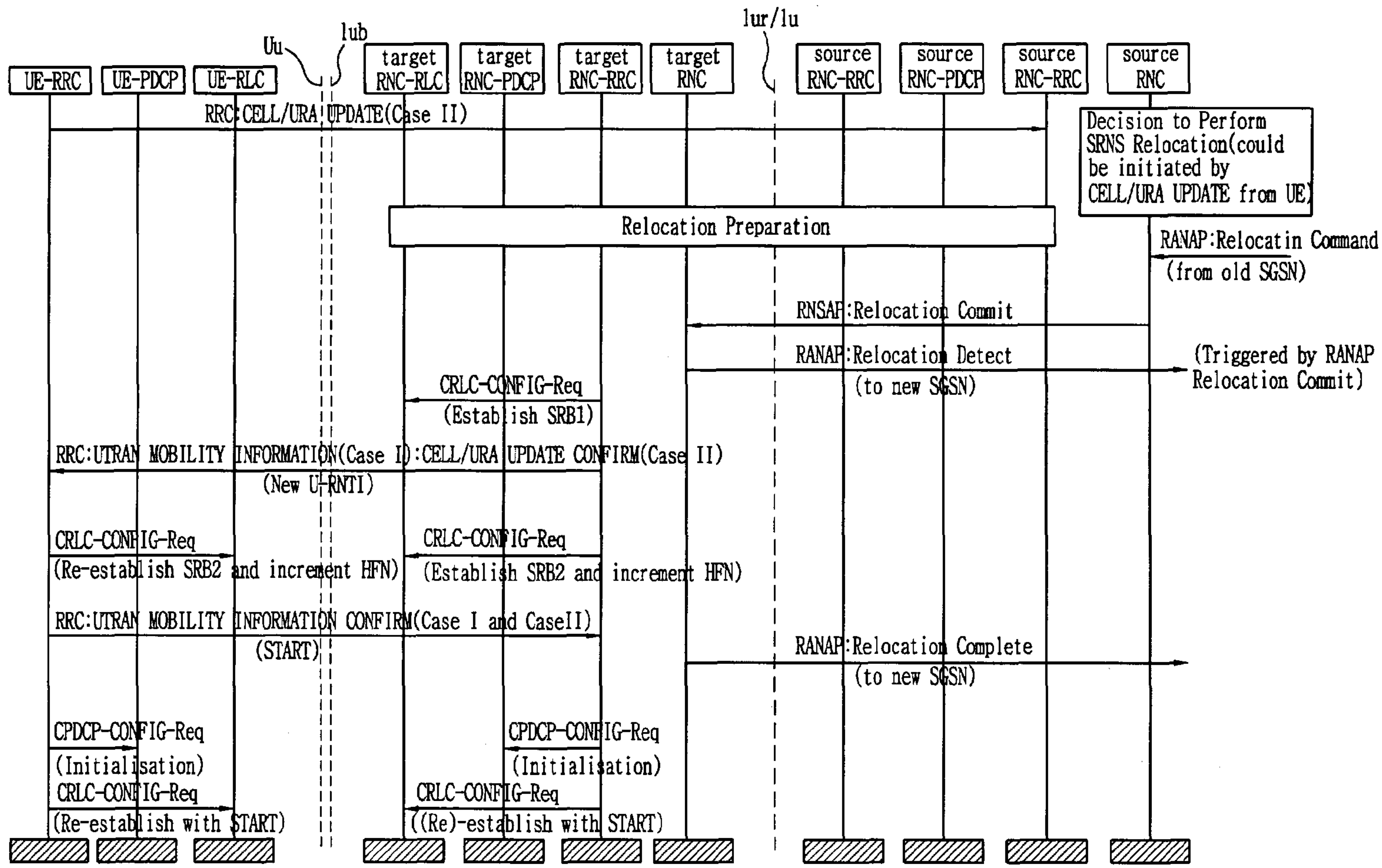

Uu
Iub
Iur/Iu
UE-RRC
UE-PDCP
UE-RLC
target RNC-RLC
target RNC-PDCP
target RNC-RRC
target RNC
source RNC-RRC
source RNC
1.RRC:CELL/URA UPDATE(Case II)
2.Decision to Perform SRNS Relocation
3.SRNS Relocation Preparation
4.Relocatin Command (from old SGSN)
5.Relocation Commit
6.Relocation Detect (to new SGSN)
7.RRC:UTRAN MOBILITY INFORMATION(Case I)
CELL/URA UPDATE CONFIRM(Case II)
(New U-RNTI)
C
CRLC-CONFIG-Req (Re-establish SRB 2 and set HFN)
120
CRLC-CONFIG-Req (Establish SRB 2 and set HFN)
110
11.Relocation Complete (to new SGSN)
8.RRC Message
9.CPDCP-CONFIG-Req (Re-imitialisation)
9.CRLC-CONFIG-Req (Re-establish)
10.CPDCP-CONFIG-Req (Initialisation)
10.CRLC-CONFIG-Req (Establish)

FIG. 13



Uu
Iub
Iur/Iu
UE-RRC
UE-PDCP
UE-RLC
target RNC-RLC
target RNC-PDCP
target RNC-RRC
target RNC
source RNC-RRC
source RNC-PDCP
source RNC-RRC
source RNC
RRC CELL/URA UPDATE(Case II)
Decision to Perform SRNS Relocation(could be initiated by CELL/URA UPDATE from UE)
Relocation Preparation
RANAP:Relocatin Command
(from old SGSN)
CRLC-CONFIG-Req
(stop)
CPDCP-RELOC-Req
CPDCP-RELOC-Conf
(send_SN,Receive_SN)
RNSAP:Relocation Commit
Forwarding of Data
RANAP:Relocation Detect
(to new SGSN)
(Triggered by RANAP Relocation Commit)
CRLC-CONFIG-Req
(Establish SRB1)
RRC:UTRAN MOBILITY INFORMATION(Case I):CELL/URA UPDATE CONFIRM(Case II)
(New U-RNTI,Receive_SN)
CRLC-CONFIG-Req(stop)
CPDCP-RELOC-Req(Receive_SN)
CPDCP-RELOC-Conf(Receive_SN)
CPDCP-CONFIG-Req(Reinitiation)
RANAP:Relocation Complete
(to new SGSN)
CRLC-CONFIG-Req
(Re-establish SRB2 and increment HFN)
CRLC-CONFIG-Req
(Establish SRB2 and increment HFN)
RRC:UTRAN MOBILITY INFORMATION CONFIRM(Case I and CaseII)
(Receive_SN,START)
CPDCP-SN-Req
(PDCP_SN)
CPDCP-CONFIG-Req
(Initialisation)
CRLC-CONFIG-Req
(Re-establish with START)
CRLC-CONFIG-Req
((Re)-establish with START)

FIG.14


Uu
Iub
Iur/Iu
UE-RRC
UE-PDCP
UE-RLC
target RNC-RLC
target RNC-PDCP
target RNC-RRC
target RNC
source RNC-RRC
source RNC-PDCP
source RNC-RRC
source RNC
RRC:CELL/URA UPDATE(Case II)
Decision to Perform SRNS Relocation(could be initiated by CELL/URA UPDATE from UE)
Relocation Preparation
RANAP:Relocatin Command (from old SGSN)
RNSAP:Relocation Commit
RANAP:Relocation Detect (to new SGSN)
(Triggered by RANAP Relocation Commit)
CRLC-CONFIG-Req (Establish SRB1)
RRC:UTRAN MOBILITY INFORMATION(Case I):CELL/URA UPDATE CONFIRM(Case II)
(New U-RNTI)
CRLC-CONFIG-Req (Re-establish SRB2 and increment HFN)
CRLC-CONFIG-Req (Establish SRB2 and increment HFN)
RRC:UTRAN MOBILITY INFORMATION CONFIRM(Case I and CaseII)
(START)
RANAP:Relocation Complete (to new SGSN)
CPDCP-CONFIG-Req (Initialisation)
CPDCP-CONFIG-Req (Initialisation)
CRLC-CONFIG-Req (Re-establish with START)
CRLC-CONFIG-Req ((Re)-establish with START)

METHOD FOR RELOCATING SRNS IN A MOBILE COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This invention generally relates to wireless communication systems, and more particularly to a system and method for performing a serving radio network sub-system (SRNS) relocation procedure in a communications system.

[0003] 2. Background of the Related Art

[0004] A universal mobile telecommunications system (UMTS) is a third generation mobile communication system that has evolved from a standard known as Global System for Mobile communications (GSM). This standard is a European standard which aims to provide an improved mobile communication service based on a GSM core network and wideband code division multiple access (W-CDMA) technology. In December, 1998, the ETSI of Europe, the ARIB/TTC of Japan, the T1 of the United States, and the TTA of Korea formed a Third Generation Partnership Project (3GPP) for the purpose of creating a specification for standardizing the UMTS.

[0005] The work towards standardizing the UMTS performed by the 3GPP has resulted in the formation of five technical specification groups (TSG), each of which is directed to forming network elements having independent operations. More specifically, each TSG develops, approves, and manages a standard specification in a related region. Among them, a radio access network (RAN) group (TSG-RAN) develops a specification for the function, items desired, and interface of a UMTS terrestrial radio access network (UTRAN), which is a new RAN for supporting a W-CDMA access technology in the UMTS.

[0006] The TSG-RAN group includes a plenary group and four working groups. Working group 1 (WG1) develops a specification for a physical layer (a first layer). Working group 2 (WG2) specifies the functions of a data link layer (a second layer) and a network layer (a third layer). Working group 3 (WG3) defines a specification for an interface among a base station in the UTRAN, a radio network controller (RNC), and a core network. Finally, Working group 4 (WG4) discusses terms desired for a radio link performance and items desired for radio resource management.

[0007] **FIG. 1** shows a structure of a 3GPP UTRAN to which the present invention may be applied. This UTRAN includes one or more radio network sub-systems (RNS). Each RNS includes an RNC and one or more Nodes B (e.g., a base station) managed by the RNCs. RNCs are connected to a mobile switching center (MSC) which performs line exchange communications with the GSM network. The RNCs are also connected to a serving general packet radio service support node (SGSN) which performs packet exchange communications with a general packet radio service (GPRS) network.

[0008] Nodes B are managed by the RNCs, receive information sent by the physical layer of a terminal (e.g., mobile station, user equipment and/or subscriber unit) through an uplink, and transmit data to a terminal through a downlink. Nodes B, thus, operate as access points of the UTRAN for the terminal.

[0009] The RNCs perform functions which include assigning and managing radio resources. An RNC that directly manages a Node B is referred to as a control RNC (CRNC). The CRNC manages common radio resources. A serving RNC (SRNC), on the other hand, manages dedicated radio resources assigned to the respective terminals. The CRNC can be the same as the SRNC. However, when the terminal deviates from the region of the SRNC and moves to the region of another RNC, the CRNC can be different from the SRNC. Because the physical positions of various elements in the UMTS network can vary, an interface for connecting the elements is necessary. Nodes B and the RNCs are connected to each other by an Iub interface. Two RNCs are connected to each other by an lur interface. An interface between the RNC and a core network is referred to as Iu.

[0010] Services provided to the UE may generally be classified into circuit-switching services and packet-switching services. A voice telephone service may be included in the circuit-switching service and a Web-browsing service may be included in a packet-switching service through an Internet connection. The circuit-switching service is connected to an MSC of the core network, and this MSC is connected to a gateway mobile switching center (GMSC) for communicating with one or more external networks. The GMSC manages the connections between the MSC and the external networks.

[0011] The packet-switching service is connected to a serving general packet radio service (GPRS) support node (SGSN), this node is connected to a gateway GPRS support node (GGSN) of the core network. The SGSN communicates packets between the SRNC and GGSN, and the GGSN manages connections between the SGSN and another packet-switching network such as the Internet.

[0012] A variety of interfaces are provided for performing mutual data exchanges between these network components. An interface between an RNC and the core network is known as an Iu interface. When the Iu is connected to the packet-switching domain, it is called an Iu PS interface, and when the Iu is connected to the circuit-switching domain it is called a Iu CS interface.

[0013] **FIG. 2** shows a structure of a radio access interface protocol between a terminal which operates based on a 3GPP RAN specification and a UTRAN. The radio access interface protocol is horizontally formed of a physical layer (PHY), a data link layer, and a network layer and is vertically divided into a control plane for transmitting control information and a user plane for transmitting data information. The user plane is a region to which traffic information of a user such as voice or an IP packet is transmitted. The control plane is a region to which control information such as an interface of a network or maintenance and management of a call is transmitted.

[0014] In **FIG. 2**, protocol layers can be divided into a first layer (L1), a second layer (L2), and a third layer (L3) based on three lower layers of an open system interconnection (OSI) standard model well known in a communication system. The first layer (L1) operates as a physical layer (PHY) for a radio interface and is connected to an upper medium access control (MAC) layer through one or more transport channels. The physical layer transmits data delivered to the physical layer (PHY) through a transport channel to a receiver using various coding and modulating methods suitable for radio circumstances. The transport channel between the physical layer (PHY) and the MAC layer is divided into a dedicated transport channel and a common transport channel based on whether it is exclusively used by a single terminal or shared by several terminals.

[**0015**] The second layer L**2** operates as a data link layer and lets various terminals share the radio resources of a W-CDMA network. The second layer L**2** is divided into the MAC layer, a radio link control (RLC) layer, a packet data convergence protocol (PDCP) layer, and a broadcast/multicast control (BMC) layer.

[**0016**] The MAC layer delivers data through an appropriate mapping relationship between a logical channel and a transport channel. The logical channels connect an upper layer to the MAC layer. Various logical channels are provided based on the kind of transmitted information. In general, when information of the control plane is transmitted, a control channel is used. When information of the user plane is transmitted, a traffic channel is used. The MAC layer is divided two sub-layers according to performed functions. The two sub-layers are a MAC-d sub-layer that is positioned in the SRNC and manages the dedicated transport channel and a MAC-c/sh sub-layer that is positioned in the CRNC and manages the common transport channel.

[**0017**] The RLC layer forms an appropriate RLC protocol data unit (PDU) suitable for transmission by the segmentation and concatenation functions of an RLC service data unit (SDU) received from an upper layer. The RLC layer also performs an automatic repeat request (ARQ) function by which an RLC PDU lost during transmission is re-transmitted. The RLC layer operates in three modes: a transparent mode (TM), an unacknowledged mode (UM), and an acknowledged mode (AM). The mode selected depends upon the method used to process the RLC SDU received from the upper layer. An RLC buffer stores the RLC SDUs or the RLC PDUs received from the upper layer. A more detailed explanation of the modes of operation of the RLC layer will follow.

[**0018**] The packet data convergence protocol (PDCP) layer is an upper layer of the RLC layer which allows data items to be transmitted through a network protocol such as IP.v4 or IP.v6. A header compression technique for compressing and transmitting the header information in a packet can be used for effective transmission of the IP packet.

[**0019**] The broadcast/multicast control (BMC) layer allows a message to be transmitted from a cell broadcast center (CBC) through the radio interface. The main function of the BMC layer is scheduling and transmitting a cell broadcast message to a terminal. In general, data is transmitted through the RLC layer operating in the unacknowledged mode.

[**0020**] The PDCP layer and the BMC layer are connected to the SGSN because a packet exchange method is used, and are located only in the user plane because they transmit only user data. Unlike the PDCP layer and the BMC layer, the RLC layer can be included in the user plane and the control plane according to a layer connected to the upper layer. When the RLC layer belongs to the control plane, data is received from a radio resource control (RRC) layer.

[**0021**] In general, the transmission service of user data provided to the upper layer by the second layer (L**2**) in the user plane is referred to as a radio bearer (RB). The transmission service of control information provided to the upper layer by the second layer (L**2**) in the control plane is referred to as a signaling radio bearer (SRB). As shown in **FIG. 2, a** plurality of entities can exist in the RLC and PDCP layers. This is because a terminal has a plurality of RBs, and one or two RLC entities and only one PDCP entity are generally used for one RB. The entities of the RLC layer and the PDCP layer can perform an independent function in each layer.

[**0022**] The RRC layer positioned in the lowest portion of the third layer (L**3**) is defined only in the control plane and controls the logical channels, the transport channels, and the physical channels in relation to the setting, the re-setting, and the cancellation of the RBs. At this time, setting up the RB means processes of stipulating the characteristics of a protocol layer and a channel, which are required for providing a specific service, and setting the respective detailed parameters and operation methods. It is possible to transmit control messages received from the upper layer through a RRC message.

[**0023**] Operation of the radio bearer and the RLC layer will be now described in detail. As previously discussed, a radio bearer (RB) is a transmission service which delivers user data in the user plane to an upper layer through the second layer L**2**. The transmission service which delivers control information in the control plane to the upper layer through the second layer L**2** is defined as a signaling radio bearer (SRB).

[**0024**] As previously noted, the RLC layer operates in one of three modes: transparent mode (ITM), unacknowledged mode (UM), and acknowledged mode (AM).

[**0025**] When operating in the TM mode, header information is not added to the RLC SDU received from the upper layer, no sequence number is attached to the RLC PDU and data re-transmission is not performed. Also, though segmentation and reassembly of the RLC SDU are generally not performed, use of segmentation and reassembly when the radio bearer is set up is determined in certain circumstances.

[**0026**] When operating in UM mode, re-transmission of RLC PDUs is not performed even when a transmission failure occurs. The receiver does not request retransmission of data. Instead, a different approach is taken. In UM mode, the RLC layer constructs RLC PDUs by segmenting or concatenating RLC SDUs, and then attaching sequence numbers to the RLC PDUs. The receiver can restore lost data based on the sequence numbers by a re-assembly procedure.

[**0027**] When operating in the AM mode, re-transmission is used to support error-free transmission in the following manner. Status information corresponding to received RLC PDUs is transmitted from the receiver in the form of a Status Report. After receiving this report, the transmitter re-transmits unsuccessfully transmitted RLC PDUs.

[**0028**] More specifically, in AM mode, the transmitter forms each RLC PDU from one or more RLC SDUs that have been received from an upper layer, and header information, (e.g. sequence number and length indicators) are then attached. Since the size of an AM RLC PDU is fixed, the transmitter segments or concatenates one or more RLC SDUs to fit the PDU size. Then, the formed RLC PDU is stored in the transmission buffer. The stored RLC PDUs are sequentially delivered to the MAC layer at a rate controlled by the MAC layer. Since each RLC PDU has its own sequence number, the receiver can check which RLC PDUs are successfully received and which are not. The receiver requests the retransmission for the unsuccessfully received RLC PDUs to the transmitter by the Status Report.

[0029] The AM retransmission procedure may be more clearly understood by the following example. If the sequence numbers of the received RLC PDUs are #23, #24, #25, #32, and #34, the receiver considers that RLC PDUs having the sequence numbers of #26 to #31 and #33 are lost during transmission. The receiver then sends a Status Report to the transmitter, and the transmitter checks the Status Report, and re-transmits the unsuccessfully transmitted RLC PDUs, i.e. #26 to #31 and #33.

[0030] **FIG. 3** shows the structure of an RLC PDU of AM or UM mode used in the RLC layer. The RLC PDU is comprised of a header and a payload. The header shown includes a sequence number and a length indicator. The sequence number is used as an identifier of the corresponding RLC PDU, and the length indicator indicates a boundary of the RLC SDU. The sequence numbers may be, for example, 7 (seven) bits for UM mode, and 12 (twelve) bits for AM mode. A 1 (one) bit E field may be included to indicate whether the next field is the length indicator or data.

[0031] The length indicator is used to indicate the boundary of each RLC SDU ending within the RLC PDU. Therefore, the length indicator may not be present if the RLC SDU is not ended within the RLC PDU. The length indicator may also be used for other purposes. For example, the length indicator may be used as a padding indicator and/or a data start indicator. Padding is used to fill the whole RLC PDU when there is no RLC SDU to be concatenated. The padding can have any value and the receiver and the sender disregard it. When used as a data start indicator the length indicator may indicate that the RLC SDU begins in the beginning of the RLC PDU.

[0032] The data start indicator is useful because it can prevent additional loss of data in the UM RLC. For example, assume that an RLC PDU of sequence number #4 is lost and an RLC PDU of sequence number #5 is received. Assume further that a new RLC SDU begins at the beginning of the PDU of sequence number #5 and ends within the PDU of sequence number #5. In this case, because the RLC SDU begins at the beginning of the PDU of sequence number #5, the data start indicator is present at the header of the PDU of sequence number #5. But, if the data start indicator is not present, the receiver RLC layer considers that only continued segments of an RLC SDU contained in the RLC PDU of sequence number #5 is received. In this case, the receiver discards the segments because the receiver thinks that the entire RLC SDU has not been received.

[0033] **FIG. 4** shows an exemplary snapshot of the status of an RLC buffer. As shown, the RLC PDUs are sequentially stored in the buffer and the successfully transmitted RLC PDUs are deleted from the buffer. As shown, the RLC layer uses state variables for managing the transmission of data using the RLC buffer.

[0034] When operating in AM mode, the RLC layer uses a state variable VT(S) to indicate the sequence number of the next RLC PDU to be transmitted for the first time, and a state variable VT(A) to indicate the sequence number of the first RLC PDU to be positively acknowledged by the receiver. The status of the buffer therefore indicates that the transmitter has transmitted RLC PDUs up to the PDU of sequence number of VT(S)-**1** and has received positive acknowledgments up to the RLC PDU of VT(A)-**1** from the receiver.

[0035] When operating in the UM mode, the RLC layer uses a state variable VT(US) which is similar to VT(S) in AM mode. That is, VT(US) indicates the sequence number of the next RLC PDU to be transmitted. However, since there is no feedback from the receiver in UM mode, the state variable such as VT(A) is not defined.

[0036] In both modes of operation, the initial value of the state variables may be set to 0 (zero). When the RLC layer is established, re-established or reset, the state variables are set to this initial value.

[0037] Returning now to radio communications protocol shown in **FIG. 2**, as previously indicated, the service provided to the upper layer by the second layer L**2** in the control plane is defined as a signaling radio bearer (SRB). In operation, all RRC messages are exchanged between the terminal and the RNC through the signaling radio bearers SRBs. Using the RRC messages, the RNC can setup, modify, and release the radio bearers as needed in order to, for example, perform an SRNS relocation procedure, the details of which are described in greater detail below.

[0038] Signaling radio bearer (SRB) characteristics as previously indicated are determined based on the mode of operation of the RLC and the type of logical channel used. A common control channel (CCCH) and dedicated control channel (DCCH) are used for the SRBs. CCCH is a logical channel carrying common control information to several terminals. Since CCCH is a common logical channel, CCCH contains a UTRAN radio network temporary identity (U-RNTI) to identify a specific terminal. The DCCH is a logical channel carrying dedicated control information to a specific terminal.

[0039] The characteristics of each type of SRB are as follows.

[0040] SRB**0**: For the uplink (UL) TM RLC is used, and for the downlink (DL)UM RLC is used. The logical channel used for the SRBO is CCCH.

[0041] SRB**1**: UM RLC is used, and the logical channel is DCCH.

[0042] SRB**2**: AM RLC is used, and the logical channel is DCCH. The SRB**2** carries only the messages generated in the RRC layer. The SRB**2** does not carry the upper layer messages.

[0043] SRB**3**: AM RLC is used, and the logical channel is DCCH. The SRB**3** carries the messages received from the upper layer.

[0044] SRB**4**: AM RLC is used, and the logical channel is DCCH. The SRB**4** also carries the messages received from the upper layer. The difference is that the SRB**3** carries higher priority messages while the SRB**4** carries lower priority messages.

[0045] SRB**5**-**31**: TM RLC is used, and the logical channel is DCCH. These SRBs are optionally used.

SRNS Relocation Procedure

[0046] FIG. 5 is a diagram showing how a serving radio network sub-system (SRNS) procedure may be performed in a packet-switching based service domain. As shown, this procedure involves changing the RNS serving a user terminal from one RNS (or RNC) to another. When making this change, it is preferable to establish the shortest route between the terminal and core network by changing the Iu connection point. As is further shown, changing the Iu connection point may in some instances cause the core network to switch from one SGSN (Old SGSN) to another (New SGSN) for purposes of performing communications with the user terminal. The SRNS relocation procedure may also be performed in the circuit-switching based service domain.

[0047] An SRNS relocation procedure may be performed for at least the following reasons:

[0048] Connection Point Change: Relocation is performed to move the UTRAN to a CN connection point at the UTRAN side from the source RNC to the target RNC.

[0049] Combined Hard Handover: Relocation is performed to move the UTRAN to a CN connection point at the UTRAN side from the source RNC to the target RNC, while performing a hard handover decided by the UTRAN.

[0050] Combined Cell/URA Update: Relocation is performed to move the UTRAN to the CN connection point at the UTRAN side from the source RNC to the target RNC, while performing a cell reselection in the UTRAN.

[0051] As will be discussed in greater detail, an SRNS relocation procedure may require the use of different radio bearers depending upon the mode of operation of the RLC layer.

[0052] SRNS relocation is usually classified into two cases: (1) terminal not involved case (Case I) and (2) terminal involved case (Case II). In Case I, SRNS relocation is initiated by a network's own decision and the terminal does not know whether the SRNS relocation is performed until the relocation procedure is terminated. In Case II, SRNS relocation is initiated as a result of the terminal's cell change (e.g., handover) request and the terminal knows the SRNS relocation at the beginning of the procedure. Though Cases I and II are different in that one is involved with the terminal and the other is not, the two cases have no substantial difference with respect to the SRNS relocation procedure. A more detailed explanation of this procedure now follows.

[0053] During the SRNS relocation procedure, various signaling messages are exchanged between the terminal and one RNC, between the one RNC and another RNC, and between one of the RNCs and the core network.

[0054] FIG. 6 shows the exchange of signaling messages that takes place between the terminal and core network in the SRNS relocation procedure of the UMTS. In this exchange, the "source RNC" is the RNC that plays the role of the SRNC before SRNS relocation and the "target RNC" is the RNC that plays the role of the SRNC after SRNS relocation. Likewise, the "old SGSN" is the SGSN before the relocation procedure and the "new SGSN" is the SGSN after the relocation procedure. Though the old and new SGSNs are shown to be different, the old SGSN and new SGSN may be the same in certain circumstances. Moreover, the procedure shown in FIG. 6 may be applied to both Case I and Case II.

[0055] The steps of the SRNS relocation procedure will now be summarized. In an initial step, step 1, the source RNC decides to perform an SRNS relocation. Either Case I or Case II may be used to trigger the relocation procedure.

[0056] In step 2, the source RNC sends a Relocation Required message to the old SGSN. The Relocation Required message includes information for performing, for example, relocation co-ordination, security functionality, RRC protocol context information, and the terminal capabilities.

[0057] In step 3, the old SGSN determines from the Relocation Required message if the SRNS relocation is intra-SGSN or inter-SGSN SRNS relocation. An intra-SGSN procedure is performed when the old and new SGSNs are the same, and an inter-SGSN procedure is performed when the two are different. A Forward Relocation Request message is applicable only in the case of inter-SGSN SRNS relocation.

[0058] In step 4, the new SGSN sends a Relocation Request message to the target RNC so that the necessary resources are allocated between the target RNC and the new SGSN. After all necessary resources are successfully allocated, the target RNC sends the Relocation Request Acknowledge message to the new SGSN.

[0059] In step 5, when a resource for the transmission of user data between the target RNC and the new SGSN have been allocated and the new SGSN is ready for SRNS relocation, the Forward Relocation Response message is sent from the new SGSN to old SGSN.

[0060] In step 6, the old SGSN continues SRNS relocation by sending a Relocation Command message to the source RNC. The source RNC is ready for forward downlink user data directly to the target RNC.

[0061] In step 7, when the source RNC is ready for data-forwarding, it triggers execution of SRNS relocation by sending a Relocation Commit message to the target RNC.

[0062] In step 8, the source RNC begins to forward data for the radio access bearers. The data forwarding may be carried out through the Iu interface, which means that data is not directly exchanged between the source RNC and the target RNC but through the core network.

[0063] In step 9, the target RNC sends a Relocation Detect message to the new SGSN. When the Relocation Detect message is sent, the target RNC starts SRNC operation.

[0064] In step 10, the target RNC sends a UTRAN mobility information (Case I) message or a Cell/URA (UTRAN registration area) update (Case II) message to the terminal. Both messages contain terminal information elements and core network information elements. The terminal information elements include new U-RNTI used for the identification of the terminal in the target RNC. The core network information elements include location area identification and routing area identification information.

[0065] Upon receipt of the UTRAN Mobility Information message the terminal can start sending uplink (UL) user data to the target RNC. When the terminal has reconfigured itself, it sends the UTRAN Mobility Information Confirm message to the target RNC. This indicates that the terminal is also ready to receive downlink (DL) data from the target RNC.

[0066] In step **11**, upon receipt of the Relocation Detect message the core network switches the user plane from source RNC to target RNC. In the case of an inter-SGSN SRNS relocation, the new SGSN sends Update PDP Context Request messages to the GGSNs concerned. The GGSNs update their PDP context fields and return an Update PDP Context Response.

[0067] In step **12**, when the target RNC receives the UTRAN Mobility Information Confirm message, (i.e., the new U-RNTI is successfully exchanged with the terminal by the radio protocols), the target RNC sends the Relocation Complete message to the new SGSN. The purpose of the Relocation Complete message is to indicate by the target RNC completion of the relocation of the SRNS to the core network. In the case of an inter-SGSN SRNS relocation, the new SGSN signals the old SGSN of the completion of the SRNS relocation procedure by sending a Forward Relocation Complete message.

[0068] In step **13**, upon receiving the Relocation Complete message or the Forward Relocation Complete message, the old SGSN sends an Iu Release Command message to the source RNC so that the Iu connection between the source RNC and the old SGSN is released.

[0069] **FIG. 7** shows the steps of the SRNS relocation procedure including the exchange of RRC messages between the UTRAN and the terrminal. In this figure, RRC messages are transmitted at steps **1**, **7**, and **8**, and the UTRAN can either be the source RNC or target RNC depending on the case. Also, UE refers to user equipment and therefore may include a user terminal. The RRC messages transmitted in this procedure are described as follows.

[0070] (1) Cell Update message and Cell Update Confirm message: When the terminal moves to a new cell, a Cell Update message is sent from the terminal to the UTRAN. If the UTRAN decides to perform SRNS relocation, the target RNC sends the Cell Update Confirm message to the terminal as a response to the Cell Update message. The Cell Update Confirm message contains the new U-RNTI, which indicates to the terminal the SRNS relocation procedure being performed. The Cell Update message is transmitted through SRBO using TM RLC, and the Cell Update Confirm message is through either SRB**0** or SRB**1** using UM RLC.

[0071] (2) URA Update message and URA Update Confirm message: A URA (UTRAN registration area) is an area comprised of one or several cells, and is internally known to the UTRAN. The URAs may partially overlap in order to prevent a ping-pong effect of the terminal. Therefore, one cell can belong to one or more URAs. The terminal knows the current URA identity from the URA list broadcast in each cell and performs the URA update procedure whenever the URA is changed.

[0072] The URA update procedure is initiated when the terminal sends the URA Update message to the UTRAN. The UTRAN transmits the URA Update Confirm message in response to the URA Update message to the terminal, in order to inform the terminal of the new URA identity. The URA Update Confirm message includes a new U-RNTI which is the same as in the Cell Update Confirm message. The URA Update message is transmitted through SRB**0** using TM RLC, and the URA Update Confirm message is transmitted through SRB**0** or SRB**1** using UM RLC.

[0073] (3) UTRAN Mobility Information message and UTRAN Mobility Information Confirm message: The UTRAN Mobility Information message is used when the UTRAN assigns a new U-RNTI to the terminal or when mobility information is transmitted. The terminal transmits UTRAN Mobility Information Confirm message in response. After successfully transmitting the UTRAN Mobility Information Confirm message, the target RNC and the terminal establish/re-establish the PDCP and RLC entities using CPDCP-CONFIG-Req and CRLC-CONFIG-Req commands, respectively. The UTRAN Mobility Information message is transmitted through SRB**1** using UM RLC or SRB**2** using AM RLC. The UTRAN mobility Information Confirm message is transmitted through SRB**2** using AM RLC.

Ciphering

[0074] The SRNS relocation procedure has been described in terms of the steps taken in both the UMTS system and the UTRAN. From this description, it is clear that the SRNS relocation procedure is primarily based on the exchange of messages between the terminal and RNC, and between the RNC and the core network. Among these messages, RRC messages exchanged between the terminal and the RNC are usually ciphered for the sake of security.

[0075] In some cases, the ciphered RRC messages cannot be deciphered in the receiver because the ciphering parameters are different between the terminal and the UTRAN. In order to gain a better understanding of this problem, the ciphering method in general must first to be considered.

[0076] Ciphering is a method which prevents unauthorized access of data, for example, as a result of eavesdropping. Because unique ciphering parameters exist between the terminal and the RNC, a user who does not know the ciphering parameters cannot decipher the data.

[0077] The ciphering method adopted by the 3GPP is performed in the RLC layer or the MAC layer according to the RLC mode of operation. That is, when the RLC mode is AM or UM, ciphering is performed in the RLC layer. When the RLC mode is TM, ciphering is performed in the MAC layer. Preferably, in this system ciphering is applied only for the DCCH and DTCH channels.

[0078] During this ciphering method, a MASK used for ciphering is generated based on various input parameters. The MASK is then added to RLC PDUs or MAC SDUs to generate the ciphered data. In the user terminal, the same MASK is used to decipher the data.

[0079] **FIG. 8** shows steps included in the ciphering process. Here, PLAINTEXT BLOCK is the data before ciphering and KEYSTREAM BLOCK is a ciphering MASK. The PLAINTEXT BLOCK is ciphered to CIPHERTEXT BLOCK through a bit operation with the KEYSTREAM BLOCK. Then, the ciphered CIPHERTEXT BLOCK is transmitted to a radio interface. After receiving the CIPHERTEXT BLOCK, the receiver deciphers it by applying the KEYSTREAM BLOCK that is the same MASK as in the transmitter. That is, if the ciphered data is extracted during transmission, the data cannot be deciphered unless the KEYSTREAM BLOCK is known.

[0080] The core technology of ciphering lies in the generation of the KEYSTREAM BLOCK, i.e. the ciphering MASK. To achieve effective results, the MASK should have the following characteristics. First, generation of the MASK by reverse tracing should be impossible. Second, each radio bearer RB should have its own MASK. Third, the MASK should continuously change over time.

[0081] Among the various ciphering algorithms that exist, a method referred to as **F8** has been adopted by 3GPP communications systems. The **F8** algorithm generates the KEYSTREAM BLOCK using input parameters including:

[0082] CK (Ciphering key, 128 bits): There is one CK_{CS} for a circuit-switching based service domain and one CK_{PS} for a packet-switching based service domain.

[0083] BEARER (Radio Bearer Identifier, 5 bits): One value exists for each RB.

[0084] DIRECTION (Direction Identifier, 1 bit): Indicates the direction of the RB. It is set to **0** for uplink and **1** for downlink.

[0085] LENGTH (16 bits): Indicates the length of the KEYSTREAM BLOCK, i.e. the generated MASK.

[0086] COUNT-C (32 bits): A ciphering sequence number. For RBs using AM or UM RLC, one COUNT-C is used for each RB. For RBs using TM RLC, one COUNT-C value is used for all the RBs. Those skilled in the art can appreciate that the bit and other values provided above are preferred values and may be changed if desired.

[0087] Among the ciphering input parameters, COUNT-C is the only time-varying parameter. That is, different COUNT-C values are used for each PDU. Other ciphering input parameters are fixed parameters and therefore the same values may be used for these parameters for all PDUs in a data stream. The COUNT-C parameter is divided into two parts: a forward part and a rear part. The forward part includes a long sequence number and the rear part includes a short sequence number.

[0088] **FIG. 9** shows detailed structures of the COUNT-C parameter for the various modes of operation of the RLC layer. The respective structures are as follows:

[0089] TM RLC case

[0090] long sequence number: MAC-d Hyper Frame Number (HFN) of 24 bits

[0091] short sequence number: Connection Frame Number (CFN) of 8 bits

[0092] UM RLC case

[0093] long sequence number: RLC Hyper Frame Number (HFN) of 25 bits

[0094] short sequence number: RLC UM Sequence Number (SN) of 7 bits

[0095] AM RLC case

[0096] long sequence number: RLC Hyper Frame Number (HFN) of 20 bits

[0097] short sequence number: RLC AM Sequence Number (SN) of 12 bits

[0098] The CFN is a counter for synchronizing the transport channels of the MAC layer between the terminal and the UTRAN. The CFN may have a value between 0 and 255 and it increases by one for each radio frame (10 ms).

[0099] The RLC SN is a sequence number used for identifying each RLC PDU. For UM RLC, the RLC SN has a value between 0 and 127 (7 bits). For AM RLC, the RLC SN has a value between 0 and 4095 (12 bits). The RLC SN increases by 1 for each RLC PDU.

[0100] Since a short sequence number is too short to be used alone for COUNT-C, a long sequence number known as HFN is added in front of the short sequence number. More specifically, the HFN corresponds to the MSBs (Most Significant Bits) and short sequence number corresponds to the LSBs (Least Significant Bits) of the COUNT-C. Therefore, HFN is increased by 1 when the short sequence number wraps around to 0. The adjustment of this HFN is one of the factors which causes ciphering problems to occur in related art systems, details of which will now be discussed.

Drawbacks of Related-Art SRNS Relocation Procedures

[0101] Ciphering problems are usually caused when the HFNs become out of synchronization between the RLC entities of the terminal and the RNS (or RNC) in the UTRAN. This synchronization problem is mainly attributable to the COUNT-C parameter. More specifically, as previously discussed, all ciphering parameters except COUNT-C are fixed parameters and therefore may remain synchronized throughout the connection. The short sequence number (i.e. the LSBs of the COUNT-C) is also synchronized because, for TM RLC, the CFN is known to both the terminal and the UTRAN and, for UM and AM RLC, the RLC SN is included in the PDU header and transmitted through the radio interface. For TM RLC, the long sequence number corresponding to HFN is also synchronized because the CFN is calculated from the SFN (System Frame Number) which is continuously broadcast in a cell. For UM and AM RLC, however, the HFN is sometimes out-of-synchronization due to lost or re-transmitted RLC PDUs. This condition is explained in greater detail below.

[0102] Under normal conditions, the HFN is never exchanged and is locally managed by the terminal and the UTRAN. The locally managed HFNs may become out-of-synchronization for UM and AM RLC modes when RLC PDUs are lost or re-transmitted, as previously mentioned. If the HFN values managed by the terminal and the UTRAN become different, then the MASKs used in the terminal and the UTRAN also become different. As a result, the ciphered data cannot be deciphered in the receiver. Thus, once the HFNs become out-of-synchronization, data transmission cannot be successfully performed until the HFNs are synchronized.

[0103] The problems in the related-art SRNS relocation procedure are caused when this ciphering problem (i.e., unsynchronized HFNs) arises in UM and AM RLC operation. In **FIG. 7**, these problems affect steps **7** and **8**. The manner in which the steps are adversely affected will now be described in detail. (Note that step **1** has no ciphering problem since the RRC message is transmitted using TM RLC).

Problems in Step **7**

[**0104**] In Case I (UE not involved) and Case II (UE involved), RRC messages are transmitted to the terminal using an appropriate serving radio bearer SRB. The RLC layer in the target RNC is newly generated and the status variables and timers are initialized. As a result of this initialization, the sequence number of the RLC PDU transmitted from the RLC layer in the target RNC to the terminal is initialized to 0 (zero). The terminal RLC layer, however, may be expecting the next PDU it receives to have a different sequence number. The possible problems in transmitting RRC messages resulting from this discrepancy will be described for each of these cases.

[**0105**] (1) UTRAN Mobility Information Message is Transmitted Through SRB**1**: In this case, the relocation procedure is performed during a UM RLC mode of operation. During this procedure, the UTRAN HFN is transferred from the source RNC to the target RNC and the target RNC transmits a protocol data unit (PDU) including the UTRAN HFN to the terminal. As previously explained, however, before the PDU is transmitted its sequence number is initialized to some number, e.g., zero. In most cases, this initialized value does not correspond to the sequence number of the next PDU the terminal expects to receive. As a result, when the terminal receives the PDU with its initialized sequence number, it concludes that one or more PDUs have not been successfully received, e.g., there are some missing PDUs. The terminal will therefore operate based on the assumption that an RLC sequence-number wrap around condition has occurred. When this condition is detected, the transmitter RLC will alter its ciphering information by incrementing its HFN parameter by one. This presents the following problem.

[**0106**] When the relocation procedure caused the serving RNS (SRNS) to change from the source RNC to the target RNC, the value of the HFN parameter was not changed. As a result, the target RNC will transmit PDUs with the original UTRAN HFN value. The terminal, however, will attempt to decipher these PDUs with the newly incremented HFN value. Because the terminal and UTRAN are operating based on different HFN values, the terminal and UTRAN (target RNC) are considered to be out of synchronization and the transmitter will not be able to decipher any PDUs from the UTRAN.

[**0107**] (2) UTRAN Mobility Information Message is Transmitted Through SRB**2**: In this case, the relocation procedure is performed during AM RLC mode of operation, and the terminal RLC only accepts PDUs having sequence numbers that fall within a valid range, which is maintained for purposes of efficient management of data re-transmissions. This valid range is defined by the size and position of a receiving window maintained by the terminal receiver during AM operation. When the terminal receives RLC PDUs which lie outside of the receiving window, the terminal just discards these PDUs.

[**0108**] During the relocation procedure, the next PDU transmitted to the terminal has a sequence number which has been initialized to zero. If this sequence number lies outside of the receiving window of the transmitter, it will be immediately discarded. However, even if the sequence number lies within the range of the receiving window, the PDU will not be able to be deciphered by the transmitter. This is because the next sequence number the terminal expects to receive does not correspond to the sequence number of the received PDU. The terminal will therefore conclude that missing PDUs exist and that a wrap-around condition with respect to PDU sequence numbers has occurred. When this condition is detected, the transmitter RLC will alter its ciphering information by incrementing its HFN parameter by one, thereby causing the HFN of the terminal and the HFN of the UTRAN to be different. This discrepancy will prevent the terminal from deciphering any data from the UTRAN

[**0109**] (3) Cell/URA Update Confirm Message is transmitted through SRB**1**: In this case, the relocation procedure is performed during UM RLC operation. The same problem occurs as in (1) above, i.e., the RRC messages transmitted from the target RNC in step **7** cannot be deciphered by the terminal because of a discrepancy in HFN values which occurred as a result of the initialization of the sequence number of the next PDU transmitted from the UTRAN.

[**0110**] In all the above cases, the terminal and UTRAN will not be able to communicate after SRNS relocation has been performed unless and until the out-of-synchronization problem with regard to their HFNs is resolved. Complications which arise in connection with Step **8** will now be discussed.

Problems in Step **8**

[**0111**] In Case I (UE not involved) and Case II (UE involved), the terminal transmits a UTRAN Mobility Information Confirm message through SRB**2** when the relocation procedure is performed during the AM RLC mode of operation. The similar problems occur as indicated in (2) above for step **7**. The difference is that the roles are reversed, i.e., the transmitter is the terminal RLC and the receiver is the target RNC RLC.

[**0112**] In view of the foregoing considerations, it is clear that there is a need for an improved system and method for performing an SRNS relocation procedure in a wireless communications system, and more specifically one which efficiently resolves deciphering discrepancies that arise between transmitting and receiving entities as a result of an initialization performed during the relocation procedure.

SUMMARY OF THE INVENTION

[**0113**] An object of the invention is to solve at least the above problems and/or disadvantages and to provide at least the advantages described hereinafter.

[**0114**] Another object of the present invention is to provide a system and method for performing an SRNS relocation procedure in a wireless communications system in a manner which increases transmission efficiency compared with other systems which have been proposed.

[**0115**] Another object of the present invention is to achieve the aforementioned object by efficiently resolving deciphering discrepancies that arise between transmitting and receiving entities when an initialization step is performed in the relocation procedure.

[**0116**] Another object of the present invention is to resolve these deciphering discrepancies by ensuring that the transmitting and receiving entities operate using the same HFN parameter during or immediately after the relocation procedure is performed. By coordinating this information, the out-of-synchronization problem that other proposed systems experience is resolved. In accordance with one embodiment, the transmitting entity may be a UTRAN RNC and the receiving entity may be a user terminal, otherwise known as user equipment in the standards developed by the 3GPP, including but not limited to the universal mobile telecommunications system (UMTS) which is one form of IMT-2000 system. In another embodiment, the transmitting entity may be the user terminal and the receiving entity may be a UTRAN RNC. The present invention is also advantageous because it may be applied to UM and AM modes of RLC operation.

[**0117**] The foregoing and other objects of the invention are achieved by providing a system and method which performs SRNS relocation in a mobile communication system, and more specifically in a serving radio network sub-system which includes a radio network controller for managing a radio resource allocated to a terminal in the mobile communication system. In accordance with one embodiment, the method includes reserving a requiring resource in a serving radio network sub-system relocation on a network; transmitting a radio resource control message corresponding to the serving radio network sub-system relocation to the terminal in order that the radio network controller communicates the terminal, and transmitting a response radio resource control message corresponding to the serving radio network sub-system relocation to the radio network controller to which the radio resource control message is transmitted.

[**0118**] The radio network controller transmits data by setting a corresponding radio link layer and adjusting a frame number used for ciphering so that the terminal successfully restores ciphered data before the radio network controller transmits the corresponding radio resource control message to the terminal. The frame number is increased by 1 more than a value used at a present time, and a unit data of the corresponding radio link layer is transmitted by ciphering. A radio resource control layer may transmit a command for setting a link control layer and the frame number to the corresponding radio link control layer.

[**0119**] In addition to these steps, an original radio network controller may perform the role of a serving radio network controller before the serving radio network sub-system relocation transfers status information of a radio link control layer used at a present time to a target radio network controller. This is performed so that the terminal successfully receives a serving radio resource control message before the target radio network controller transmits a radio resource control message corresponding to the serving radio network sub-system relocation to the terminal. The transferred status information may include a parameter corresponding to the radio link control layer operated in an unacknowledged mode. Also, a first sequence number of a unit data of the radio link control layer including the radio resource control message corresponding to the serving radio network sub-system relocation transferred from the target radio network controller to the terminal is transmitted by being set with a VT(US) of a parameter corresponding the radio link control layer operated in the unacknowledged mode.

[**0120**] In accordance with another embodiment, the transferred status information includes a parameter or data corresponding to the radio link control layer operated in an acknowledged mode. Also, a first sequence number of unit data of the radio link control layer including the radio resource control message corresponding to the serving radio network sub-system relocation transferred from the target radio network controller to the terminal is transmitted by being set with a VT(US) of a parameter corresponding the radio link control layer operated in the unacknowledged mode. The radio link control layer of the target radio network controller may transmit unit data of the radio link control layer being transmitting which is transferred from the original radio network controller.

[**0121**] The original radio network controller finishes transmission of the radio resource control message being transmitting or being waited for being transmitted prior to transferring parameter corresponding to the radio link control layer operated in the acknowledged mode.

[**0122**] The radio link control layer of the target radio network controller transmits a receiving window movement command to a radio link control layer of the terminal in order to prevent a transmission of an unit data of the radio link control layer having a sequence number below a sequence number of VT(S)-**1**. The radio resource control layer of the target radio network controller indicates the radio link control layer to start the receiving window movement command in order to transmit the receiving window movement command.

[**0123**] In the foregoing embodiments, the radio resource control layer transfers the parameter or the data transferred from the original radio network controller to the radio link control layer. Also, a value of a field of a length indicator of the unit data of a first radio link control layer including the radio resource control message transmitted from the target radio network controller to the terminal after the serving radio network sub-system relocation indicates an information that the unit data of the corresponding radio link control includes the radio resource control message from a first portion thereof.

[**0124**] In addition to these features, any one or more of the embodiments of the present invention may include an initialization step for the radio link control layer, where a status variable is initialized and a frame number is synchronized between the radio link control layer of the terminal and the radio link control layer of the target radio network controller. This will enable the terminal to successfully receive the radio resource control message before the target radio network controller transmits the radio resource control message corresponding to the serving radio network sub-system relocation to the terminal. The target radio network controller may transmit an initial unit data to the radio link control layer of the terminal as a command performing an initialization of the radio link control.

[**0125**] Further, the radio resource control layer of the target radio network controller may transfer an initialization start command to the radio link control layer in order that the radio link control layer of the target radio controller start in an initialization process of the radio link control layer.

[**0126**] The radio link control layers of the target radio network controller and the terminal are preferably set in order to allow the target radio network controller to successfully receive the corresponding radio resource control message before the terminal transmits the radio resource control message corresponding the serving radio network sub-system relocation to the target radio network controller. Here, a frame number may be synchronized during setting of the radio link control layers of the target radio network controller and the terminal. A setting of the frame number may be transferred from an upper layer, and may be performed by increasing frame numbers used in the terminal and the target radio network controller by 1 (one). Alternatively, setting of the frame numbers used in the radio link control layer of the terminal and the radio link control layer of the target radio network controller may be performed by increasing a larger value among an uplink frame number and a downlink frame number used in the radio link control layer of the terminal and the radio link control layer of the target radio network controller by 1 (one) based on the larger value.

[0127] The radio resource control layers of the terminal and the target radio network controller transmit respective command for a setting/resetting of corresponding radio link control layers.

[0128] A setting/resetting of a signaling radio bearer and a radio bearer in the terminal and the target radio network controller are performed after a process that the terminal transmits a response radio resource control message corresponding to the serving radio network sub-system relocation to the target radio network controller. Here, a frame number in the setting/resetting of the signaling radio bearer and the radio bearer between the terminal and the target radio network controller is set to a frame number initial value included in the response radio resource control message corresponding to the serving radio network sub-system relocation transmitted from the terminal to the target radio network controller. The frame number initial value included in the radio resource control message may correspond to an initial value stored in a ciphering module of the terminal defined in a Universal Mobile Telecommunications System standard of asynchronous IMT2000 system.

[0129] Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objects and advantages of the invention may be realized and attained as particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0130] The invention will be described in detail with reference to the following drawings in which like reference numerals refer to like elements wherein:

[0131] **FIG. 1** shows a network architecture of a Universal Mobile Telecommunications System (UMTS);

[0132] **FIG. 2** shows a structure of a radio interface protocol which may be implemented within the UMTS system;

[0133] **FIG. 3** shows a structure of a Protocol Data Unit (PDU) used in a Radio Link Control (RLC) layer of the radio interface protocol of **FIG. 2**;

[0134] **FIG. 4** is an exemplary snapshot of the state of an AM RLC buffer;

[0135] **FIG. 5** is a diagram illustrating the concept of an SRNS Relocation procedure;

[0136] **FIG. 6** is an SRNS Relocation signaling procedure in UMTS system;

[0137] **FIG. 7** is an SRNS Relocation signaling procedure of a related-art system which includes a UMTS Terrestrial Radio Access Network (UTRAN);

[0138] **FIG. 8** shows a ciphering process performed in the radio interface protocol of **FIG. 2**;

[0139] **FIG. 9** is the structure of COUNT-C parameter used within RLC mode;

[0140] **FIG. 10** is a flow diagram showing steps included in a series of embodiments of the method of the present invention identified as A**1** and A**2** for performing an SRNS relocation procedure;

[0141] **FIG. 11** is a flow diagram showing steps included in a series of embodiments of the method of the present invention identified as B**1** and B**2** for performing an SRNS relocation procedure;

[0142] **FIG. 12** is a flow diagram showing steps included in a series of embodiments of the method of the present invention identified as C**1**, C**2**, and C**3** for performing an SRNS relocation procedure;

[0143] **FIG. 13** is a flow diagram showing steps included in an embodiment of the method of the present invention which performs SRNS relocation for the case of lossless radio bearers; and

[0144] **FIG. 14** is a flow diagram showing steps included in an embodiment of the method of the present invention which performs SRNS relocation for the case of seamless radio bearers.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0145] The present invention is a system and method for performing an SRNS relocation procedure in a wireless communications system. The relocation procedure is performed in a manner which prevents an out-of-synchronization condition from arising between transmitting and receiving entities. In one embodiment, the invention synchronizes ciphering information in the transmitting and receiving entities. By taking these steps, the present invention improves the reliability and efficiency of communications in the system. While the invention is suitable for use in a UMTS system, those skilled in the art can appreciate that the method may be performed in communications systems which adhere to other standards and/or protocols.

[0146] The method of the present invention controls the manner in which information is transmitted between a receiver and transmitter, and is especially well suited for use in the non-limiting application of where the transmitter is a UTRAN and the receiver is a user terminal (or user equipment as it is called by the 3GPP initiative). When applied in this manner, the steps of the method may differ depending upon the type of SRNS relocation to be performed and the mode of operation of the RLC layers of the UTRAN and user terminal.

[0147] The SRNS relocation procedure may be classified into two cases. In Case I, SRNS relocation is initiated by the core or another network and the terminal is not informed that relocation is performed until the relocation procedure is terminated. Case I may therefore be characterized as corresponding to the situation where the terminal is not involved in making the decision to perform relocation. In Case II, SRNS relocation is initiated by the user terminal. The terminal is therefore aware that relocation is being performed at the very start of the procedure. Case II may therefore be characterized as corresponding to the situation where the terminal is involved in making the decision to perform SRNS relocation.

[0148] The various embodiments of the present invention method may be initially understood by distinguishing them from the related-art method of **FIG. 7**. While the present invention may share some of the steps in the related-art method, the following discussion makes clear that the present invention advantageously overcomes the synchronization and other problems that arise in this system. A description of the related-art system will therefore be initially be provided.

[0149] Referring to **FIG. 7**, an initial step of the method differs depending upon whether the SRNS relocation procedure is requested by the network (Case I) or user terminal (Case II). In Case I, the method of the present invention begins when the network decides to perform SRNS relocation, i.e., when the UTRAN decides to switch from one RNS (or a source RNC) to another RNS (or a target RNC) for purposes of communication with the user terminal. (Step **2**). The network may decide to perform an SRNS relocation based on any one of a variety of factors. For example, relocation may be desirable to reduce the amount of traffic being handled by the source RNC, to locate a shorter or more efficient communications path for purposes of handling a call with the user terminal, or other reasons which may be understood by those skilled in the art.

[0150] In Case II, the method of the present invention begins when the user terminal transmits an RRC message in the form of a Cell/URA Update message to the source RNC. (Step **1**). This message includes a request for changing the SRNS of the UTRAN. Such a message may be transmitted, for example, when the user terminal moves to a new cell within the wireless system, e.g., when a handoff operation is imminent or required. At this time, the network may decide whether to favorably respond by satisfying the request or may immediately respond.

[0151] The second through fifth steps are commonly performed for Cases I and II. In the second step, relocation preparation is performed. (Step **3**). This involves forwarding relevant parameters for communicating with the user terminal from the source RNC to the target RNC through an RRC information container. This container includes, for example, ciphering information (e.g., downlink HFN and uplink HFN parameters) for signaling radio bearers, as well as radio resources including new RABs for purposes of changing the serving RNS from the source RNC to the target RNC. The type of radio bearers reserved in this step depends on whether AM or UM RLC mode is being supported in the UTRAN. If AM mode is supported, one or more lossless radio bearers are reserved so that lossless SRNS relocation may be performed. If UM mode is supported, one or more seamless radio bearers are reserved so that seamless SRNS relocation may be performed.

[0152] The third step includes receiving an RANAP Relocation Command from the core network, and more specifically from an existing SGSN in the core network. (Step **4**). The existing SGSN may be referred to as the "old SGSN," and if relocation results in requiring a change of SGSNs (which may not always be the case) a "new SGSN" will be assigned after relocation. The Relocation Command informs the source RNC of the RABs to be released and the RABs that are subject to data forwarding in connection with the relocation procedure. Lossless SRNC (performed for AM RLC operation) may be configured for RABs subject to data forwarding. The PDCP layer supports PDCP sequence numbering when lossless SRNS relocation is supported.

[0153] The fourth step includes transmitting a Relocation Commit message from the source RNC to the target RNC. (Step **5**). In this step, for the affected radio bearers, the source RLC is stopped and the PDCP transmission sequence numbers are retrieved by the RRC. The PDCP of the source RNC transfers the sequence numbers and other information for communicating with the user terminal to the target RNC.

[0154] The fifth step includes transmitting an RANAP Relocation Detect message from the target RNC to the source RNC. (Step **6**). When this message is received, the target RNC becomes the serving RNC. A corresponding change from the old SGSN to the new SGSN may be performed at this time. After these steps, the relocation has occurred.

[0155] The sixth step includes transmitting an RRC message from the target RNC to the user terminal, and more specifically to the RRC layer of the user terminal. In Case I, the RRC message is in the form of a UTRAN Mobility Information message. In Case II, the RRC message is in the form of a Cell/URA Update Confirm message. In each of these messages, a new U-RNTI is included to inform the user terminal that an SRNS relocation procedure was performed.

[0156] A seventh step includes calculating a START value in the user terminal in response to downlink counter synchronization information. The START value is then transmitted from the user terminal to the RRC layer of the target RNC in an RRC message called a UTRAN Mobility Information Confirm message. (Step **7**).

[0157] An eighth step includes establishing RLC entities in the target RNC based on the START value included in the UTRAN Mobility Information Confirm message. In the meantime, the user terminal may also re-establish its RLC entities with the transmitted START value. (Step **8**).

[0158] The foregoing description may serve as a framework for the approach taken by the method of the present invention for overcoming the out-of-synchronization problem that adversely affects the performance of the related-art method of **FIG. 7**. This problem occurs in the sixth step discussed above.

[0159] In this step, the target RNC transmits an RRC message either on SRB**1** or SRB**2** depending upon the case and the mode of operation of the RLC entities. More specifically, either a UTRAN Mobility Information message is sent on an AM/DCCH (SRB**2**) or UM/DCCH (SRB**1**), or a Cell URA Update Confirm message is sent on UM/DCCH (SRB1). Although the Cell/URA Update Confirm message can use UM/CCCH (SRBO), SRNS relocation policy (if SRNS is relocated before the Cell/URA Update confirmation is sent, a DCCH should be used to allow ciphering of the message contents) may require that this message should not use SRBO in case of SRNS relocation.

[0160] When the steps shown in **FIG. 7** are performed, out-of-synchronization problems arise between the user terminal and UTRAN which prevent communications from being performed. Some of these problems occurs as follows.

[0161] Problem 1: CL RRC Message is Sent on SRB1 (LJM/DCCH). Before SRNS relocation, the source RNC may be communicating PDUs with the user terminal based on synchronized deciphering information. For example, the source RNC may transmit PDUs based on a downlink HFN parameter=X and a transmission sequence number corresponding to a state variable VT(US)=50 for UM mode of operation. Similarly, the user terminal may transmit PDUs based on an uplink HFN=X and a VR(US)=50. Because the deciphering information and transmission sequence numbers are synchronized, the user terminal and source RNC can communicate without problems. However, when SRNS relocation occurs, since the HFN value is transferred from the source to the target RNC without any additional information (e.g., without transmission sequence number information in the form of one or more of state variables VT(US) or VR(US)), the target RNC establishes a UM RLC entity with the same deciphering information used by the source RNC (i.e., DL HFN=X) but with state variable VT(US) set to a newly initialized value, e.g., zero.

[0162] Accordingly, when the target RNC sends an RRC message to the user terminal, the user terminal will in most cases recognize the transmission sequence number in the RRC message as corresponding to an out-of-sequence number, because it does not include the sequence number that follows the last PDU transmitted by the source RNC. When this occurs (e.g., when the user terminal detects that the received RRC message has a serial number SN=0), it will conclude that a new PDU has been received and more specifically that PDUs having serial numbers of between 50 and 127 are missing. As a result, the user terminal will increase its HFN to a value of X+1 for purposes of deciphering future PDUs. However, the target RNC will continue to transmit PDUs based on HFN =X. Because there is a discrepancy in the deciphering information used by the user terminal and target RNC, the user terminal will not be able to decipher and thus successfully receive the PDUs transmitted from the target RNC. This means that the user terminal cannot receive the RRC message.

[0163] Problem 2: DL RRC Message is Sent on SRB2 (AM/DCCH). Before SRNS relocation, assume that DL HFN=X and VT(S)=3000 in the source RNC and DL HFN=X and VR(R)=3000 in the user terminal. Because the deciphering information and transmission sequence numbers are synchronized, the user terminal and source RNC can successfully communicate. However, when SRNS relocation occurs, since the HFN value is transferred from the source RNC to the target RNC without VT(S) indicative of transmission sequence number, the target RNC will establish an AM RLC entity with DL HFN=X but with VT(S) set to an initial value, e.g., VT(S)=0.

[0164] When the RRC message is sent from the target RNC to the user terminal, the user terminal will discard the message if its transmission sequence number (which is zero in this case) lies outside of the range of the receiving window. However, even if the sequence number of the RRC message lies within the receiving window, the user terminal will consider it to be a new PDU, i.e., that PDUs having sequence numbers from 3000-4095 are missing. When this occurs, the user terminal sets its HFN=X+1. As a result, the deciphering information in the user terminal and target RNC are different and therefore the user terminal will not be able to receive the RRC message transmitted from the target RNC.

[0165] In both problems discussed above (SRB1 or SRB2), the user terminal in most cases cannot receive the RRC message transmitted from the target RNC. As a result, SRNS relocation fails. Of course, it is noted that there is a slim possibility that the user terminal will be able to receive the initial RRC message from the target RNC, but this can only happen when VT(US)=VR(US)=0 or VT(S)=VR(R)=0. However, even if the initial RRC message from the target RNC is successfully received and deciphered by the user terminal, the target RNC will not be able to receive the UTAN Mobility Information Confirm RRC message transmitted from the user terminal. This message is sent on AM/DCCH (SRB2), and it cannot be received by the target RNC because VT(S)=3000 in the user terminal but VR(R)=0 in the target RNC.

[0166] The system and method of the present invention overcomes these and other problems that arise in the related-art system as a result of synchronization and transmission sequence number mis-matches. As the following embodiments will reflect, the target RNC and user terminal will be controlled to synchronize all information required in order for a successful relocation procedure to be performed. The specific embodiments will now be discussed.

[0167] The method of the present invention may be performed differently depending upon whether Case I or Case II applies. When SRNS relocation is requested by the network (Case I), the sixth step includes synchronizing ciphering information in the target RNC to ciphering information that is expected to be used in the user terminal. This synchronization may be performed in view of the following realization.

[0168] During the relocation procedure, RLC PDUs transmitted from the target RNC to the user terminal will have initialized values. For example, the first PDU transmitted will be given an initial transmission sequence number such as zero. On the user terminal side, the RLC layer receives PDUs and orders them based on transmission sequence number. Since the user terminal was communicating with the source RNC prior to relocation, the next PDU the RLC of the user terminal will expect to receive is one whose transmission sequence number consecutively follows the transmission sequence number of the last-received PDU. The first PDU transmitted from the target RNC in the UTRAN, however, will have an initialized sequence number and thus in all probability will not correspond to the expected number.

[0169] When this occurs once or a predetermined number of times, the user terminal RLC will conclude that a wrap-around condition has occurred. When such a condition is detected, the RLC of the user terminal will adjust its deciphering information by changing its HFN parameter to a new value. This change may involve incrementing the HFN parameter by 1.

[**0170**] In the related-art method of **FIG. 7**, the target RNC did not compensate for this change in deciphering information in the user terminal. Instead, PDUs were ciphered using ciphering information (i.e., the HFN parameter) included in the RRC information container sent from the source RNC to the target RNC. As a result, PDUs transmitted from the target RNC could not be deciphered by the user terminal and a stall in communications occurred.

[**0171**] The present invention overcomes this problem by taking one of several approaches. On approach involves adjusting ciphering information in the target RNC received from the source RNC. This adjustment ensures that the target RNC ciphers PDUs with the same HFN parameter the user terminal will use during deciphering. Since UTRAN management software is programmed to know how the user terminal will adjust its HFN parameter when a PDU having an out-of-sequence transmission sequence number is received, the target RNC may cipher the PDUs to be sent to the user terminal using the same adjusted HFN parameter. The nature of the adjustment performed by the present invention depends on whether Case I or II is being observed and whether the RLCs of the user terminal and target RNCs are operating in AM or UM mode. The following situations apply.

A. Downlink RRC Message Sent on SRB1 (UM/DCCH)

[**0172**] In this case, the RLCs of the target RNC and user terminal are operating in UM mode. The target RNC sends an RRC message on a serving radio beater SRB1 (which corresponds to a UM DCCH channel) to the user terminal. The following situations apply.

A.1. Target RNC Establishes SRB1 and Increments DL HFN

[**0173**] Referring to **FIG. 10**, the target RNC receives an RRC information container from the source RNC. The container includes ciphering information which preferably includes an HFN parameter which the source RNC was using to communicate with the user terminal. When the RRC information container is received, the target RNC increments the HFN parameter and establishes a new SRB1. Because the target RNC has foreknowledge of the way in which the user terminal changes its HFN parameter when a wrap-around condition occurs or when an out-of-sequence PDU is received, the target RNC increments its HFN parameter in an identical manner. As a result, the PDUs generated by the target RNC will be ciphered in a way which is decipherable by the user terminal.

[**0174**] Once the PDUs have been generated, they are transmitted from a UM RLC of the target RNC to the user terminal. The first PDU transmitted includes an initial transmission sequence number, e.g., SN=0. When the user terminal receives the PDUs, the user terminal detects that the first PDU has an out-of-sequence transmission sequence number. The user terminal may perform this detection function by extracting state variable VR(US) from the first PDU. Since this state variable provides an indication of the transmission sequence number that corresponds to this PDU, a wrap-around or out-of-sequence condition may be detected. For example, in the case where VR(US) has values from 0 to 127, the user terminal may determine that PDUs having the value of the VR(US) in the received PDU to VR number 127 are missing.

[**0175**] When this condition is detected, the user terminal will adjust its HFN parameter, for example, by incrementing this parameter by 1. Since the PDUs transmitted from the target RNC were generated and transmitted in accordance with this same HFN parameter, the PDUs may be deciphered and communications may take place in spite of the relocation procedure. By synchronizing the ciphering information in the user terminal and target RNC, the present invention advantageously overcomes the out-of-synchronization problem that occurs in the related-art system of **FIG. 7**.

[**0176**] An optional but desirable step involves including a data start indicator (which may be referred to as Special L**1**) in one or more PDUs transmitted from the target RNC to the user terminal. In accordance with the present invention, the data start indicator may be incorporated into the PDUs transmitted by the target RNC over a UM DCCH channel. The inclusion of this indicator is advantageous. For example, if the user terminal receives a PDU from the target RNC without the data start indicator, the user terminal may consider the PDU to be part of a previous SDU and may just discard it. When received by the user terminal, the data start indicator will be interpreted to indicate that the PDU to which it is attached is not part of a previous SDU. Including this indicator will therefore ensure that PDUs received from the target RNC will not be discarded. In order to maximize transmission efficiency, the first PDU transmitted from the target RNC (i.e., the PDU having a transmission sequence number SN =**0**) preferably includes the Special L**1** indicator.

A.2. Source RNC Transfers VT(JS) to Target RNC

[**0177**] This approach differs from the approach in A.1. in that instead of incrementing its HFN parameter, the first PDU transmitted from the target RNC to the user terminal contains the next transmission sequence number which the user terminal expects to receive. Thus, the HFN parameter used by the target RNC and user terminal remains synchronized and therefore data communications may be performed. A more detailed description of this approach will now be provided.

[**0178**] In an initial step, the source RNC delivers an RRC information container **50** that includes state variable VT(US) of serving radio bearer SRB**1** to the target RNC. State variable VT(US) is indicative of a transmission sequence number related to the transmission sequence number of the last or one of the last PDUs transmitted from the source RNC to the user terminal. The target RNC uses state variable VT(US) as a basis for transmitting its first PDU **60** to the user terminal. For example, if VT(US) corresponds to the last sequence number transmitted, the target RNC may increment the transmission sequence number corresponding to VT(US) by one and then transmit the first PDU containing this value. When the user terminal receives this PDU, it will detect that this PDU is has the next-in-sequence number that it expected and thus no wrap-around or missing PDU condition will be detected. As a result, the user terminal will not increment its HFN value as in the previous case; and because the PDU was ciphered based on the same HFN value, the user terminal will be able to decipher it.

[0179] As an alternative to this approach, the VT(US) variable delivered from the source RNC to the target RNC may be the next-in-sequence number which the user equipment expects to receive. In this case, the target RNC will transmit the first PDU with the number corresponding to VT(US).

[0180] This approach may include a number of additional steps. First, a new IE (Information element) may be used in light of the addition of VT(US) of SRB1 into the RRC information container.

[0181] Second, the RLC establishment step may be modified. For example, when the RLC entity is established, all the state variables may be set to initial values (e.g., 0). As a result, it may not be possible to establish the UM RLC entity with VT(US) other than 0. In order to compensate for setting the state variables to initial values, an establish and modify procedure should be performed. That is, at first, RLC entity is established with all the state variables to be 0, at second, the state variables are modified to be desired values.

[0182] Third, a data start indicator (e.g., Start LI) should be included in the first UM PDU transmitted from the target RNC to the user terminal. If the first PDU is transmitted without this indicator and if, for example, the PDU with sequence number SN VT(US)-1 is lost, the user equipment will discard the PDU. Because the user equipment considers that the PDU contains incomplete SDU a portion of which may be contained in the former PDU. Including the data start indicator in the first PDU transmitted from the target RNC will therefore guarantee that the RRC message will be received by the user terminal.

B. Downlink RRC Message Sent on SRB2 (AM/DCCH)

[0183] In this case, the RLCs of the target RNC and user terminal are operating in AM mode. The target RNC sends an RRC message on a serving radio bearer SRB2 (which corresponds to an AM DCCH channel) to the user terminal.

B.1. Target RNC Establishes SRB2 and Initializes RLC RESET Procedure

[0184] Referring to **FIG. 11**, before sending the RRC message, the target RNC performs an RLC RESET operation which involves resetting the transmission sequence number and state variables to initial values. Preferably at the same time, the target RNC transmits a Reset PDU **70** to the user terminal. According to one aspect of the invention, the Reset PDU is transmitted without being ciphered and has no transmission sequence number. Consequently, the user terminal will be able to receive the Reset PDU transmitted through SRB2. Upon receiving the Reset PDU, the user terminal will reset its state variables and transmission sequence number to the same initial values set in the target RNC.

[0185] Because the Reset PDU has no transmission sequence number, the user terminal will not detect a wrap-around or out-of-sequence condition when the Reset PDU is received. Therefore, the HFN parameter in the user terminal will not be incremented. As a result, the HFN parameter which the target RNC received from the source RNC and the HFN parameter of the user terminal will be the same. And, since the state variables and transmission sequence numbers of the target RNC and user terminal have been initialized to like values, the target RNC and user terminal may successfully communication with one another. When reset is completed in the user terminal, a reset acknowledgment message Reset ACIK PDU **80** will be transmitted from the user terminal to the target RNC.

[0186] As an alternative to this embodiment, the Reset operation performed in the target RNC may cause the HFN parameter to be incremented. The Reset PDU may then be modified so that the user terminal increments its HFN value upon receipt. This may be accomplished, for example, by transmitting the Reset PDU with an initial or out-of-sequence transmission sequence number.

[0187] As a result of the foregoing steps, the HFN parameters and transmission sequence numbers of the target RNC and user terminal will be synchronized. In order to achieve this synchronization, it is preferable but not necessary to provide a new trigger for the RLC Reset procedure. More specifically, under normal operating conditions an RLC Reset procedure is performed when an RLC protocol error is detected and/or when one of three trigger conditions specified in the 3GPP specification is detected. In this embodiment of the present invention, the Reset procedure may be performed when a fourth trigger condition is detected. Referring to the specification, RLC reset procedure is performed, if one of the following triggers is detected.

[0188] 1) "No_Discard after MaxDAT number of retransmissions" is configured and VT(DAT) equals the value MaxDAT;

[0189] 2) VT(MRW) equals the value MaxMRW;

[0190] 3) A STATUS PDU including "erroneous Sequence Number" is received;

[0191] More specifically, in accordance with an alternative embodiment of the present invention, a new C-primitive (a control message from RRC to RLC) and a new trigger in RLC protocol is used for initiating the Reset procedure.

[0192] During the Reset procedure, at least one additional step may be performed. In this step, all RLC SDUs in the user terminal and the target RNC are flushed. Though this embodiment of the invention requires some time to perform and may suffer some loss of data, it provides a clear solution to the problem of unsynchronized ciphering passwords realized by the related-art system.

B.2. Source RNC Transfers VT(S) to Target RNC

[0193] Referring again to **FIG. 11**, this embodiment of the invention is similar to the embodiment discussed in A.2 above, except that a different approach is taken to account for the receiving window in the user terminal and the fact that RLC PDUs are re-transmitted in the AM operational mode. Accordingly, other than adjusting the sequence number of the RLC PDU to be transmitted to the terminal and synchronizing the HFN value, the target RNC may be required to consider data units previously transmitted to the terminal by the source RNC which were not confirmed by the user terminal. The following steps may be taken to compensate for this prospective problem.

[0194] In process step B.2.1., the source RNC transfers a message **90** containing information related to the setting of the SRB**2** to the target RNC. This information includes the sequence number, state variable VT(S), and the HFN parameter used by the RLC layer of the source RNC, together with one or more RLC PDUs or an RRC message that is being re-transmitted. In process step B.2.2., the target RNC then transmits one or more PDUs **100** to be re-transmitted to the user terminal using the information transferred from the source RNC. As a result, the target RNC will transmit the PDUs in the same manner and with the same information as the source RNC.

[0195] As an example, consider the case where the source RNC transmits its HFN parameter, one or more RLC PDUs to be re-transmitted, VT(S) indicating sequence number, and VT(A) in step B1 of **FIG. 11**. The target RNC stores the PDUs from the source RNC after configures the RLC layer with the received parameters (Step B.2.2 in **FIG. 11**), and sends a UTRAN Mobility Information Message with a new PDU starting with the sequence number corresponding to VT(S). Because the target RNC can transmit data while sustaining a re-transmission buffer state of the SRB**2** equal to the re-transmission buffer state of the source RNC, the user terminal can recover the re-transmitted data from the target RNC through the SRB**2** channel.

[0196] In accordance with another embodiment, the source RNC delivers VT(S) to the target RNC through an RRC information container. The target RNC then establishes SRB**2** (AM RLC) with the transferred values and sends an RRC message to the user terminal with those values. The user terminal operates in a different manner compared with A.2. because the AM RLC of the terminal receives PDUs that only lie within a valid range of a receiving window.

[0197] If the transmission sequence number corresponding to variable VT(S) is equal to VR(R), no problem occurs. But if VT(S) is larger than VR(R) (mainly due to the unconfirmed RLC SDUs in the source RLC), the user terminal will transmit a status PDU to the target RNC indicating that AMD PDUs from VR(R) to VT(S)-**1** are missing. If appropriate action is not taken, the following problem may occur: Since VT(A)=VT(S), the target RLC finds that the received status PDU contains an "erroneous Sequence Number" and it will initiate a Reset procedure. The RLC PDUs transmitted before the Reset procedure is implemented will be lost (note that the RLC buffers may be flushed during the Reset procedure).

[0198] To guarantee successful transmission, this embodiment of the present invention delivers VT(A) in addition to VT(S) from the source RNC to the target RNC. The target RNC then transmits PDUs in SRB**2** based on VT(A), VT(S) and the HFN parameter transferred from the source RNC. An establish and modify procedure may then be performed as discussed in connection with the A.2. embodiment of the invention.

[0199] The RRC message is transmitted by the AMD PDUs from VT(S). If a status PDU indicating that the user terminal did not receive the PDUs from VR(R) to VT(S)-**1** is transmitted from the terminal to the target RNC, the target RNC transmits an MRW SUFI message to the user terminal in order to move the receiver window to VT(S). In order to implement these features, an additional trigger for transmitting the MRW SUFI message may be used. Consequently, a new C-primitive may be implemented along with a new trigger for performing an SDU discard with explicit signaling procedure.

[0200] In accordance with an alternative embodiment, the source RNC delivers its HFN value and VT(S) to the target RNC (Step B.**2**.**1**. in **FIG. 11**), and stops transmitting PDUs to the user terminal prior to SRNS relocation. In the RLC of the terminal, the processing of previous RRC messages is completed. Therefore, the first PDU received after SRNS relocation includes the UTRAN Mobility Information message having the VT(S) value.

[0201] In accordance with another embodiment, the source RNC delivers its HFN value and VT(S) to the target RNC (process B.**2**.**1**. in **FIG. 11**). The source RNC then transmits a command to the user terminal to instruct the RLC layer of the user terminal to move its receiving window and to not request re-transmission data. The RRC layer of the UTRAN may be used to instruct the RLC layer of the source RNC to transmit this command. Remaining steps of the method are similar to the embodiment discussed immediately above, however this embodiment may be implemented to remove RRC messages before the SRNS is relocated and for solving the re-transmission problem.

[0202] In any one or more of the B.2. embodiments discussed above, an optional step of including a data start indicator in the first PDU transmitted by the target RNC to the user terminal may be performed. The data start indicator may be the same type transmitted in the RRC message transmitted from the target RNC though SRB**1** in accordance with the embodiment previously discussed.

[0203] The following example applies: the RLC PDU corresponding to the sequence number of VT(S)-**1** may not be correctly received. The next RLC PDU transmitted by the target RNC right after the relocation procedure is performed may include the data start indicator

[0204] B.3. Do Not Send UTRAN Mobility Information on SRB**2** in Case of SRNS Relocation. From embodiments B.1. and B.2., it is clear that the transmission of an RRC message on SRB**2** may be problematic in some respects. In this B.3 embodiment, embodiment A.1 or A.2 may be implemented without the transmission of UTRAN Mobility Information on SRB**2**.

[0205] The embodiments discussed above are all preferably performed before or during transmission of UTRAN Mobility Information (Case I) or a Cell/URA Update Confirm message (Case II). That is, either type of message can be received by the user terminal when the A and B embodiments of the invention are performed. Even though the user terminal may receive downlink RRC messages correctly from the UTRAN, certain situations may arise which will prevent the target RNC from receiving a UTRAN Mobility Information Confirm message from the user terminal in both Cases I and II. This confirmation message may be sent in SRB**2** (AM/DCCH), but because the VT(S) in the user terminal and the VR(R) in the target RNC are usually different (e.g., VT(S)≠0, VR(R)=0) a need may arise to synchronize the HFN and SN values in the user terminal and target RNC before the UTRAN Mobility Information Confirm message is transmitted. The following embodiments of the present invention address this problem

[0206] C.1. User Terminal Receives Downlink RRC Message on SRB**1** (UM/CCCH). Referring to **FIG. 12**, in this case only the downlink HFN of SRB1 is synchronized. Before transmission of an uplink RRC message (i.e., an RRC message from the terminal to the target RNC), both the target RNC and the user terminal should perform operations 110 and 120 which respectively establish and re-establish SRB2. This includes setting both the target RNC and user terminal to the same HFN value. These steps may be accomplished by ciphering a message transmitted from the user terminal to the target RNC with an incremented HFN value (e.g., the current value of HFN+1) as is performed in the case of a combined Hard Handover and SRNS relocation. Another possible value for HFN is MAX(UL HFN of SRB2|DL HFN of SRB2)+1. Any value can be used as long as the user terminal and target RNC have the same HFN.

[0207] C.2. User Terminal Receives Downlink RRC Message on SRB2 (AM/DCCH) with a RESET Procedure. If the user terminal receives a downlink RRC message on SRB2 and the embodiment of B.1 is performed, SRB2 does not have to be established/re-established after the message is received. During the Reset procedure, the HFN values in the user terminal and target RNC (UL and DL HFNs) are synchronized and the user terminal sends an UL RRC message to the target RRC without reestablishing SRB2. After transmission of the UL RRC message, both the user terminal and the UTRAN should establish/re-establish the SRBs (except SRB2) and RBs with the START value included in the UTRAN Mobility Information Confirm message

[0208] C.3. User Terminal Receives Downlink RRC message on SRB2 (AM/DCCH) with an SDU Discard with Explicit Signaling Procedure. If the user terminal receives a DL RRC message on SRB2 and the embodiment of B.2. is performed, only the DL HFN of SRB2 is synchronized. Since the UL HFN is not synchronized, SRB2 must be established/re-established in both the user terminal and the UTRAN. The rest of the procedure is the same as in C.1. except that DL SRB1 needs to be re-established.

[0209] In one or more of the C embodiments discussed above, after transmission of the UL RRC message, both the user terminal and the UTRAN may re-establish/establish the SRBs (except SRB2) and RBs with a START value which corresponds to an initial value of the HFN. This may be accomplished by transmitting the START value in the RRC message, i.e., the UTRAN Mobility Information Confirm message. As an example, the START value may be stored in the upper 20 bits of the HFN. If the size of the HFN exceeds 20 bits, the remaining bits may be initialized to 0. The START value may correspond to a predetermined value (which may, for example, be defined in accordance with the standards developed by the 3GPP) and may be managed by a ciphering module of the terminal. The START value may be disconnected from the terminal or may be updated according to a change in the HFN value during connection.

[0210] It should be noted that the embodiment of C.1. may be applied for all cases. Though the user terminal receives a DL RRC message on SRB2 with a Reset Procedure in C.2, the reestablishment of SRB2 does not create problems in normal operation. In this case, the HFNs may be updated a maximum of two times.

[0211] In the foregoing embodiments, it may be preferable not to include an IE (Information element) "RLC re-establishment indicator (RB2, RB3, and RB4)" in the Cell Update Confirm message. If it is included, the user terminal may re-establish SRB2, SRB3, and SRB 4 and set their HFN values to a START value included in the latest transmitted Cell Update message. Since the user terminal SRB2 is re-established with this START value, the UTRAN may not be able to receive a UTRAN Mobility Information Confirm message (UTRAN SRB2 is established with either HFN+1 or MAX(UL HFN of SRB2 DL HFN of SRB2)+1). It is further noted that these embodiments may correspond to all of the SRBs and common RBs. However, for SRB2, because the HFN value is synchronized before the UTRAN Mobility Information Confirm message is transmitted, it may not be necessary to reset the HFN value. Also, while the initial value for VT(US) has been illustratively discussed as corresponding to zero, those skilled in the art can appreciate that other initial values may be used for this or any other state variable discussed herein.

[0212] The embodiments of the present invention have been adopted in the following 3GPP Technical Specifications which are incorporated by reference herein: Technical Specification TS 25.303 v3.10.0, Technical Specification TS 25.303 v3.11.0, Technical Specification TS 25.322 v3.9.0, Technical Specification TS 25.331 v3.9.0, Technical Specification TS 25.331 v3.10.0, and all updates, revisions, and modification thereto.

[0213] A re-statement of various embodiments of the invention as indicated above may be provided as follows.

Combined Cell/ URA Update and SRNS Relocation

(Lossless Radio Bearers)

[0214] The method of the present invention may be initiated by the source RNC deciding to perform an SRNS relocation. Steps of this method, which have been previously discussed and are re-stated below, are shown in greater detail in FIG. 13. Here, Case 1 represents the situation where the user equipment (UE) is not involved and Case 2 represents the situation wherein the UE is involved and a Combined Cell/URA update and SRNS relocation is performed.

[0215] In an initial step, an RANAP Relocation Command is received by the source RNC from the CN, indicating the RABs to be released and the RABs that are subject to data forwarding. Lossless SRNS relocation may be configured for RABs that are subject to data forwarding. The PDCP layer supports PDCP sequence numbering when lossless SRNS relocation is supported.

[0216] For the affected radio bearers, the RLC entity is stopped and the PDCP sequence numbers are retrieved by the RRC. The PDCP send and receive sequence numbers are then transferred in the RNSAP Relocation Commit message from the source to the target RNC for RABs that support lossless SRNS relocation. The target RNC becomes the serving RNC when the RANAP Relocation Detect message is sent.

[0217] The target RNC then sends a UTRAN MOBILITY INFORMATION (Case 1) message on SRB#1 (UM/DCCH) or SRB#2 (AM/DCCH), or a CELL/URA UPDATE CONFIRM message (Case 2) on SRB#1 (UM/DCCH), which configures the UE with the new U-RNTI and indicates the uplink receive PDCP sequence number for each radio bearer configured to support lossless SRNS relocation.

[0218] If SRB#1 is to be used, the target RNC establishes the UM RLC entity for SRB#1 and the DL HFN and/or the VT(US) values are set to the values in the RRC container. In performing this step, the DL HFN value may be set to the current DL HFN value incremented by one. In the UM RLC entity, a "Special LI" is preferably used to indicate that an RLC SDU begins in the beginning of an RLC PDU.

[0219] If SRB#2 is to be used, the target RNC establishes the AM RLC entity and the DL and UL HFN values are set to the current DL and UL HFN values. Before sending a UTRAN MOBILITY INFORMATION message, the transmitting side of the AM RLC entity initiates RLC RESET procedure to synchronize the HFN values between the UTRAN and UE.

[0220] Upon reception by the UE of the message, the UE compares the uplink receive PDCP sequence number with the UE uplink send PDCP sequence number. If this confirms that PDCP SDUs were successfully transferred before the start of relocation (i.e., already received by the source RNC), then these are discarded by the UE. The UE reinitializes the PDCP header compression entities of the radio bearers configured to use a header compression protocol. The RLC (e.g.,. AM RLC) entity for SRB#2 is (re-)established both on the UTRAN and UE sides, and their HFN values are set to VALUE incremented by one. (Here, VALUE may be defined as either the current HFN value or MAX (UL HFN of SRB2□ DL HFN of SRB2)).

[0221] If the UE has successfully configured itself, it shall send a UTRAN MOBILITY INFORMATION CONFIRM message (Case 1 and Case 2). These messages preferably contain the START values and the downlink receive PDCP sequence number for each radio bearer configured to support lossless SRNS relocation.

[0222] Upon reception and acknowledgment by the UTRAN of the message, the UTRAN compares the downlink receive PDCP sequence number with the downlink send PDCP sequence number. The UTRAN initializes the PDCP header compression entities of the radio bearers configured to use a header compression protocol. The RLC entities for affected radio bearers (other than SRB#2) are (re-)established both on the UTRAN and UE side. The HFN values for each RB are preferably set to the START value in the message for the corresponding CN domain, and all the data buffers are flushed.

[0223] In case of failure, the UE shall send a UTRAN MOBILITY INFORMATION FAILURE message (Case 1 and Case 2).

[0224] Upon reception of the UTRAN MOBILITY INFORMATION CONFIRM/FAILURE (Case 1 and Case 2), the relocation procedure ends.

Combined Cell URA Update and SRNS Relocation

(Seamless Radio Bearers)

[0225] The method of the present invention may be initiated by the source RNC deciding to perform an SRNS relocation. Steps of this method, which have been previously discussed and are re-stated below, are shown in greater detail in **FIG. 14**. Here, Case 1 represents the situation where the user equipment (UE) is not involved and Case 2 represents the situation wherein the UE is involved and a Combined Cell/URA update and SRNS relocation is performed.

[0226] In an initial step, an RANAP Relocation Command is received by the source RNC from the CN, indicating the RABs to be released. The source RNC continues the downlink data transmission on radio bearers supporting seamless SRNS relocation until the target RNC becomes the serving RNC. The target RNC becomes the serving RNC when the RANAP Relocation Detect message is sent.

[0227] The target RNC sends a UTRAN MOBILITY INFORMATION message (Case 1) on SRB#1 (UM/DCCH) or SRB#2 (AM/DCCH), or a CELL/URA UPDATE CONFIRM message (case 2) on SRB#1 (UM/DCCH), which configures the UE with the new U-RNTI.

[0228] If SRB#1 is to be used, the target RNC establishes the UM RLC entity and the DL HFN value is set to the current DL HFN value incremented by one. In the UM RLC entity, a "Special LI" is preferably used to indicate that an RLC SDU begins in the beginning of an RLC PDU.

[0229] If SRB#2 is to be used, the target RNC establishes the AM RLC entity and the DL and UL HFN values are set to the current DL and UL HFN values. Before sending a UTRAN MOBILITY INFORMATION message, the transmitting side of the AM RLC entity initiates RLC RESET procedure to synchronize the HFN values between the UTRAN and UE.

[0230] Upon reception by the UE of the message, the RLC entity for SRB#2 is (re-)established both on the UTRAN and UE sides, and their HFN values are set to VALUE incremented by one. (Here, VALUE may be defined as either the current HFN value or MAX (UL HFN of SRB2|DL HFN of SRB2)).

[0231] If the UE has successfully configured itself, it shall send a UTRAN MOBILITY INFORMATION CONFIRM message (Case 1 and Case 2). These message preferably contain the START values (to be used in integrity protection and in ciphering on radio bearers using UM and AM RLC).

[0232] Upon reception and acknowledgment by the UTRAN of the message, the UTRAN initializes and the UE re-initializes the PDCP header compression entities of the radio bearers configured to use a header compression protocol. The RLC entities for affected radio bearers (other than SRB#2) are (re-)established both on the UTRAN and UE side. The HFN values for each RB are preferably set to the START value in the message for the corresponding CN domain and all the data buffers are flushed.

[0233] In case of failure, the UE shall send a UTRAN MOBILITY INFORMATION FAILURE message (Case 1 and Case 2).

[0234] Upon reception of the UTRAN MOBILITY INFORMATION CONFIRM/FAILURE message (Case 1 and Case 2), the relocation procedure ends.

[0235] In the foregoing embodiments, to initiate the method the UTRAN may transmit a UTRAN MOBILITY INFORMATION message to the UE on the downlink DCCH using AM or UM RLC. In the case of SRNS relocation, the message may be sent using UM RLC only.

Signaling Radio Bearers/RRC Connection Mobility Procedures

Cell and URA Update Procedures

[0236] When an RRC message is transmitted in DL on DCCH or CCCH or SHCCH using RLC UM, RRC will preferably indicate to the RLC that a special RLC length indicator should be used. The UE may assume that this indication has been given. The special length indicator indicates that an RLC SDU begins in the beginning of an RLC PDU.

[0237] Reception of a CELL UPDATE/URA UPDATE message by the UTRAN based on such a special length indicator will now be discussed in accordance with one embodiment of the present invention. When the UTRAN receives a CELL UPDATE/URA UPDATE message, the UTRAN:

[0238] 1> in the case where the procedure was triggered by reception of a CELL UPDATE:

[0239] 2> if SRNS relocation was performed:

[0240] 3> transmit a CELL UPDATE CONFIRM message on the downlink DCCH

[0241] 2> otherwise:

[0242] 3> update the START value for each CN domain as maintained in UTRAN with "START" in the IE "START list" for the CN domain as indicated by "CN domain identity" in the IE "START list";

[0243] 3> if this procedure was triggered while the UE was not in CELL_DCH state, then for each CN domain as indicated by "CN domain identity" in the IE "START list";

[0244] 4> set the 20 MSB of the MAC-d HFN with the corresponding START value in the IE "START list";

[0245] 4> set the remaining LSB of the MAC-d HFN to zero.

[0246] 3> transmit a CELL UPDATE CONFIRM message on the downlink DCCH or optionally on the CCCH but only if ciphering is not required; and

[0247] 3> optionally include the IE "RLC re-establish indicator (RB5 and upwards" to request an RLC reestablishment in the UE, in which case the corresponding RLC entities should also be re-established in UTRAN; or

[0248] 1> in the case the procedure was triggered by reception of a URA UPDATE:

[0249] 2> if SRNS relocation was performed:

[0250] 3> transmit a URA UPDATE CONFIRM message on the downlink DCCH

[0251] 2> otherwise:

[0252] 3> transmit a URA UPDATE CONFIRM message on the downlink CCCH or DCCH

[0253] 2> include the IE "URA identity" in the URA UPDATE CONFIRM message in a cell where multiple URA identifiers are broadcast, or

[0254] 1> initiate an RRC connection release procedure by transmitting an RRC CONNECTION RELEASE message on the downlink CCCH. In particular, the UTRAN should:

[0255] 2> if the CELL UPDATE message was sent because of an unrecoverable error in RB2, RB3, or RB4:

[0256] 3> initiate an RRC connection release procedure by transmitting an RRC CONNECTION RELEASE message on the downlink CCCH.

Reception of CEFLL UPDATE CONFIRM/URA UPDATE

CONFIRM Message by the UE

[0257] When the UE receives a CELL UPDATE CONFIRM/URA UPDATE CONFIRM message; and

[0258] if the message is received on the CCCH and IE "U-RNTI" is present and has the same value as the variable U_NTI; or

[0259] if the message is received on DCCH; the UE may:

[0260] if the CELL UPDATE CONFIRM message includes the IE "RLC reestablish indicator (RB2, RB3, and RB4)";

[0261] reestablish the RLC entities for signaling radio bearer RB2, signaling radio bearer RB3 and signaling radio bearer RB4 (if established);

[0262] if the value of the IE "Status" in the variable CIPHERING_STATUS of the CN domain stored in the variable LATEST_CONFIGURED_CN_DOMAIN is set to "Started";

[0263] set the HFN values for AM RLC entities with RB identity 2, RB identity 3 and RB identity 4 (if established) equal to the START value included in the latest transmitted CELL UPDATE message for the CN domain stored in the variable LATEST_CONFIGURED_CN_DOMAIN;

[0264] The foregoing embodiments and advantages are merely exemplary and are not to be construed as limiting the present invention. The present teaching can be readily applied to other types of apparatuses. The description of the present invention is intended to be illustrative, and not to limit the scope of the claims. Many alternatives, modifications, and variations will be apparent to those skilled in the art. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents but also equivalent structures.

What is claimed is:

1. A method for performing SRNS relocation, comprising:

receiving in a target RNC radio resource information from a source RNC, said radio resource information including a ciphering parameter;

modifying the ciphering parameter to coincide with a deciphering parameter of a user terminal, said deciphering parameter corresponding to one the user terminal uses when out-of-sequence data is received;

ciphering a data unit based on the modified ciphering parameter; and

transmitting the ciphered data unit from the target RNC to the user terminal.

2. The method of claim 1, wherein the target RNC and the user terminal are operating in UM mode.

3. The method of claim 2, further comprising:

transmitting the ciphered data unit over a serving radio bearer SRB**1**.

4. The method of claim 2, further comprising:

transmitting the ciphered data unit over a UM DCCH channel.

5. The method of claim 1, wherein said out-of-sequence data includes data having a transmission sequence number which does not consecutively follow a transmission sequence number of a last PDU transmitted from the source RNC to the user terminal.

6. The method of claim 1, wherein the ciphering parameter and said deciphering parameter are HFN parameters.

7. The method of claim 1, wherein said modifying step includes:

adjusting an HFN value of the ciphering parameter to equal an HFN value of said deciphering parameter when said out-of-sequence data is received.

8. The method of claim 7, wherein said adjusting step includes:

incrementing the HFN value of the ciphering parameter to equal an incremented value of said deciphering parameter.

9. The method of claim 1, wherein the transmitting step includes:

transmitting a data start indicator with the ciphered data unit.

10. The method of claim 9, wherein said data start indicator indicates that the ciphered data unit is not included as part of an SDU previously transmitted to the user terminal.

11. A method for performing SRNS relocation, comprising:

receiving in a target RNC radio resource information from a source RNC; and

transmitting a data unit from the target RNC to a user terminal, said data unit including a transmission sequence number which consecutively follows a transmission sequence number of a data unit last transmitted from the source RNC to the user terminal.

12. The method of claim 11, further comprising:

ciphering the data unit before said transmitting step.

13. The method of claim 12, wherein the ciphering step includes:

ciphering the data unit with a same ciphering parameter the user terminal used to decipher a data unit transmitted from the source RNC to the user terminal.

14. The method of claim 13, wherein said same ciphering parameter includes a same HFN value.

15. The method of claim 11, wherein the target RNC and the user terminal are operating in UM mode.

16. The method of claim 11, further comprising:

transmitting the data unit over a UM DCCH channel.

17. The method of claim 11, further comprising:

transmitting the data unit over a serving radio bearer SRB**1**.

18. The method of claim 11, wherein the transmitting step includes:

transmitting a data start indicator with the data unit.

19. The method of claim 18, wherein said data start indicator indicates that the data unit is not included as part of an SDU previously transmitted to the user terminal.

20. A method for performing SRNS relocation, comprising:

resetting transmission information of a target RNC; and

transmitting a message instructing a user terminal to reset reception information to values which coincide with said reset transmission information of the target RNC.

21. The method of claim 20, wherein said resetting step includes resetting a transmission sequence number to an initial value in the target RNC, and wherein said reset reception information includes a transmission sequence number of a next-expected data unit set to said initial value.

22. The method of claim 20, wherein said resetting step includes resetting a state variable to an initial value in the target RNC, and wherein said message includes information instructing the user terminal to be set to said state variable.

23. The method of claim 20, wherein said message is an unciphered message.

24. The method of claim 20, further comprising:

receiving a message from the user terminal indicating that the user terminal has reset said reception information.

25. The method of claim 20, wherein said resetting step includes setting a ciphering parameter to an initial value, and wherein said reset reception information includes a deciphering parameter which coincides with the initial value of said ciphering parameter.

26. The method of claim 25, wherein said ciphering parameter and said deciphering parameter include a same HFN value.

27. The method of claim 20, wherein said resetting step includes flushing SDUs in the target RNC and wherein said message instructs the user terminal to flush SDUs.

28. The method of claim 20, further comprising:

transmitting a data unit from the target RNC to the user terminal over a serving radio bearer SRB**2**.

29. The method of claim 20, wherein the target RNC and the user terminal are operating in AM mode.

30. The method of claim 29, further comprising:

transmitting a ciphering parameter and transmission sequence number information from a source RNC to the target RNC, wherein said ciphering parameter coincides with a deciphering parameter used in the user terminal and a ciphering parameter the source RNC used to transmit a data unit to the user terminal, and wherein said transmission sequence number information is indicative of a next-expected transmission sequence number in the user terminal.

31. The method of claim 20, further comprising:

transmitting a data unit from the target RNC to the user terminal, said data unit including a data start indicator indicating that the data unit is not included as part of an SDU previously transmitted to the user terminal.

32. The method of claim 20, further comprising:

transmitting a data unit from the target RNC to the user terminal over an AM DCCH channel.

33. A method for performing SRNS relocation, comprising:

delivering radio resource information from a source RNC to a target RNC in a UTRAN, said radio resource information including:

a) a ciphering parameter the source RNC used to transmit PDUs to a user terminal, and

b) a transmission sequence number corresponding to one of a next PDU to be transmitted by the source RNC to a user terminal or a last PDU that was transmitted from the source RNC to the user terminal;

generating a PDU/RRC message based on said transmission sequence number;

ciphering the PDU/RRC message with said ciphering parameter; and

transmitting the ciphered message from the target RNC to a user terminal.

34. The method of claim 33, wherein the target RNC and the user terminal are operating in AM RLC mode.

35. A method for performing a relocation procedure in a communications system, said communications system including a transmitter and a receiver; said method comprising:

initializing the transmitter to communicate with the receiver, said initializing step including setting a transmission sequence number to a first value and setting a deciphering parameter to a second value;

transmitting a PDU including said initial sequence number and said deciphering parameter from the transmitter to the receiver;

determining, in the receiver, that the initial sequence number in the PDU does not equal a next sequence number expected by the receiver;

setting a deciphering parameter in the receiver to the second value; and

deciphering the PDU.

36. A transmission unit, comprising:

a target RNC which receives radio resource information from a source RNC, said radio resource information including a ciphering parameter; and

a processor which modifies the ciphering parameter to coincide with a deciphering parameter of a user terminal, and which ciphers a data unit based on the modified ciphering parameter; and

a transmitter which transmits the ciphered data unit from the target RNC to the user terminal, wherein said deciphering parameter corresponding to one the user terminal uses when out-of-sequence data is received.

37. The transmission unit of claim 36, wherein the target RNC and the user terminal are operating in UM mode.

38. The transmission unit of claim 37, wherein the transmitter transmits the ciphered data unit over a serving radio bearer SRB1.

39. The transmission unit of claim 36, wherein the transmitter transmits the ciphered data unit over a UM DCCH channel.

40. The transmission unit of claim 36, wherein said out-of-sequence data includes data having a transmission sequence number which does not consecutively follow a transmission sequence number of a last PDU transmitted from the source RNC to the user terminal.

41. The transmission unit of claim 36, wherein the ciphering parameter and said deciphering parameter are HFN parameters.

42. The transmission unit of claim 36, wherein said processor adjusts an HFN value of the ciphering parameter to equal an HFN value of said deciphering parameter when said out-of-sequence data is received.

43. The transmission unit of claim 42, wherein said processor increments the HFN value of the ciphering parameter to equal an incremented value of said deciphering parameter.

44. The transmission unit of claim 36, wherein the transmitter transmits a data start indicator with the ciphered data unit.

45. The transmission unit of claim 44, wherein said data start indicator indicates that the ciphered data unit is not included as part of an SDU previously transmitted to the user terminal.

46. A transmission unit, comprising:

a target RNC which receives radio resource information from a source RNC; and

a transmitter which transmits a data unit from the target RNC to a user terminal, said data unit including a transmission sequence number which consecutively follows a transmission sequence number of a data unit last transmitted from the source RNC to the user terminal.

47. The transmission unit of claim 46, further comprising:

a processor which ciphers the data unit before transmission.

48. The transmission unit of claim 47, wherein the processor ciphers the data unit with a same ciphering parameter the user terminal used to decipher a data unit transmitted from the source RNC to the user terminal.

49. The transmission unit of claim 48, wherein said same ciphering parameter includes a same HFN value.

50. The transmission unit of claim 46, wherein the target RNC and the user terminal are operating in UM mode.

51. The transmission unit of claim 46, wherein the transmitter transmits the data unit over a UM DCCH channel.

52. The transmission unit of claim 46, wherein the transmitter transmits the data unit over a serving radio bearer SRB1.

53. The transmission unit of claim 46, wherein the transmitter transmits a data start indicator with the data unit.

54. The transmission unit of claim 53, wherein said data start indicator indicates that the data unit is not included as part of an SDU previously transmitted to the user terminal.

55. A method for performing SRNS relocation, comprising:

receiving in a target RNC an RNSAP Relocation Commit message from a source RNC, said message including an HFN ciphering parameter;

modifying the HFN ciphering parameter to coincide with an HFN parameter of a UE, said UE HFN parameter corresponding to one the UE uses when an out-of-sequence PDCP sequence number is received;

ciphering an RLC PDU based on the modified HFN ciphering parameter; and

transmitting the ciphered RLC PDUE from the target RNC to the UE.

56. The method of claim 55, wherein the target RNC and the UER are operating in UM mode.

57. The method of claim 56, further comprising:

transmitting the ciphered RLC PDU over a serving radio bearer SRB**1**.

58. The method of claim 56, further comprising:

transmitting the ciphered RLC PDU over a UM DCCH channel.

59. The method of claim 55, wherein said out-of-sequence PDCP sequence number does not consecutively follow a PDCP sequence number of a last RLC PDU transmitted from the source RNC to the UE.

60. The method of claim 55, wherein said modifying step includes:

adjusting a value of the HFN ciphering parameter to equal a value of said UE HFN parameter when said out-of-sequence PDCP sequence number is received.

61. The method of claim 60, wherein said adjusting step includes:

incrementing the HFN ciphering parameter to equal an incremented value of said UE HFN parameter.

62. The method of claim 55, wherein the transmitting step includes:

transmitting a START value with the ciphered RLC PDU, said START value indicating that the ciphered RLC PDU is not included as part of an SDU previously transmitted to the UE.

63. A method of sending information in a mobile radio communication system comprising:

receiving the information including the numbers related to a ciphering sequence number and the state variable of a radio link control entity of a radio network cont roller which was previously a serving radio network controller of a terminal;

establishing a radio link control entity for sending information to said terminal;

setting the state variable of a radio link control entity synchronized with said received state variable; and

sending a data unit of said information starting with the state variable to said terminal.

64. A method of claim 63, further comprising:

setting an indicator indicates that a service data unit contains the information begins in the beginning of a data unit of said radio link control entity.

65. A method of claim 63, wherein, one of the state variables of a radio lin k control entity is the sequence number of the RLC PDU to be transmitted next time.

66. A method of claim 65, wherein, one of the state variables of a radio lin k control entity is the most prior sequence number of the RLC PDU to be retransmitted.

67. A method of claim 64, further comprising; sending an instruction for moving the receiving window to said terminal.

68. A method of sending information in a mobile radio communication system comprising:

receiving the instruction which instructs to become the serving radio network controller of a terminal from core network with the information including the numbers related to a ciphering sequence number;

establishing a radio link control entity for signalling control information to said terminal;

setting the ciphering sequence number according to said numbers received from other radio network controller; setting a length indicator indicates that an RLC SDU begins in the beginning of an RLC PDU; and

sending information ciphered with the ciphering sequence number through said radio link control entity to said terminal.

69. A method of sending information in mobile radio communication system comprising:

receiving down link radio resource control message on signalling radio bearer;

checking the serving radio network controller changes;

changing hyper frame number value for another signalling radio bearer; and

transmitting up link radio resource control message ciphered with a number from the changed hyper frame number.

70. A method of claim 69, further comprising:

sending a predetermined value for the hyper frame number to the serving radio network controller; and

establishing other signalling radio bearers with said predetermined value.

71. A method of claim 70, wherein said predetermined value is the start value of the hyper frame number.

72. A method of claim 69, wherein the changed hyper frame number value is current value +1.

73. A method of claim 69, wherein the changed hyper frame number value is the larger value between those of uplink and downlink +1

* * * * *

US 20040246917A1

(19) United States
(12) Patent Application Publication (10) Pub. No.: US 2004/0246917 A1
Cheng et al. (43) Pub. Date: Dec. 9, 2004

(54) **METHOD AND SYSTEM FOR FORWARD LINK CELL SWITCHING APPROACH WITHOUT ABIS TRAFFIC FLOODING IN CDMA2000-1X EV-DV SYSTEM**

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(21) Appl. No.: **10/311,893**

(22) PCT Filed: **Apr. 24, 2002**

(86) PCT No.: **PCT/IB02/01357**

Related U.S. Application Data

(60) Provisional application No. 60/286,037, filed on Apr. 25, 2001.

Publication Classification

(51) **Int. Cl.**[7] **H04Q 7/00**
(52) **U.S. Cl.** **370/328**

(57) **ABSTRACT**

The invention is a system and a method in a system including a mobile station (MS), a group of active cells including a first serving cell (cell a) and a second target cell (cell b) and a controller of the active cells which switches forward link transmissions of data packets from the controller (BSC) through the first serving cell to the mobile station to forward link transmission of data packets from the controller through a second cell to the mobile station. The method determines at the mobile station that switching of forward link transmissions should occur from the first serving cell to the second target cell while forward link transmission of the data packets through the first serving cell to the mobile station are occurring; transmitting an indication to switch the forward link transmission of data packets to the second target cell b from the mobile station to the controller; the controller in response to the indication switches the transmission of data packets from the first serving cell a to the second target cell b; and the second target cell transmits the data packets to the mobile station. A cell switch delay, which may be zero or an integer multiple of a time frame interval required to transmit a data packet on the forward link, provides time to ready the second target cell b to begin transmission of the data packets to the mobile station. The cell switch delay may be determined or configured by the network dependent upon the source and target pilots in the active set are within the same BTS or are in different cells.

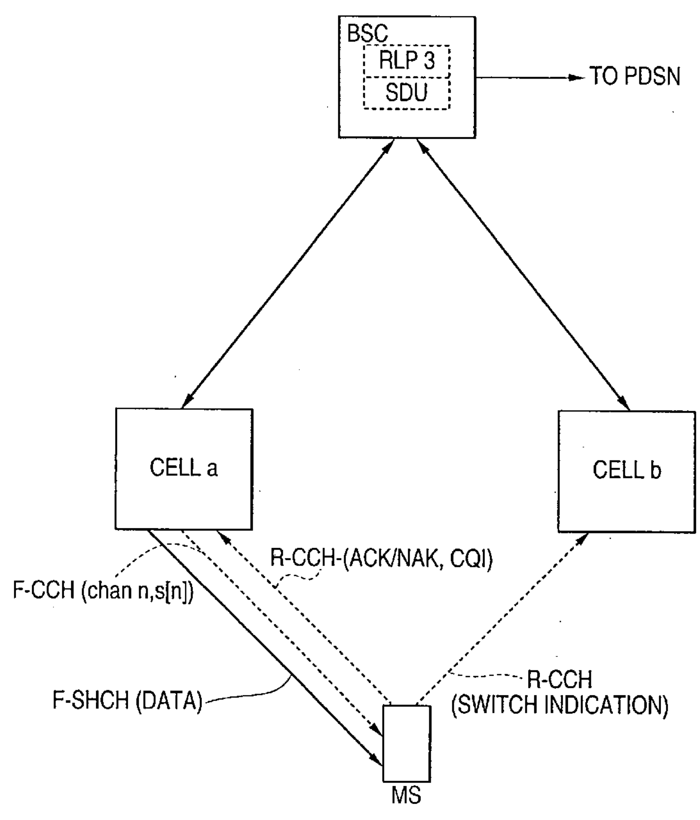


FIG. 1

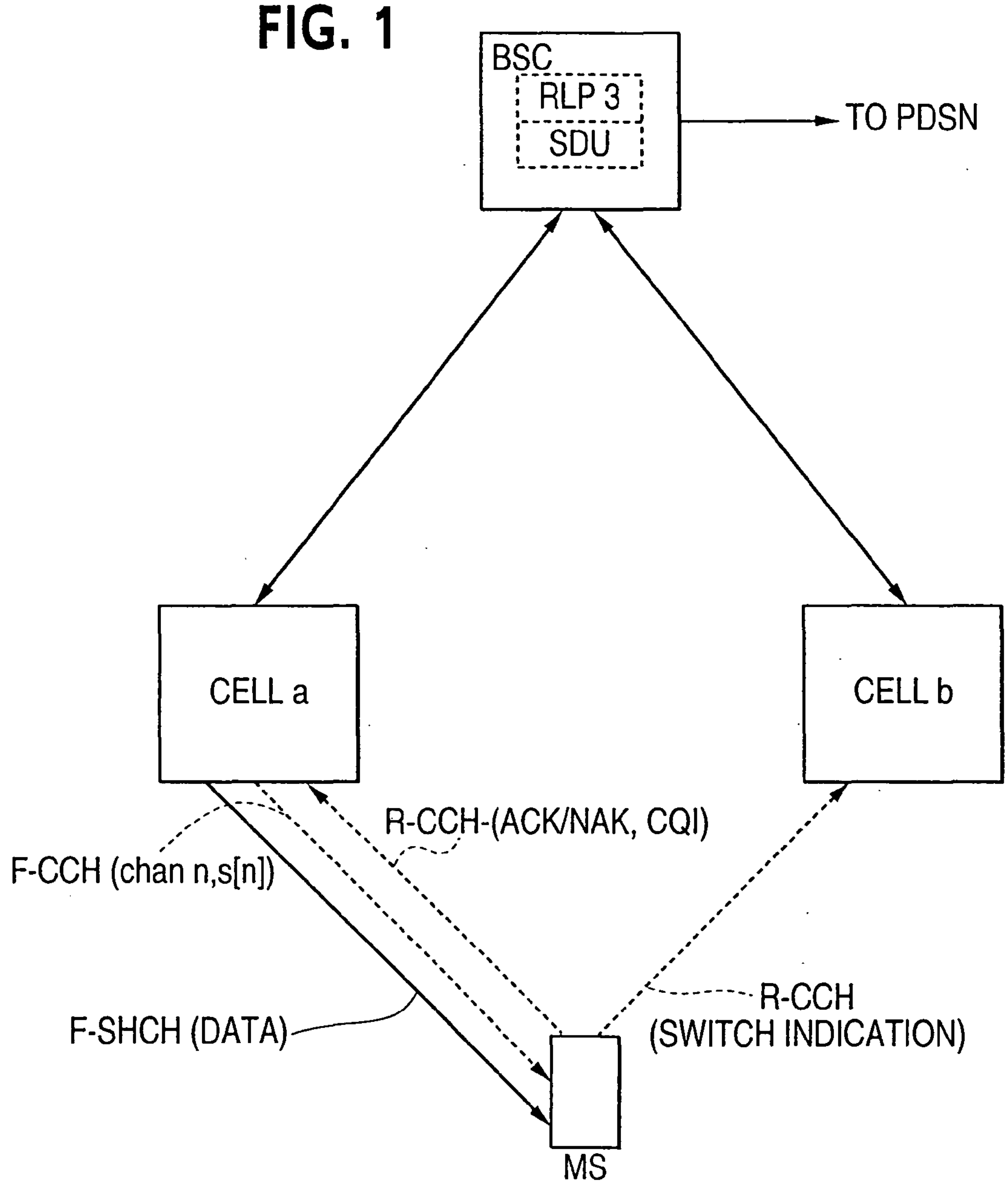

BSC
RLP 3
SDU
TO PDSN
CELL a
CELL b
R-CCH-(ACK/NAK, CQI)
F-CCH (chan n,s[n])
F-SHCH (DATA)
R-CCH
(SWITCH INDICATION)
MS

FIG. 2

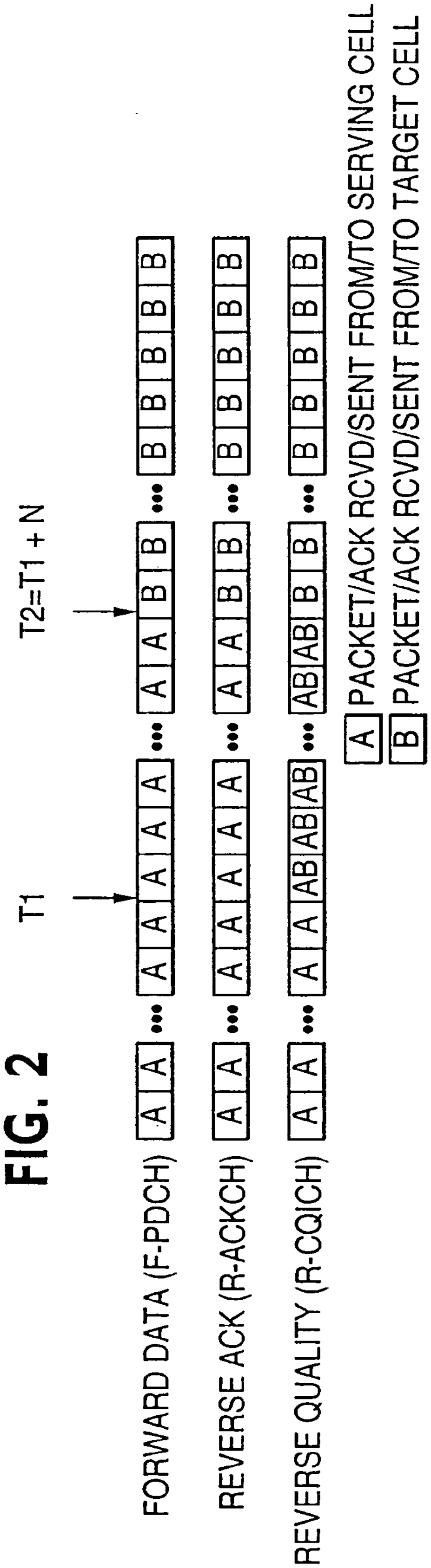

FORWARD DATA (F-PDCH)
REVERSE ACK (R-ACKCH)
REVERSE QUALITY (R-CQICH)
T1
T2=T1 + N
A
B
AB
A PACKET/ACK RCVD/SENT FROM/TO SERVING CELL
B PACKET/ACK RCVD/SENT FROM/TO TARGET CELL

FIG. 3

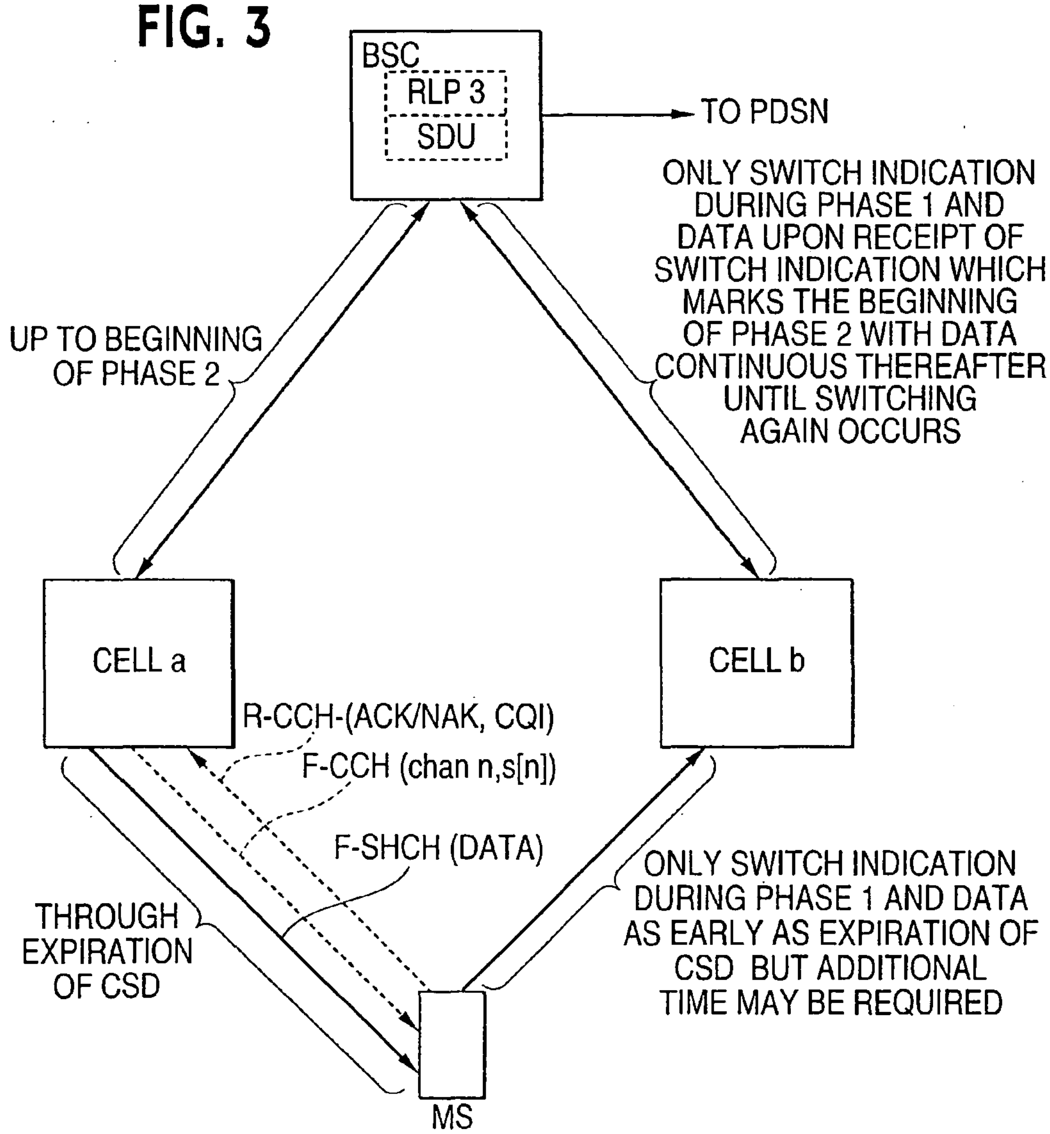
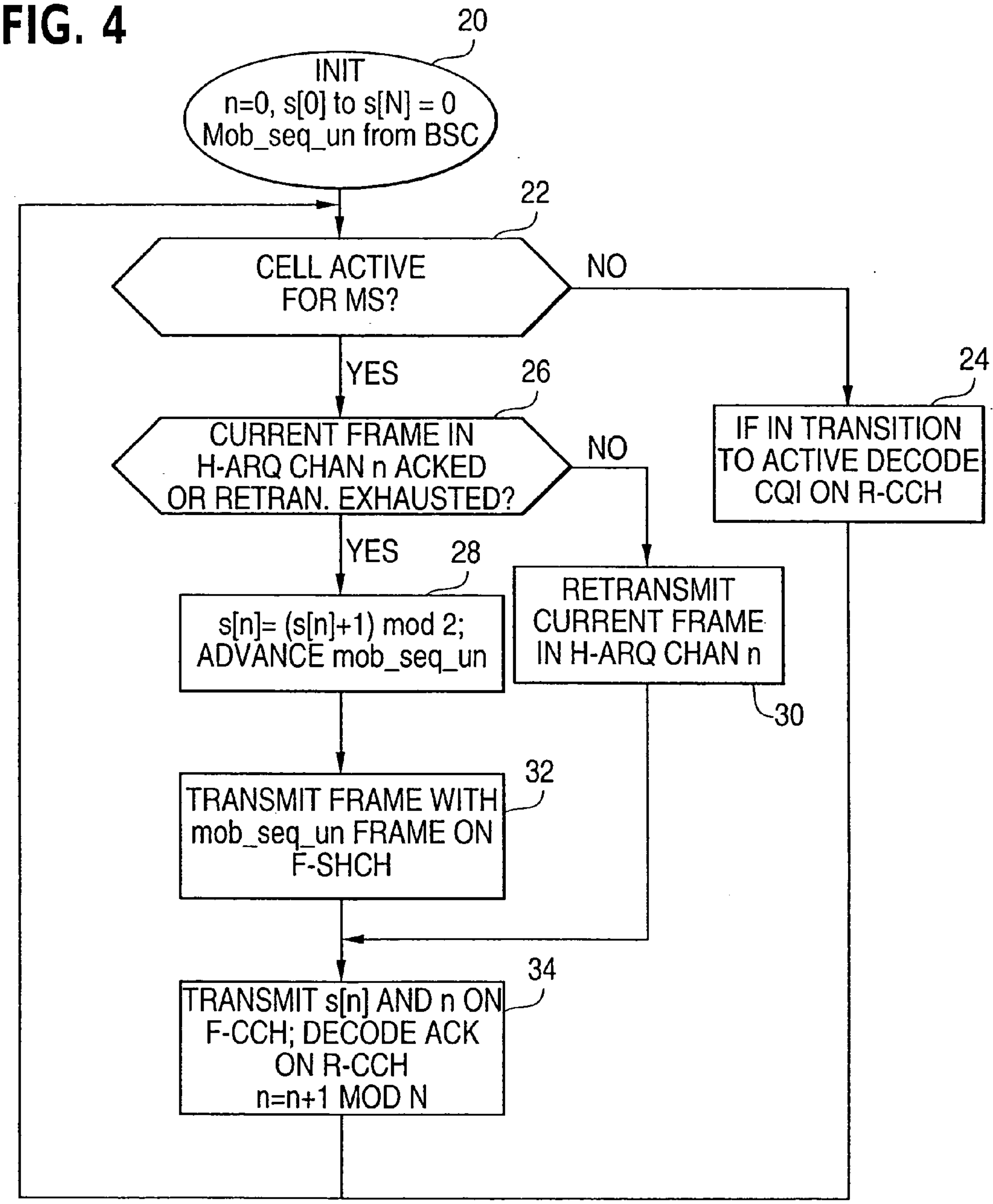
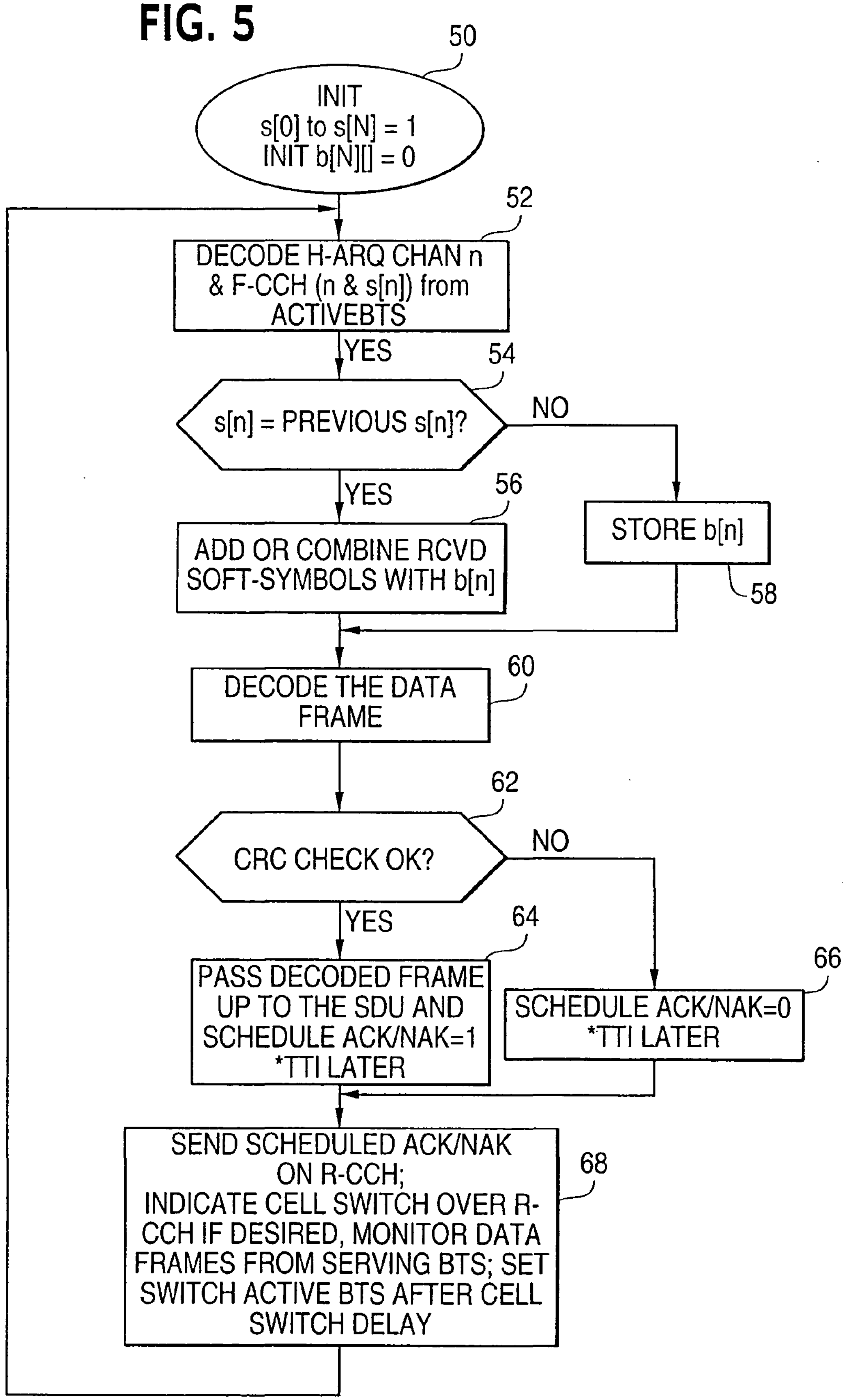

BSC
RLP 3
SDU
TO PDSN
ONLY SWITCH INDICATION DURING PHASE 1 AND DATA UPON RECEIPT OF SWITCH INDICATION WHICH MARKS THE BEGINNING OF PHASE 2 WITH DATA CONTINUOUS THEREAFTER UNTIL SWITCHING AGAIN OCCURS
UP TO BEGINNING OF PHASE 2
CELL a
CELL b
R-CCH-(ACK/NAK, CQI)
F-CCH (chan n,s[n])
F-SHCH (DATA)
THROUGH EXPIRATION OF CSD
ONLY SWITCH INDICATION DURING PHASE 1 AND DATA AS EARLY AS EXPIRATION OF CSD BUT ADDITIONAL TIME MAY BE REQUIRED
MS

FIG. 4



20
INIT
n=0, s[0] to s[N] = 0
Mob_seq_un from BSC
22
CELL ACTIVE FOR MS?
NO
YES
24
IF IN TRANSITION TO ACTIVE DECODE CQI ON R-CCH
26
CURRENT FRAME IN H-ARQ CHAN n ACKED OR RETRAN. EXHAUSTED?
NO
YES
28
s[n]= (s[n]+1) mod 2; ADVANCE mob_seq_un
RETRANSMIT CURRENT FRAME IN H-ARQ CHAN n
30
32
TRANSMIT FRAME WITH mob_seq_un FRAME ON F-SHCH
34
TRANSMIT s[n] AND n ON F-CCH; DECODE ACK ON R-CCH n=n+1 MOD N

FIG. 5


50
INIT
s[0] to s[N] = 1
INIT b[N][] = 0
52
DECODE H-ARQ CHAN n & F-CCH (n & s[n]) from ACTIVEBTS
YES
54
s[n] = PREVIOUS s[n]?
NO
YES
56
ADD OR COMBINE RCVD SOFT-SYMBOLS WITH b[n]
STORE b[n]
58
60
DECODE THE DATA FRAME
62
CRC CHECK OK?
NO
YES
64
PASS DECODED FRAME UP TO THE SDU AND SCHEDULE ACK/NAK=1 *TTI LATER
66
SCHEDULE ACK/NAK=0 *TTI LATER
SEND SCHEDULED ACK/NAK ON R-CCH; INDICATE CELL SWITCH OVER R-CCH IF DESIRED, MONITOR DATA FRAMES FROM SERVING BTS; SET SWITCH ACTIVE BTS AFTER CELL SWITCH DELAY
68

METHOD AND SYSTEM FOR FORWARD LINK CELL SWITCHING APPROACH WITHOUT ABIS TRAFFIC FLOODING IN CDMA2000-1X EV-DV SYSTEM

TECHNICAL FIELD

[**0001**] This invention relates to wireless high-speed packet data technology, e.g. in CDMA2000 1xEV-DV and 3GPP HSDPA and more specifically, to improving the cell switching techniques for forward radio channels.

BACKGROUND ART

[**0002**] Physical Layer ARQ (HARQ) and cell switching are two link-adaptation techniques that are employed by the 1xEV-DV forward link standard. Cells are comprised of base transceiver stations (BTS) in wireless environments which have lower traffic and sectors, which subtend an angular portion of a full periphery, such as 120°, in wireless environments having higher traffic.

[**0003**] The hybrid automatic repeat request (HARQ) protocol uses an adaptive automatic repeat request (ARQ) technique for retransmission combining.

[**0004**] Cell switching is a handoff technique that allows the mobile terminal (MS) to identify an optimal serving cell pilot channel based on C/I measurement with C/I being a strength ratio of the carrier signal to the interference.

[**0005**] In the 1XTREME/1xEV-DV proposal, fast cell site selection (FCSS) is proposed to ensure mobility. When a mobile moves from one cell to another cell, a central entity Network Convergence Function (NCF) is used to coordinate multiple cells in the active set. During soft handoff, a NCF provides the same data units (PDUs) to all of the cells in the active set (flooding). However, only one cell delivers the PDUs to the MS. When the MS moves from one cell to another in the active set, the MS echoes the most recently received NCF sequence number so that the new cell can resume the data transfer without delay.

[**0006**] 1. **FIG. 1** shows an example of a prior art cell switching operation. Cell a and cell b both are in the MS's active set. Prior to switching cell a sends the data frames to the MS by the Forward Shared Channel (F-SHCH). Upon a measurement threshold, the MS may decide to request new cell switching by sending a request on R-CCH to request cell switching to cell b. The serving

[**0007**] cell a serves the MS, before the cell switching, with the forward and reverse link channels. The target cell b is the cell chosen for the transmission after the cell switching is completed. An active set for the Forward Packet Data Channel is updated to cell a based on the pilot strength feedback from the MS. All cells in the active set (only two have been illustrated for convenience purposes) are eligible for forward link cell switching.

[**0008**] In **FIG. 1**, the Abis interface (the Abis interface is between the base station controller (BSC) and the cells) flooding occurs during, for example, the soft handoff of 1XTREME/1xEV-DV FCSS procedure. This problem significantly affects the BSC and cell performance. During soft handoff, both Abis links between the BSC and cell a and cell b are active as indicated by the bidirectional arrows therebetween. Flooding involves substantial transmission overhead, memory requirement inside the cells and a centralized management entity which manages the large sequence frame numbering.

[**0009**] After the MS has signalled the BSC with an indication on R-CCH as indicated in **FIG. 1** that the MS wants to switch receiving forward link transmissions from cell a to cell be, the BSC transmits the data packets simultaneously to both the serving and target cells until handoff is complete. The simultaneous use of the Abis resources by the BSC for the serving and target cells and the radio resources from the serving and target cells is wasteful especially when data rates are high such as for 1xEV-DV (around 4 Mbps).

DISCLOSURE OF INVENTION

[**0010**] This invention is to a cell switching technique which avoids the prior art flooding of the forward link soft-handoff of **FIG. 1**. The avoidance of soft handoff provides the benefits of reducing the Abis interface overhead and quick resumption of data transfer and saves the radio resource from being loaded with unnecessary information. The cell-switching technique of the present invention permits base stations including 1xEV-DV cells to provide data users with better network resource utilization and quick resumption of data transfer after switching.

[**0011**] In a system including a mobile station, cells in an active set including first serving and second target cells and a controller of the active cells, a method of switching forward link transmissions of data packets from the controller through the first serving cell to the mobile station to forward link transmission of data packets from the controller through the second target cell to the mobile station in accordance with the invention includes determining at the mobile station that switching of the forward link transmission should occur from the first serving cell to the second target cell while the forward link transmission of the data packets through the first serving cell to the mobile station is occurring; transmitting an indication to switch the forward link transmission of the data packets from the mobile station to the controller; the controller, in response to the indication, switches the transmission of data packets from the first serving cell to the second target cell; and the second target cell transmits the data packets to the mobile station. The first cell may continue transmission of data packets on the forward link to the mobile station for a cell switch delay time period measured from the indication to switch until the completion of the switching. The mobile station may transmit a quality indicator to only the first serving cell during the cell switch delay which is used by the first serving cell to control at least one of a power level of transmission or selection of modulation and a coding type used by the forward link during the cell switch delay in transmitting data packets to the mobile station. The mobile station may transmit acknowledgment information to the first serving cell during the cell switch delay; and the first serving cell may retransmit on the forward link during the cell switch delay packets which were negatively acknowledged. The acknowledgment information may be either an acknowledgment or a negative acknowledgment that data packets of the forward link has been received by the mobile station. The second cell may transmit the data packets to the mobile station after expiration of a cell switch delay period measured from the indication to switch until the completion of the cell switching. The data packets may be transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and the indication to switch may be transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and a quality indicator may be sent on the reverse control channel to the first serving cell. F-SHCH may be mapped to a forward packet data channel (F-PDCH); and R-CCH may be mapped to a reverse acknowledgment channel (R-ACKCH) and a reverse channel quality indicator channel (R-CQICH). The cell switch delay may be one of zero or an integer multiple of a time frame interval required to transmit a data packet on the forward link. The cell switch delay may be determined or configured by the network dependent upon the servicing and target cells in the active set being between sectors or being in different base transceiver stations. The indication to switch may be a Walsh code cover of the second target cell base transceiver stations. The second target cell switches transmission of data packets to the mobile station at an end of a time including an additional time delay measured from an end of the cell switch delay period.

[0012] A system in accordance with the invention includes a mobile station, cells in an active set including first serving and second target cells, and a controller of the active cells, and wherein switching of forward link transmission of data packets from the controller through the first serving cell to the mobile station to forward link transmission of data packets from the controller through the second target cell to the mobile station occurs by determining at the mobile station that switching of forward link transmission should occur from the first serving cell to the second target cell while forward link transmission of the data packets through the first serving cell to the mobile station is occurring, transmitting an indication to switch the forward link transmission of the data packets from the mobile station to the controller, the controller in response to the indication switches the transmission of data packets from the first serving cell to the second target cell and the second target cell transmits the data packets to the mobile station. The first serving cell may continue transmission of data packets on the forward link to the mobile station for a cell switch delay time period measured from the indication to switch until the completion of the switching. The mobile station may transmit a quality indicator to only the first serving cell during the cell switch delay which is used by the first serving cell to control at least one of a power level of transmission or selection of modulation and coding type used by the forward link to the mobile station during the cell switch delay. The mobile station may transmit acknowledgment information to the first serving cell during the cell switch delay; and the first serving cell may retransmit on the forward link during the cell switch delay packets which were negatively acknowledged. The acknowledgment information may be either an acknowledgement or a negative acknowledgment that data packets of the forward link have been received by the mobile station. The second target cell may transmit the data packets to the mobile station after expiration of a cell switch delay period measured from the indication to switch until the completion of the switch. The data packets may be transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and the indication to switch may be transmitted from the mobile station to the second target cell on the reverse control channel (R-CCH) and a quality indicator may be sent on the reverse control channel to the first serving cell. The cell switch delay may be one of zero or an integer multiple of a time frame interval required to transmit a data packet on the forward link. The cell switch delay may be determined or configured by the network dependent upon the source and target pilots in the active set being between sectors within the same BTS or being in different base transceiver stations. The indication to switch may be a Walsh code cover of the second target cell. The second target cell switches transmission of data packets to the mobile station at an end of a time including an additional time delay measured from an end of the cell switch delay period.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] **FIG. 1** is a diagram of a prior art forward link cell switching operation which floods the Abis interface;

[0014] **FIG. 2** is a diagram of forward link data transmission and reverse link feedback during the cell switching according to an embodiment of the present invention;

[0015] **FIG. 3** is a diagram of communications between a base station controller, a first serving and a second target cell and a mobile station in accordance with the invention.

[0016] **FIG. 4** is a flowchart of a cell processing according to an embodiment of the present invention; and

[0017] **FIG. 5** is a flowchart of a MS processing according to an embodiment of the present invention.

[0018] Like parts are identified by like identifications throughout the drawings.

BEST MODE FOR CARRYING OUT THE INVENTION

[0019] Forward Link Cell Switching

[0020] To reduce the Abis interface overhead during cell switching the invention:

[0021] 1. Limits the data transfer from the BSC to only one cell at a time.

[0022] 2. Moves buffered data from the serving (first) cell to the target (second) cell for fast data recovery during the switching period.

[0023] 3. Optionally uses a new sequence numbering format with a bit field of fewer bits than the prior art or an existing radio link protocol (RLP) sequence number optionally may be utilized.

[0024] The present invention is useful for 1xEV-DV cell and MS implementation and is also related to 1xEV-DV standardization.

[0025] MS switching of data reception from cell to cell in accordance with the invention is described as follows. Each MS is assigned an active set of cells dynamically by the network. Data packets are sent on the forward shared channel (F-SHCH) and acknowledgements are sent on the reverse control channel (R-CCH). The indication to switch cells is sent on the R-CCH. For 1XTREME, R-CCH is mapped to the "Reverse Acknowledgement Indication Channel" (R-AISCH) and "Transmit Sector Indicator Channel" (R-TSICH). For 1xEV-DV, F-SHCH is mapped to the "Forward Packet Data Channel" (F-PDCH); R-CCH is mapped to "Reverse Acknowledgement Channel" (R-ACKCH); and "Reverse Channel Quality Indicator Channel" (R-CQICH).

[0026] The table below defines the timing relationships between T1 and T2 shown in **FIG. 2** and described with reference to **FIG. 3**.

T1	The MS indicates cell switching to target cell b to invoke a cell switching procedure.
T2	T1 + CSD where CSD is the cell switching delay required to ready target cell b for the packet data transmission when the R-CQICH transmissions are directed to target cell b after T2.

[0027] **FIGS. 2 and 3** illustrates the transmission of data packets and acknowledgements during cell switching in accordance with the invention. There are three phases during the transition period:

[0028] 1. Phase 1—Time duration before T1.

[0029] 2. Phase 2—Time duration between T1 and T2.

[0030] 3. Phase 3—Time duration after T2.

[0031] The table below describes three significant types of transmissions which head three columns entitled "BSC Sends Data to", "MS Receives Data from & Sends CQI" and "CELL that Decodes ACK/NAK" during the phases 1, 2 and 3 as defined above which row identifications therein.

	BSC Sends Data to	MS Receives Data from & Sends CQI to	CELL that Decodes ACK/NAK Responses
Phase 1	CELL a	CELL a	CELL a
Phase 2	CELL b	CELL a	CELL a
Phase 3	CELL b	CELL b	CELL b

[0032] Data transmission up to the end of phase 1 at time T1 when transmission of data packets occurs only to the first serving cell a. At the beginning of phase 2, the invention switches data packet transmission to second target cell b thus eliminating the flooding of the prior art in **FIG. 1** when both Abis resources between the BSC and the first serving and second target cell are active. During the remainder of phase 2 and through phase 3, the data transmission continues from the BSC to target cell b. The MS receives data from and sends CQI to cell a all the way up to the end of phase 2 which is also the end of the CSD described below at which transmission is switched to target cell b. The transmission of CQI up to the end of phase 2 enables cell a to adjust power level on the forward link to continue to change signal strength in response to changing conditions or to select modulation and a coding type used on the forward link. Decoding of ACK/NAK transmissions occurs at serving cell a until the end of phase 2 at which time decoding of ACK/NAK transmissions switches to target cell b. The MS also receives any pending retransmitted frames from serving cell a up to the end of the CSD as described below. The unified sequence number or RLP Sequence Number may be used by target cell b to continue the new frame transmission after switching occurs. The frames sent during phase 1 cannot be retransmitted after entry into phase 3. In that case, the upper layer (e.g. RLP in the BSC) handles the retransmission of the erroneous frames.

[0033] The data packets are transmitted by the target (second) cell to the MS after the CSD. The CSD is required for the target cell to allocate network and radio resources and for the serving (first) cell to complete any pending data packet retransmissions and their acknowledgements. The CSD equals M*Xms where M is zero or a positive integer and X is a time duration of transmission of a data frame. The CSD time duration is between when the MS generates an indication for cell switching from target cell a to serving cell b is to occur and the time when the forward link packet data transmission is ready or occurs from the target cell (for example, cell b). If the target cell is not ready after the expiration of the CSD due to signaling delay or time latency, additional handoff delay time may be needed in addition to the CSD to complete the handoff to the target cell. However, in this circumstance, the data transmission between the serving cell and the MS indicated at time T2 at the end of phase 2 in **FIG. 2** is dropped after expiration of the CSD regardless of whether the handoff is complete. The value of CSD can be determined or configured by the network depending upon the serving and target cells in the active set being between sectors or being in different base transceiver stations. The additional handoff delay is determined by the traffic load of the target cell and the transport capacity of the cells. The indication to switch may be a Walsh code cover of the second target cell.

[0034] **FIG. 3** illustrates the sequence of transmissions between the BSC, serving cell a and target cell b and the MS. The forward link and reverse link transmissions occur between the BSC and the MS through serving cell a throughout phase 1. The reverse link transmission between the serving cell a and the BSC are only generally discussed to the extent necessary to understand the invention. The switch indication is transmitted from the MS to the active group of cells indicating that target cell b has been determined by the MS to be the target cell. The switch indication is represented by a Walsh cover of the target cell b. A Walsh cover is an identification of the cell b in the wireless system. Phase 1 ends when the indication to switch to target cell b is received by the BSC. At the beginning of phase 2, as indicated in the column of **FIG. 2** entitled, "BSC Sends Data to", the transmission of forward link data to serving cell a switches to target cell b without the flooding of the Abis interface of the prior art. Data packet transmission on the forward link from serving cell a to the MS and CQI on the reverse link between the MS and the serving cell a occurs until the CSD time out at which time all transmissions between serving cell a and the MS stop. Transmission of the data from target cell b to the MS should begin at the end of the CSD which is normally the time for target cell b to be set up as the new serving cell and to acquire the necessary radio resources. If the CSD is not sufficient to complete the switch over to target cell b, nevertheless the MS ceases to receive data packets from serving cell a and the aforementioned additional time delay may be necessary to complete switching.

[0035] A New Sequence Numbering Format

[0036] In 1XTREME MAC layer, a sequence number is defined for the MuxPDU (Multiplex Sublayer Protocol Data Unit). This sequence number is used to synchronize buffer management and package retransmission during a fast cell site selection (FCSS). In the prior art 12 bits are defined for the sequence number. The length of the sequence number is coincidently the same as the Radio Link Protocol (RLP) ARQ sequence length. The use of 12 bits may be an over specification for the purpose of HARQ. If RLP is used for the data transmission, the RLP sequence number can also be used for this purpose.

[**0037**] Since the main purpose of sequence numbering is to synchronize the serving cell and the target during switching, the switching period should be fast and completed within a few frames duration (e.g. 2 frames or Xms). For a worst case (e.g. 4 HARQ channels and 4 transmissions), 6 bits of sequence number length is sufficient with the switching sequence of the invention. This length reduction reduces traffic overhead over the air. Hence, the sequence number length may be reduced from 12 bits to 6 bits in the 1XEV-DV specifications if the RLP sequence number is not used.

[**0038**] The following procedures are used by the cells and MS according to the present invention.

[**0039**] Forward Link Cell Switching and Cell Procedures

[**0040**] The cell defines and initializes the following data structures. The cell is considered active for a MS when the cell has the MAC Identifier (MAC_ID) assigned for the MS and is decoding the signal quality CQI feedback received from the MS. For example, target cell b in **FIGS. 2 and 3** is active in phase 3 and serving cell a is in transition in phase 2 and active in phase 1.

[**0041**] With reference to **FIG. 4**, the serving cell a performs the operations therein every Transmission Time Interval (TTI) ms as long as there are packets to transmit. The cell operation starts at initialization point **20** wherein N=number of H-ARQ channels, mob_seq_un=unified sequence number (initialized by BSC), n=current H-ARQ channel being processed (initialized to 0) and int s[N]=one-bit H-ARQ channel sequence number (initialized to '0'). The cell operation proceeds to point **22** where a determination is made if the cell is active for the MS. If the answer is "no" at point **22**, operation proceeds to point **24**, where decoding the CQI and ACK/NAK sent on R-CCH by the MS occurs and operation proceeds back to point **22**. If the cell is active at point **22**, operation proceeds to point **26** wherein a determination is made if an ACK/NAK='1' was received from the previous transmission to the H-ARQ channel n, or if the maximum number of retransmissions has been exhausted. If the determination is "yes" at point **26**, operation proceeds to point **28** where incrementing of the H-ARQ channel sequence number s(n) mod **2** and advance mob_seq_un occurs. If the determination is "no" at point **26**, operation proceeds to point **30** where retransmission of the buffered frame associated with the current H-ARQ channel on the F-SHCH occurs. Operation proceeds from point **28** to point **32** wherein transmission of the encoded and modulated frame with the sequence number mob_seq_un occurs on F-SHCH. Operation proceeds from point **32** to point **34**, from either of points **30** or **32** depending upon the previous determinations made at point **26**, where transmission of the current H-ARQ sequence number s(n) on F-CCH occurs; decoding the ACK/NAK sent on the Reverse Control Channel from the MS occurs and incrementing of the H-ARQ channel n=n+1 mod N occurs.

[**0042**] Forward Link CSS MS Station Procedures

[**0043**] The MS runs the operations of **FIG. 5** every TTI ms. The following data structures are defined at initialization point **50**: n=current H-ARQ channel, int s[N]=one-bit H-ARQ channel sequence number (initialized to '1'); float b[N][Interleaver Size]=H-ARQ channel soft-symbol buffer (initialized to '0'I and d=delay measured in units of TTI ms, between transmission of a H-ARQ channel on the Forward Link and the associated acknowledgement on the Reverse Link. The operation proceeds from initialization at point **50** to point **52** where decoding of the H-ARQ channel n and the associated sequence numbers [n] received on the Forward Control Channel (F-CCH) from the active cell occurs. The operation proceeds from point **52** to point **54** where determination is made if the H-ARQ channel sequence number s(n) is the same as the previous transmission. If the answer is "yes" at point **54**, operation proceeds to point **56** where the received soft-symbols are added with the soft-symbols stored in b(n). If the answer is "no" at point **54**, operation proceeds to point **58** where the new soft-symbols are stored into b(n). Operation proceeds form point **56** to point **60** where decoding the frame occurs. Operation proceeds to point **62** where a determination is made if the cyclic redundancy code is OK. If the answer is "yes" at point **62**, operation proceeds to point **64** where the decoded frame is passed up to the selection and distributed unit in the BSC and scheduling of an ACK/NAK="1" occurs on the Reverse Control Channel (R-CCH)k*TTI ms frames later where k is a positive integer. If the answer is "no" at point **62**, operation proceeds to point **66** where the decoded frame and scheduling an ACK/NAK='0' on the R-CCH k*TTI ms frames later occurs. Operation proceeds from points **64** and **66** to point **68** where any scheduled ACK/NAK is sent on the R-CCH; if the MS desires a cell switch, indication of the cell switching on the R-CCH for the target cell b occurs; if the MS indicates cell switching, the cells in the active set monitor of the R-CQICH transmissions for the target cell Walsh cover; and setting the target cell b to active after CSD, which is Xms, occurs. Operation then returns to point **52**.

[**0044**] While the invention has been described in terms of its preferred embodiments, it should be understood that numerous modifications may be made thereto. It is intended that all such modifications fall within the scope of the appended claims.

1. In a system including a mobile station, cells in an active set including first serving and second target cells and a controller of the active cells, a method of switching forward link transmissions of data packets from the controller through the first serving cell to the mobile station to forward link transmission of data packets from the controller through the second target cell to the mobile station comprising:

determining at the mobile station that switching of the forward link transmission should occur from the first serving cell to the second target cell while the forward link transmission of the data packets through the first serving cell to the mobile station is occurring;

transmitting an indication to switch the forward link transmission of the data packets from the mobile station to the controller;

the controller, in response to the indication, switches the transmission of data packets from the first serving cell to the second target cell; and

the second target cell transmits the data packets to the mobile station.

2. A method in accordance with claim 1 wherein:

the first cell continues transmission of data packets on the

forward link to the mobile station for a cell switch delay time period measured from the indication to switch until the completion of the switching.

3. A method in accordance with claim 2 wherein:

the mobile station transmits a quality indicator to only the first

serving cell during the cell switch delay which is used by the first serving cell to control at least one of a power level of transmission or selection of modulation and coding type used by the forward link during the cell switch delay in transmitting data packets to the mobile station.

4. A method in accordance with claim 1 wherein:

the mobile station transmits acknowledgment information to the first serving cell during the cell switch delay; and

the first serving cell retransmits on the forward link during the cell switch delay packets which were negatively acknowledged.

5. A method in accordance with claim 4 wherein:

the acknowledgment information is either an acknowledgment or a negative acknowledgment that data packets of the forward link have been received by the mobile station.

6. A method in accordance with claim 1 wherein:

the second cell transmits the data packets to the mobile station after expiration of a cell switch delay period measured from the indication to switch until the completion of the switching.

7. A method in accordance with claim 2 wherein:

the second target cell transmits the data packets to the mobile station after the expiration of the cell switch delay.

8. A method in accordance with claim 1 wherein:

the data packets are transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and

the indication to switch is transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and a quality indicator is sent on the reverse control channel to the first serving cell.

9. A method in accordance with claim 3 wherein:

the data packets are transmitted from the cells to the mobile station on a forward shared channel (F-SHCH);

the indication to switch is transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and the quality indicator is sent on the reverse control channel to the first serving cell.

10. A method in accordance with claim 8 wherein:

F-SHCH is mapped to a forward packet data channel (F-PDCH);

and R-CCH is mapped to a reverse acknowledgment channel (R-ACKCH) and a reverse channel quality indicator channel (R-CQICH).

11. A method in accordance with claim 2 wherein:

the cell switch delay is one of zero or an integer multiple of a time frame interval required to transmit a data packet on the forward link.

12. A method in accordance with claim 2 wherein:

the cell switch delay is determined or configured by the network dependent upon the serving and target cells in the active set being between sectors or being in different base transceiver stations.

13. A method in accordance with claim 1 wherein:

the indication to switch is a Walsh code cover of the second target cell.

14. A method in accordance with claim 6 wherein:

the second target cell switches transmission of data packets to the mobile station at an end of a time including an additional time delay measured from an end of the cell switch delay period.

15. A system comprising:

a mobile station, cells in an active set including first serving and second target cells, and a controller of the active cells, and wherein

switching of forward link transmission of data packets from the controller through the first serving cell to the mobile station to forward link transmission of data packets from the controller through the second target cell to the mobile station occurs by determining at the mobile station that switching of forward link transmission should occur from the first serving cell to the second target cell while forward link transmission of the data packets through the first serving cell to the mobile station is occurring, transmitting an indication to switch the forward link transmission of the data packets from the mobile station to the controller, the controller in response to the indication switches the transmission of data packets from the first serving cell to the second target cell and the second target cell transmits the data packets to the mobile station.

16. A system in accordance with claim 15 wherein:

the first serving cell continues transmission of data packets on the forward link to the mobile station for a cell switch delay time period measured from the indication to switch until the completion of the switching.

17. A system in accordance with claim 16 wherein:

the mobile station transmits a quality indicator to only the first serving cell during the cell switch delay which is used by the first serving cell to control at least one of a power level of transmission or selection of modulation and coding type used by the forward link to the mobile station during the cell switch delay.

18. A method in accordance with claim 15 wherein:

the mobile terminal transmits acknowledgment information to the first serving cell during a cell switch delay; and

the first serving cell retransmits on the forward link during the cell switch delay packets which were negatively acknowledged.

19. A method in accordance with claim 16 wherein:

the acknowledgment information is either an acknowledgement or a negative acknowledgment that data packets of the forward link have been received by the mobile station.

20. A system in accordance with claim 15 wherein:

the second target cell transmits the data packets to the mobile station after expiration of a cell switch delay period measured from the indication to switch until the completion of the switching.

21. A system in accordance with claim 15 wherein:

the data packets are transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and

the indication to switch is transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and a quality indicator is sent on the reverse control channel to the first serving cell.

22. A system in accordance with claim 21 wherein:

F-SHCH is mapped to a forward packet data channel (F-PDCH); and

R-CCH is mapped to a reverse acknowledgment channel (R-ACKCH) and a reverse channel quality indicator channel (R-CQICH).

23. A system in accordance with claim 15 wherein:

the cell switch delay is one of zero or an integer multiple of a time frame interval required to transmit a data packet on the forward link.

24. A system in accordance with claim 15 wherein:

the cell switch delay is determined or configured by the network dependent upon the serving and target cells in the active set being between sectors or being in different base transceiver stations.

25. A system in accordance with claim 15 wherein:

the indication to switch is a Walsh code cover of the second target cell.

26. A system in accordance with claim 20 wherein:

the second target cell switches transmission of data packets to the mobile station at an end of a time including an additional time delay measured from an end of the cell switch delay period.

27. A method in accordance with claim 4 wherein:

the second cell transmits the data packets to the mobile station after expiration of a cell switch delay period measured from the indication to switch until the completion of the switching.

28. A method in accordance with claim 5 wherein:

the second cell transmits the data packets to the mobile station after expiration of a cell switch delay period measured from the indication to switch until the completion of the switching.

29. A method in accordance with claim 3 wherein:

the second target cell transmits the data packets to the mobile station after the expiration of the cell switch delay.

30. A method in accordance with claim 2 wherein:

the data packets are transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and

the indication to switch is transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and a quality indicator is sent on the reverse control channel to the first serving cell.

31. A method in accordance with claim 4 wherein:

the data packets are transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and

the indication to switch is transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and a quality indicator is sent on the reverse control channel to the first serving cell.

32. A method in accordance with claim 5 wherein:

the data packets are transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and

the indication to switch is transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and a quality indicator is sent on the reverse control channel to the first serving cell.

33. A method in accordance with claim 6 wherein:

the data packets are transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and

the indication to switch is transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and a quality indicator is sent on the reverse control channel to the first serving cell.

34. A method in accordance with claim 7 wherein:

the data packets are transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and

the indication to switch is transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and a quality indicator is sent on the reverse control channel to the first serving cell.

35. A method in accordance with claim 27 wherein:

the data packets are transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and

the indication to switch is transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and a quality indicator is sent on the reverse control channel to the first serving cell.

36. A method in accordance with claim 28 wherein:

the data packets are transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and

the indication to switch is transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and a quality indicator is sent on the reverse control channel to the first serving cell.

37. A method in accordance with claim 29 wherein:

the data packets are transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and

the indication to switch is transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and a quality indicator is sent on the reverse control channel to the first serving cell.

38. A method in accordance with claim 7 wherein:

the second target cell switches transmission of data packets to the mobile station at an end of a time including an additional time delay measured from an end of the cell switch delay period.

39. A method in accordance with claim 29 wherein:

the second target cell switches transmission of data packets to the mobile station at an end of a time including an additional time delay measured from an end of the cell switch delay period.

40. A method in accordance with claim 16 wherein:

the mobile terminal transmits acknowledgment information to the first serving cell during a cell switch delay; and

the first serving cell retransmits on the forward link during the cell switch delay packets which were negatively acknowledged.

41. A method in accordance with claim 17 wherein:

the mobile terminal transmits acknowledgment information to the first serving cell during a cell switch delay; and

the first serving cell retransmits on the forward link during the cell switch delay packets which were negatively acknowledged.

42. A system in accordance with claim 16 wherein:

the second target cell transmits the data packets to the mobile station after expiration of a cell switch delay period measured from the indication to switch until the completion of the switching.

43. A system in accordance with claim 17 wherein:

the second target cell transmits the data packets to the mobile station after expiration of a cell switch delay period measured from the indication to switch until the completion of the switching.

44. A system in accordance with claim 18 wherein:

the second target cell transmits the data packets to the mobile station after expiration of a cell switch delay period measured from the indication to switch until the completion of the switching.

45. A system in accordance with claim 19 wherein:

the second target cell transmits the data packets to the mobile station after expiration of a cell switch delay period measured from the indication to switch until the completion of the switching.

46. A system in accordance with claim 16 wherein:

the data packets are transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and

the indication to switch is transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and a quality indicator is sent on the reverse control channel to the first serving cell.

47. A system in accordance with claim 17 wherein:

the data packets are transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and

the indication to switch is transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and a quality indicator is sent on the reverse control channel to the first serving cell.

48. A system in accordance with claim 18 wherein:

the data packets are transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and

the indication to switch is transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and a quality indicator is sent on the reverse control channel to the first serving cell.

49. A system in accordance with claim 19 wherein:

the data packets are transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and

the indication to switch is transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and a quality indicator is sent on the reverse control channel to the first serving cell.

50. A system in accordance with claim 20 wherein:

the data packets are transmitted from the cells to the mobile station on a forward shared channel (F-SHCH); and

the indication to switch is transmitted from the mobile station to the group of active cells on the reverse control channel (R-CCH) and a quality indicator is sent on the reverse control channel to the first serving cell.

51. A method in accordance with claim 2 wherein:

the mobile station transmits acknowledgment information to the first serving cell during the cell switch delay; and

the first serving cell retransmits on the forward link during the cell switch delay packets which were negatively acknowledged.

52. A method in accordance with claim 3 wherein:

the mobile station transmits acknowledgment information to the first serving cell during the cell switch delay; and

the first serving cell retransmits on the forward link during the cell switch delay packets which were negatively acknowledged.

53. A method of switching forward link transmissions of data packets from the controller through a serving cell to the mobile station to forward link transmission of data packets from the controller through a target cell to the mobile station comprising:

determining at the mobile station that switching of the forward link transmission should occur from the first serving cell to the target cell;

transmitting an indication from the mobile station to the controller to switch the forward link transmission of the data packets to the controller;

receiving at the mobile station the data packets from the serving cell for a time period after the transmission of the indication; and

receiving at the mobile station the data packets from the target cell after the time period.

54. A method in accordance with claim 53 wherein:

the first cell continues transmission of data packets on the forward link to the mobile station for a cell switch delay time period measured from the indication to switch until the completion of the switching.

55. A method in accordance with claim 53 wherein:

the time period is specified by the network.

56. A method in accordance with claim 54 wherein:

the time period is specified by the network.

* * * * *

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JA NEIN

Datum/Date
22.08.03

L VOLM

Zeichen/Ref./Réf.	Anmeldung Nr./Application No./Demande n°./Patent Nr./Patent No./Brevet n°.
PHDE000173 EP	01124154.4-2412-

Anmelder/Applicant/Demandeur/Patentinhaber/Proprietor/Titulaire
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MITTEILUNG

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Das Europäische Patentamt übermittelt beiliegend den europäischen Recherchenbericht zu der obengenannten europäischen Patentanmeldung.

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Die folgende Abbildung wird mit der Zusammenfassung veröffentlicht: 3

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Falls Artikel 10 der Gebührenordnung in Anwendung kommt, ergeht noch eine gesonderte Mitteilung der Eingangsstelle hinsichtlich der Rückerstattung der Recherchengebühr.

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Nummer der Anmeldung
EP 01 12 4154

EINSCHLÄGIGE DOKUMENTE

Kategorie	Kennzeichnung des Dokuments mit Angabe, soweit erforderlich, der maßgeblichen Teile	Betrifft Anspruch	KLASSIFIKATION DER ANMELDUNG (Int.Cl.7)
Y	BALACHANDRAN K ET AL: "GPRS-136: HIGH-RATE PACKET DATA SERVICE FOR NORTH AMERICAN TDMA DIGITAL CELLULAR SYSTEMS" IEEE PERSONAL COMMUNICATIONS, IEEE COMMUNICATIONS SOCIETY, US, Bd. 6, Nr. 3, Juni 1999 (1999-06), Seiten 34-47, XP000831519 ISSN: 1070-9916 * Seite 42, rechte Spalte - Seite 44, rechte Spalte * ---	1-10	H04L12/28 H04L12/56 H04L1/18
Y	LOCKITT J A ET AL: "A SELECTIVE REPEAT ARQ SYSTEM" PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON DIGITAL SATELLITE COMMUNICATIONS. KYOTO, JAPAN, 11 - 13 NOVEMBER, 1975, KYOTO, INTELSAT, JP, Bd. CONF. 3, 1. November 1975 (1975-11-01), Seiten 189-195, XP000794400 * Seite 190, Zeile 1 - Zeile 7 * * Seite 191, Zeile 6 - Zeile 8 * * Seite 191, Zeile 16 - Zeile 20 * * Seite 191, Zeile 45 - Zeile 46 * ---	1-10	IP & S-DE zugestellt am 25. Aug. 2003 Frist
			RECHERCHIERTE SACHGEBIETE (Int.Cl.7)
A	TANENBAUM ANDREW: "Réseaux (Computer Networks)" 1997 , PRENTICE AND HALL , LONDON XP002243438 ISBN: 2-7296-0643-2 * Seite 223, Absatz 5 - Seite 224, Absatz 3 * * Seite 209, Absatz 1 - Absatz 2 * ---	3,4,7,8	H04L H04Q
A	WO 99 22481 A (AT & T CORP) 6. Mai 1999 (1999-05-06) * Seite 26, Zeile 24 - Seite 27, Zeile 22 * --- -/--	1-10	

Der vorliegende Recherchenbericht wurde für alle Patentansprüche erstellt

Recherchenort	Abschlußdatum der Recherche	Prüfer
MÜNCHEN	1. August 2003	GLASSER, J-M

KATEGORIE DER GENANNTEN DOKUMENTE

X : von besonderer Bedeutung allein betrachtet
Y : von besonderer Bedeutung in Verbindung mit einer anderen Veröffentlichung derselben Kategorie
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ANHANG ZUM EUROPÄISCHEN RECHERCHENBERICHT
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01-08-2003

Im Recherchenbericht angeführtes Patentdokument		Datum der Veröffentlichung	Mitglied(er) der Patentfamilie			Datum der Veröffentlichung
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am 25. Aug. 2003
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EPO FORM P0461

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Abstract

This article provides an overview of the flexible, high-performance packet data channel that has been designed for high-rate packet data services over IS-136 TDMA channels. To achieve the highest data rates in the limited 30 kHz channel bandwidth, the packet data channel is designed for adaptive modulation and, in addition to a fixed coding mode, permits operation using an incremental redundancy mode.

GPRS-136: High-Rate Packet Data Service for North American TDMA Digital Cellular Systems

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Current North American time-division multiple access (TDMA) systems support voice services and circuit data services at a rate limited to 9.6 kb/s. High-rate packet data services are desirable for short bursty transactions as well as applications such as World Wide Web/Internet access, electronic mail, and file transfer. This article provides a general overview of the proposed system, and describes flexible, high-performance medium access control (MAC) and radio resource management procedures that have been adopted by the Telecommunications Industry Association (TIA) for high-rate packet data services over IS-136 TDMA channels. The 30 kHz spectrum usage, symbol rate, and TDMA format (6 time slots every 40 ms) are maintained as in the IS-136 standard [1] for compatibility with existing mobiles and in order to minimize impact on existing infrastructure. Assuming these constraints, a new TDMA packet data channel (PDCH) is defined to carry both user data and information from other higher-layer control and management entities.

Current cellular TDMA systems are designed to achieve good coverage over most of a typical cell, and as a result, the signal to interference plus noise ratio is sufficient to support higher data rates through the use of 8- and 16-level modulations over a large portion of a typical cell. However, current systems rely on the use of only $\pi/4$-differential quadrature phase shift keying (DQPSK) modulation to achieve modest data rates over all operating conditions. The packet data MAC and physical layers are designed to increase throughput over a significant fraction of the cell area by using coherent 8-PSK in addition to $\pi/4$-DQPSK. The standard is designed to permit dynamic adaptation of the modulation scheme based on measured carrier-to-interference ratio (C/I). The modulation schemes are chosen to be the same as those adopted for voice services in order to simplify the development of dual-mode (voice and packet data capable) mobile stations. Hooks are provided in the standard to support a 16-level modulation such as 16-quadrature amplitude modulation (QAM), 16-PSK, or 16-DPSK in the future.

Three wireless data infrastructure options were investigated: Cellular Digital Packet Data (CDPD) infrastructure that is widely deployed in the United States; Global System for Mobile Communications (GSM) General Packet Radio Service (GPRS) infrastructure that is expected to be deployed throughout the world in 1999 and 2000; and the third option considered, an Internet service provider (ISP)-like model with Point-to-Point Protocol (PPP) tunnels to the Internet or corporate intranets. In order to achieve economies of scale and simplify evolution to third-generation systems, the upper layers (layer 3 and above) of the packet data protocol stack were chosen to be the same as that used by GSM GPRS. GPRS-136 is thus a TDMA packet data standard based on GPRS, but utilizing 30 kHz for the physical layer and allowing connection to the American National Standards Institute (ANSI)-41 network [2]. GPRS-136 utilizes most of the existing network elements from the GPRS network reference model. It adds a gateway-mobile switching center (MSC)/visitor location register (VLR) function, which allows connection of the GPRS packet data network to the ANSI-41 based mobile circuit-switched network. The relevant GPRS specification documents can be found in [3–8].

Another benefit of this choice is that the existing GPRS standard is used as a baseline, allowing for quick development. This also enables evolution to the Enhanced General Packet Radio Service (EGPRS), which has been proposed to the International Telecommunication Union (ITU) as a third-generation radio transmission technology for International Mobile Telecommunications in the year 2000 (IMT-2000). The use of EGPRS channels for TDMA packet data will be standardized during 1999 and is to be called GPRS-136HS.

Organization of the Article

The following section provides an overview of the service and network reference model. The GPRS-based protocol stack is described briefly. Provision of voice/data integration and operation with half-duplex and full-duplex terminals is discussed.

The article next describes the logical and physical structure of the PDCH. The allocation of packet paging and packet broadcast channels, and PDCH reselection procedures are described. Multiple-time-slot operation is also discussed. We then describe the MAC layer and uplink media access control procedures, including the use of the packet channel feedback (PCF) mechanism.

The article describes the procedures associated with adaptive modulation (DQPSK and coherent 8-PSK), followed by the incremental redundancy and fixed coding mode radio link protocols (RLPs). The incremental redundancy mode provides approximately 15 percent higher throughput at the cost of additional receiver memory. We provide detailed time slot formats accommodating the fields required by the RLP, MAC, and physical layers. The last section provides a brief summary.

GPRS-136 Network Reference Model and Operation

The Packet Data Network Reference Model

The network elements are as follows:

- Terminal equipment (TE), which typically interfaces with the user and contains packet data applications.
- Mobile termination (MT), which interfaces to the TE, and terminates the radio interface.
- Base station (BS), which constitutes the interface between the network and mobile station, and transfers packet data and signaling messages between serving GPRS support nodes (SGSNs) and mobile stations in its coverage area.
- SGSN, a packet data switch that routes data packets to appropriate mobile stations within its service area.
- Gateway GPRS support node (GGSN), which acts as the logical interface between the GPRS-136 network and external packet data networks. It tunnels IP packets from external networks to the SGSN using the GPRS Tunneling Protocol (GTP).
- GPRS home location register (HLR), accessible from the SGSN and GGSN, contains GPRS-136 subscription and routing information.
- ANSI-41 HLR, accessible from the serving and gateway MSC/VLR functions, contains subscription and routing information for circuit-switched service.
- ANSI-41 gateway MSC/VLR, provides functions such as circuit call routing and circuit service related paging within the GPRS-136 network.
- ANSI-41 serving MSC/VLR, provides circuit switching functions for mobile stations in its service area.
- Message center (MC), receives and accepts requests to deliver teleservice messages to the mobile subscriber.

The Protocol Stack (GPRS-136)

Figure 2 shows the GPRS-136 protocol stack. The MAC and radio resource management procedures are significantly different from GPRS because of the fundamental differences in the IS-136 and GPRS physical layers.

The radio resource (RR) sublayer provides data transfer and control services to LLC and GPRS-136 mobility management. It consists of three cooperating entities: the MAC entity, radio resource management entity (RRME), and broadcast management entity (BME).

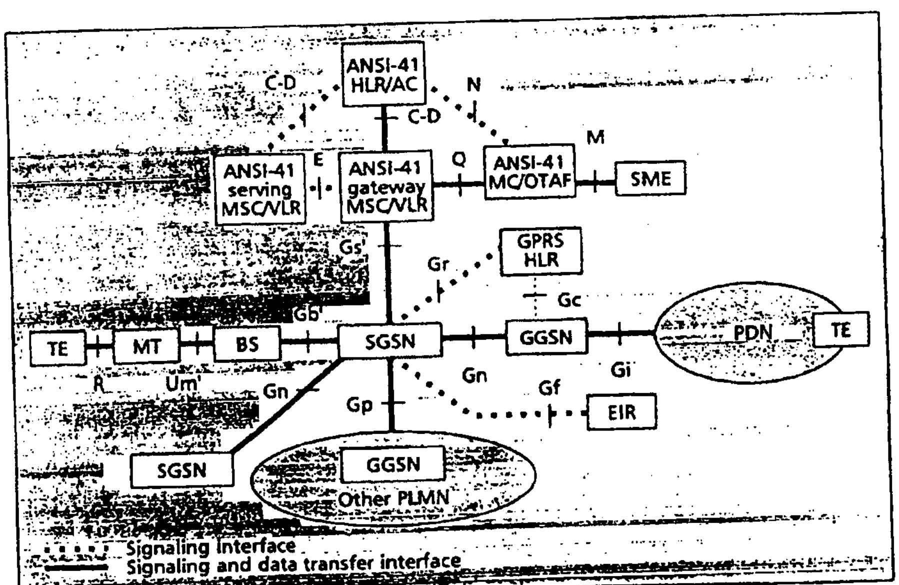
The MAC entity provides services directly to LLC through a SAP. It supports two multiplexed logical links of different priorities, one for normal data transfer and the other for providing expedited data delivery services to higher-layer and management entities.

The BME and RRME provide services to the GPRS mobility management layer through two other SAPs, and carry out both voice and packet-data-related signaling functions. These entities use the services of the MAC entity to communicate with their peers, and to control the MAC entity. The core MAC and RRME procedures are generic, and the interfaces can easily be modified to support other protocol stacks.

Joint Voice/Data Operation

In addition to packet data service, GPRS-136 allows subscribers to obtain both IS-136 and ANSI-41-based services (e.g., circuit-switched voice services, short messaging services, intelligent roaming), provided mobile stations support both circuit and packet modes. Two new classes of mobile stations are supported by GPRS-136: dual mode (i.e., circuit and packet mode capable) and packet mode only.

Integration of the GPRS packet network with the ANSI-41 circuit-switched network provides a unique challenge. GPRS provides its own set of registration, authentication, authorization, and mobility management functions which are thoroughly integrated with other GSM services such as circuit-switched voice service. These functions are implemented very differently in the ANSI-41 network. To avoid the complexity of fully integrating these two sets of functions, GPRS-136 provides a method of "tunneling" ANSI-41 signaling messages between a mobile terminal and the gateway MSC/VLR via the SGSN. These messages are tunneled as



■ **Figure 1.** *The GPRS-136 packet data network reference model. (Primed interfaces — e.g., Gb' — indicate ETSI GPRS interfaces that have been modified for GPRS-136.)*

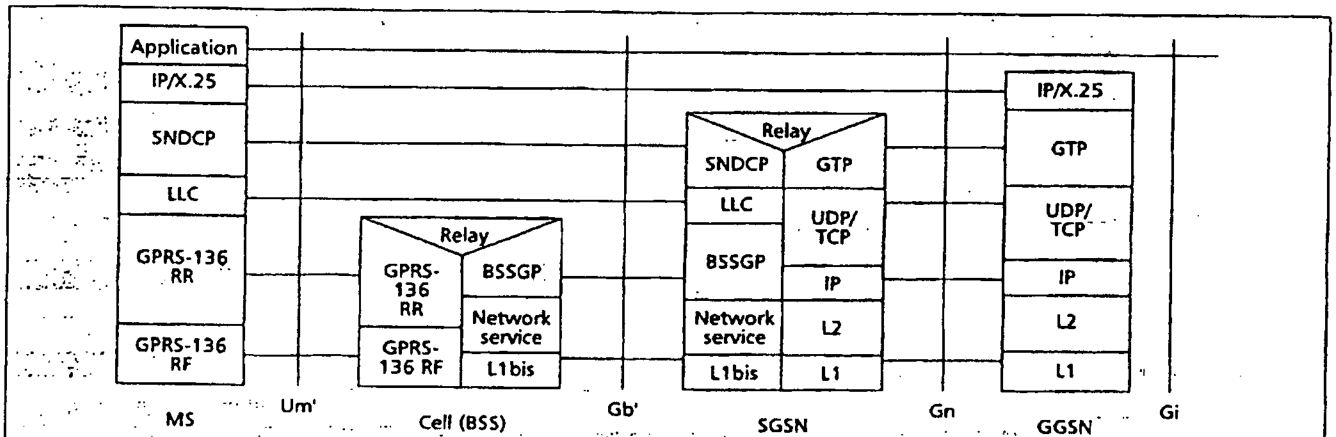
specially marked LLC frames. ANSI-41 registration, authentication, authorization, paging, and short message service (SMS) messages are delivered transparently (tunneled) through the SGSN. This allows the MSC/VLR and SGSN to implement and execute these functions independently as necessary for the proper operation of the ANSI-41 and GPRS networks, respectively. The mobile terminal provides the necessary sequencing of related functions between the ANSI-41 and GPRS networks.

The GPRS-136 mobility management layer consists of two entities: GPRS mobility management (GMM) and 136 mobility management (136MM), which support mobility management functions specific to packet data and circuit-switched services, respectively. A new tunneling function is defined in the SGSN, and the GPRS LLC and BSSGP protocols have been modified in order to route 136MM signaling messages to the mobile station over the PDCH.

Dual-mode mobile stations perform registration, authentication, authorization, and location update functions independently and in parallel with the ANSI-41 and GPRS networks while the mobile is camped on a PDCH. If an ANSI-41 SMS message needs to be delivered while a mobile is camped on a PDCH, it is delivered on the PDCH along with other packet data as tunneled LLC data. An incoming circuit call is indicated to a mobile with an ANSI-41 page message tunneled from the gateway MSC/VLR to the mobile. The mobile moves to an IS-136 control channel to respond to the page and accept the incoming call. Similarly, to initiate a circuit call, the mobile stops any activity on the PDCH and moves to the IS-136 control channel. Circuit calls take precedence over packet data transactions. When a circuit call is completed, the dual mode mobile station returns to camping on a PDCH.

Half-Duplex Operation

Half-duplex devices have complexity, size, and battery life benefits which make them attractive for applications that do not require full duplex (i.e., simultaneous transmission and reception) capability. Full-rate operation (i.e., similar to IS-136 voice) is half-duplex by definition because of fixed time offsets between the uplink and downlink [1]. The support of downlink double- and triple-rate (multislot) operation for packet data is quite straightforward, and is enabled by occasionally scheduling uplink time slots for obtaining automatic

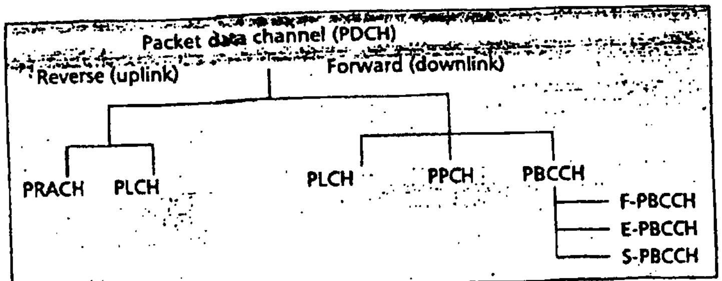


Legend:

- GPRS Tunneling Protocol (GTP) [7]: This protocol tunnels user data and signaling between GPRS support nodes in the GPRS backbone network.
- Transmission Control Protocol (TCP) carries GTP protocol data units (PDUs) in the GPRS backbone network for protocols that need a reliable data link. TCP provides flow control and protection against lost and corrupted GTP PDUs. User Datagram Protocol (UDP) carries GPT PDUs for protocols that do not need a reliable data link. UDP provides protection against corrupted GTP PDUs.
- Internet Protocol (IP) is the GPRS backbone network protocol used for routing user data and control signaling.
- Subnetwork Dependent Convergence Protocol (SNDCP) [4]: This transmission functionality maps network-level characteristics onto the characteristics of the underlying network. It provides the following services to the network layer: header compression, encryption, segmentation, and reassembly.
- Logical link control (LLC) [3]: This layer provides a highly reliable ciphered logical link, and is independent of the underlying radio interface protocols. In additional to the service access points described in [3], two additional service access points with different priorities are supported for the tunneling of signaling messages between the MS and the circuit-switched network.
- Relay: In the base station system (BSS), this function relays LLC PDUs between the Um' and Gb' interfaces. In the SGSN, this function relays PDUs between the Gb' and Gn interfaces.
- BSS GPRS Protocol (BSSGP) [6]: This layer conveys routing and quality of service related information between the BSS and SGSN.
- Network service (NS) [5]: This layer transports BSSGP PDUs, and is based on the frame relay connection between BSS and SGSN. The interface may traverse a network of frame relay switching nodes.
- GPRS-136 radio resource (GPRS-136 RR): This sublayer consists of the medium access control (MAC) entity, radio resource management entity (RRME), and broadcast management entity (BME). The MAC function provides reliable in-sequence delivery of LLC data and expedited control (radio resource signaling) over the GPRS-136 physical channel.
- GPRS-136 RF: The 30 kHz channels and time slot structure are as defined in IS-136. The GPRS-136 specification defines the modulation schemes and different fields in the time slot for the PDCH.

■ **Figure 2.** *The GPRS-136 packet data protocol stack.*

repeat request (ARQ) feedback. However, mobile stations cannot support more than full-rate operation on the uplink without simultaneous transmission and reception. GPRS-136 supports half-duplex operation on both the uplink and downlink for all mobile stations regardless of their multislot (or bandwidth) capability. Double- or triple-rate half-duplex operation on the uplink is made possible by carrying out a fixed allocation of a sequential number of time slots. No downlink transmissions are scheduled for the device during this period.



■ **Figure 3.** *Logical PDCHs.*

Packet Data Channel Structure

Logical Channel Structure

The PDCH consists of the following logical channels (Fig. 3):

- Packet broadcast control channel (PBCCH) for indicating generic system configuration related information
- Packet paging channel (PPCH) dedicated to delivering pages
- Downlink packet payload channel (PLCH) for delivering data generated by LLC, RRME, and GMM
- Packet channel feedback (PCF) for support of random access and reserved access on the uplink
- Uplink packet random access channel (PRACH) used by mobile stations to request packet data access to the system
- Uplink packet payload channel (PLCH) for delivering data generated by LLC and GMM

Physical Channel Structure

The PDCH uses 30 kHz RF channels and the time-slot structure specified in IS-136 [1]. Each 40 ms frame on a 30 kHz RF channel consists of six time slots (three time slot pairs), numbered 1 to 6. One or more time slot pairs may be allocated to a PDCH. The remaining time slot pairs may be allocated to a digital control channel (DCCH) and/or digital traffic channel (DTC).

Multirate Channels – A PDCH may be full-rate, double-rate, or triple-rate, depending on whether one, two, or three time slot pairs are allocated to the channel within each 40 ms frame. The channel bandwidth is indicated through system broadcast information.

Superframe Structure – Sleep mode is defined for mobile stations on the PDCH in order to improve mobile station standby time. A superframe structure similar to the IS-136 DCCH is defined on each full-rate portion of a PDCH in order to manage sleep mode. The total number of time slots per superframe is 32. The superframe phase (SFP) is a modulo 32 up-counter which increments every 20 ms and helps mobile stations find the start of the superframe. If a double- or triple-rate PDCH is allocated on a particular frequency, superframe synchronization across the individual full-rate portions is required.

Primary and Supplementary Phases – A multirate PDCH operates on a single channel frequency and consists of the following:

- Primary phase
- Supplementary phase(s)

In this context, a phase corresponds to a full-rate portion of a multirate PDCH. The primary phase always corresponds to a full-rate channel, and is the part of a multirate channel that contains logical broadcast and paging channels on the downlink. The supplementary phases on a multirate PDCH correspond to all time slots that are not part of the primary phase. The possible allocation of primary and supplementary phases is provided in Table 1.

The primary phase superframe consists of time slots that are reserved for the PBCCH. Nominal paging time slots are determined from among the remaining time slots using a standard hashing algorithm that relies on mobile station (subscriber) identity. The actual number of PPCH slots per superframe are configurable through a fast broadcast message. Except for the assignment of broadcast and paging channels and SFP management, a mobile station views a double- or triple-rate PDCH as one common channel (i.e., a fat pipe) regarding data transmission or reception.

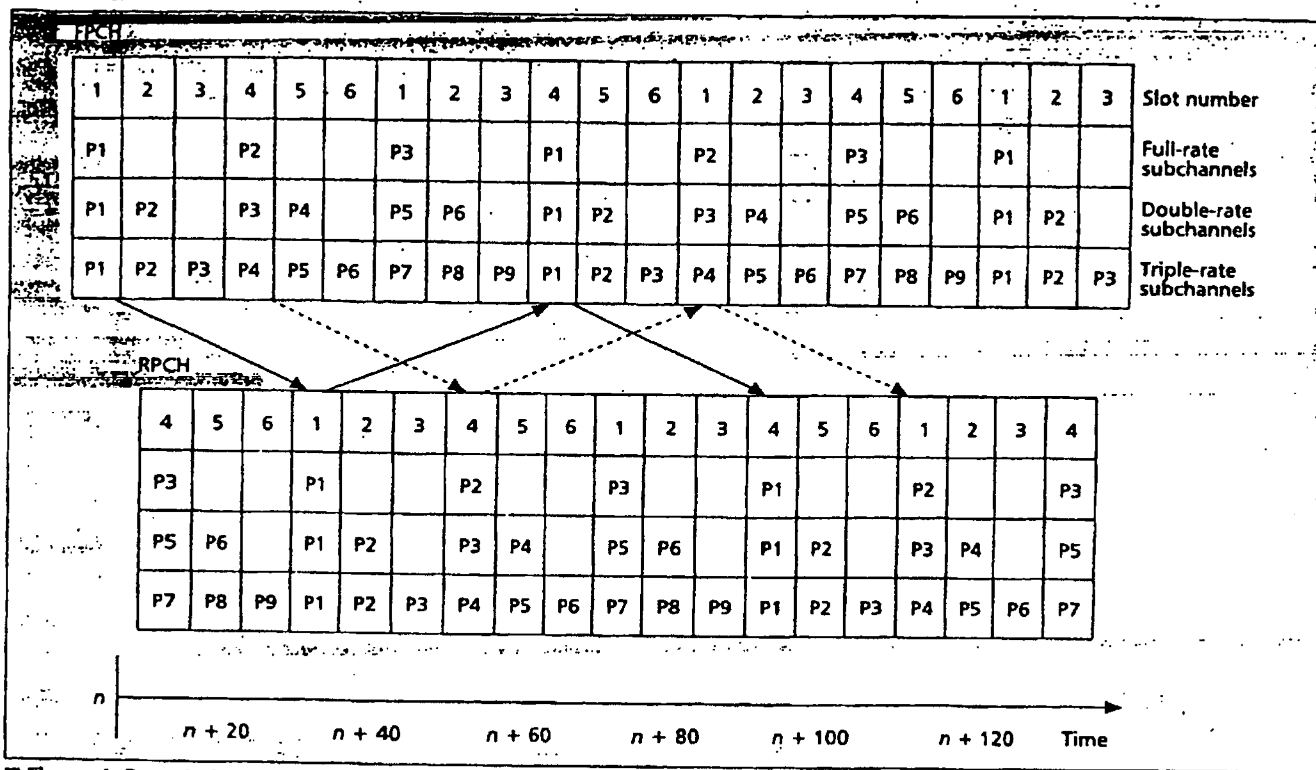
Downlink and Uplink Burst Associations – Subchannels are defined on the uplink in order to allow sufficient processing time at both the mobile station and BS in conjunction with a random access event. The full-rate PDCH is defined to consist of three subchannels; there are six subchannels in each double-rate PDCH and nine subchannels in each triple-rate PDCH (Fig. 4).

An enhanced packet channel feedback (PCF) field that relies on this association is defined on the downlink for uplink resource management. PCF flags are carried in downlink time slots to provide feedback for bursts sent previously on the uplink and to indicate subsequent assignments on the uplink. Mobile stations identify access opportunities on the uplink by reading PCF on the corresponding downlink time slots. The PCF field allows the support of contention access and reserved access on the same channel, and assumes different flag definitions depending on the context. These flags are reliably encoded to ensure good performance even under poor channel conditions.

For a full-rate PDCH, the uplink and downlink time slots are multiplexed to create three distinct access paths, as shown in Fig. 4. Assuming that path 1 (P1) in the downlink indicates that the next P1 time slot on the uplink is designated as a contention slot and is selected for a random access attempt, a mobile station sends the first burst of its access at that time

Rate	Slot numbers	Primary phase slots	Slots for supplementary phase(s)
Full-rate PDCH	1, 4	1,4	–
Full-rate PDCH	2, 5	2,5	–
Full-rate PDCH	3, 6	3,6	–
Double-rate PDCH	1, 2, 4, 5	1, 4	2, 5
Double-rate PDCH	2, 3, 5, 6	2, 5	3, 6
Double-rate PDCH	1, 3, 4, 6	1, 4	3, 6
Triple-rate PDCH	1, 2, 3, 4, 5, 6	1, 4	2, 3, 5, 6

■ **Table 1.** *Multirate PDCH phase allocations.*



■ **Figure 4.** *Downlink and uplink burst associations.*

(24.8 ms after receiving the full P1 slot on the downlink). The mobile station then starts reading the PCF flags in the next downlink P1 slot (21.8 ms after transmitting its burst) to determine the reception status of its initial access.

Similarly, there are six access paths on each double-rate channel and nine access paths on each triple-rate channel. In general, a mobile station which has data to send transmits 24.8 ms after obtaining an assignment via PCF on the downlink. The mobile station reads PCF on the downlink 21.8 ms after transmission in order to obtain the reception status of its transmitted burst.

The Medium Access Control Function

PDCH Selection, Reassignment, and Reselection

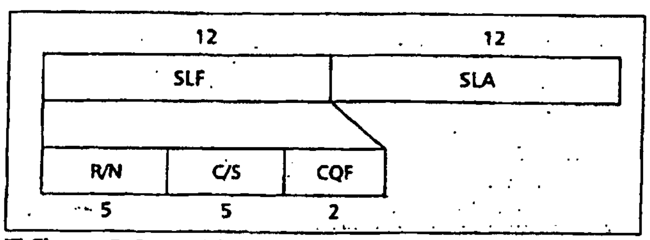
Mobile stations are directed to a PDCH through IS-136 DCCH broadcast information. In cases where there are multiple PDCHs per sector, mobile stations are directed to a beacon PDCH. The beacon PDCH broadcast information indicates the number of PDCHs, as well as the bandwidth (full-, double-, or triple-rate) of each PDCH supported. Mobile stations then hash onto a particular PDCH depending on their identity and the number of PDCHs. Load balancing may be carried out by reassigning mobile stations across radio resources, and the performance may be further improved by maintaining MAC/RLP state across reassignments. Cell reselection procedures ensure continuity of service across cell boundaries since mobile stations autonomously perform PDCH reselection when they detect a stronger signal from a neighbor cell.

Active Mobile Identity Management

Each mobile station is assigned a 7 bit temporary local identifier called an active mobile identity (AMI) which remains valid for one or several closely spaced transactions. The AMI is used to identify uplink time slot assignments and identify the recipient of data on the downlink. Of the 128 possible AMI values, only 89 are allowed for mobile stations engaged in point-to-point transactions. The all-zero AMI is excluded for PCF-related functions and also for identifying point-to-multipoint information on the downlink. The remaining 38 AMIs closest to the all-zero codeword are excluded in order to increase PCF reliability.

AMI assignment procedures are executed for both uplink and downlink transactions spanning more than one time slot. If a valid AMI has not already been assigned, the AMI assignment is carried out as a part of the transaction initiation procedure. Once an AMI has been assigned to a mobile station, it is used for transactions in both directions (i.e., the AMI is assigned on the initiation of an uplink or downlink transaction, whichever begins first, and remains assigned until released). AMI release is based on the expiration of timers at both the mobile station and BS. The AMI release procedures are designed to ensure the following:

- The availability of the same AMI to the mobile station for



■ **Figure 5.** *Logical format of the PCF. The SLF is context-dependent and contains either an AMI for providing feedback to contention slots, or three fields for providing feedback to reserved slots.*

another downlink or uplink transaction which is initiated before the expiration of the timer

- The release of the AMI first by the mobile station and subsequently by the BS in order to avoid any potential hijacking scenarios.

Transaction Initiation

A new transaction is initiated by the transmit controller when a transmission opportunity is identified and if the transmit buffer contains new data. Downlink transactions may be acknowledged or unacknowledged, but uplink transactions are always acknowledged. The initiation of a new transaction is carried out through the transmission of a BEGIN PDU. The BEGIN PDU handshake (i.e., acknowledged transfer of the BEGIN PDU) is used to initialize the AMI and an RLP in either incremental redundancy (IR) or fixed coding (FC) mode for the transaction.

For downlink transactions, the AMI and mode are assigned using the BEGIN PDU. For uplink transactions, the mobile station suggests an AMI and mode using the BEGIN PDU. If the suggested AMI and mode are acceptable to the base station, it provides an acknowledgment using the packet channel feedback (PCF) field. The PCF acknowledgment is treated as an implicit AMI and mode assignment by the mobile station. If the suggested AMI and/or mode are unacceptable to the base station, it provides a negative acknowledgment using PCF and subsequently assigns an AMI and/or mode for the transaction using a supervisory ARQ Status PDU.

Packet Channel Feedback

Functions — The IS-136 digital control channel [1] uses a shared channel feedback (SCF) field to provide acknowledgment and assignment functions. The SCF uses three flags — Received/Not Received (R/N), Busy/Reserved/Idle (BRI), and a coded partial echo identifier (CPE) — in order to manage feedback and assignment functions. The DCCH procedures and fields as specified in IS-136 are not well suited for long packet data transactions.

As described above, the uplink and downlink burst associations on the PDCH result in three subchannels per full-rate channel, six subchannels per double-rate channel, and nine subchannels per triple-rate channel. A PCF field is associated with each subchannel, and 24 bits are used in each downlink time slot for the PCF. The PCF is designed to be more reliable than the SCF and allows efficient management of contention access and reserved access on the same channel. For a particular subchannel, the PCF provides acknowledgment for a transmission on the previous time slot and also indicates assignment of the next time slot. Consistent canonical feedback and assignment fields are defined as follows: acknowledgment/negative acknowledgment (ACK/NAK) feedback identifying the transmitter when acknowledging a contention slot, and assignment of the next slot as idle (for contention-based access) or reserved (for access by a specific user). The approach presented simplifies the state machine since the acknowledgment for the previous slot and the assignment for the next slot are unambiguously identified with specific mobiles.

Figure 5 shows the logical format of the PCF field associated with each subchannel. The main purpose of the PCF field is to acknowledge an access in the previous slot and to assign the next slot to a particular mobile. The acknowledgment and assignment functions are handled *independently for each subchannel* through two logical fields, subchannel feedback (SLF) and subchannel assignment (SLA). The use of the SLF mechanism is context-dependent (i.e., the SLF field takes different values depending on whether feedback is being provided for a contention slot or a reserved slot). This provides greater reliability for acknowledgments to reservation-based transmissions. In addition, the same field may also be used for reliably reassigning the subchannel to the same user and providing continuous uplink channel quality feedback to the mobile station.

Assignments to successful contending users or users sniffing for reservation-based access may be carried out by explicitly identifying the user being assigned the next slot (i.e., by setting the SLA field to a valid coded active mobile identity). This approach is useful when there are several users on the channel, and subchannels (time slots) are constantly being assigned to new users. However, with fewer active users on the channel, subchannels may continuously be reserved for (reassigned to) the same users. Figure 6 shows that if there are three or fewer users on a full-rate channel, a round-robin assignment scheme is equivalent to reassigning subchannels to the same users. Similarly, Fig. 7 shows that if there are nine or fewer users on a triple-rate channel, a round-robin assignment scheme is equivalent to reserving one or more subchannel(s) for each user. In such cases, it is not necessary to use a coded AMI to reassign a subchannel to the same user. If there are fewer users on the channel, it is possible to provide a series of reservation-based transmission opportunities on each subchannel through the use of a 1-bit CONTINUE/STOP (C/S) indicator. The CONTINUE indication is similar to BRI = BUSY [1], but is encoded more robustly. Since the CONTINUE (or BUSY) indication is associated with feedback for a reserved slot and is relevant only to the user who transmitted on the previous time slot on a particular subchannel, the C/S flag is included in the SLF field.

PCF Encoding

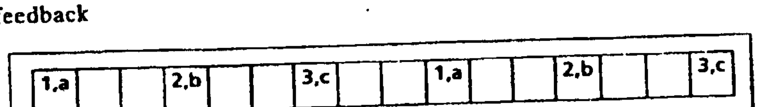
Subchannel Feedback — The 12-bit SLF field is used to acknowledge bursts transmitted in the previous slot. For feedback corresponding to contention slots SLF is defined as follows:

- SLF = valid coded AMI (provides an implicit ACK to the mobile with that coded AMI suggested or assigned)
- SLF = E-NAK (explicit NAK to all mobiles which attempted access)

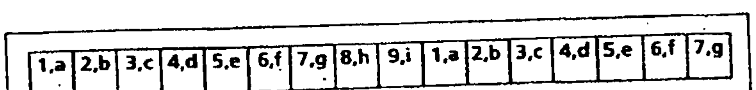
The (12,7) code described below is used to encode this field. The all-zero codeword is reserved for indicating an explicit negative acknowledgment (E-NAK) to all mobiles which attempted contention access.

For feedback corresponding to reserved slots, SLF is further divided into the following:

- R/N (5 bits): A (5,1) repetition code is used. A 1 indicates



■ **Figure 6.** *Round-robin assignments for users a, b, and c on a full-rate channel. This is equivalent to reservation of subchannels 1, 2, and 3 for users a, b, and c, respectively.*



■ **Figure 7.** *Round-robin assignments for users a, b, ..., i on a triple-rate channel. This is equivalent to reservation of subchannels 1, 2, ..., 9 for users a, b, ..., i, respectively.*

Parameter	Description
Access_Count_Max	Maximum number of times a mobile may backoff and reattempt contention access before declaring an access failure.
Access_Count	Counter indicating the number of times contention access has been attempted. This parameter can take values 0, 1, ..., *Access_Count_Max*.
T_Retry	Number of idle (contention) slots that the mobile must wait before another transmission attempt. *T_Retry* is a random integer that lies in the closed interval [0, *T_Retry_Max*].
T_Retry_Max	Value computed from other access parameters, determines the distribution used for generating random backoff.
T_Retry_Init	Initial value of *T_Retry_Max* to be used for *Access_Count* = 1.
α	Configurable parameter which is used along with *T_Retry_Init* to compute *T_Retry_Max*.

■ Table 2. *Parameters for the random access procedure*

Access_Count	*T_Retry_Max*
0	0
1, 2, ..., *Access_Count_Max*	*T_Retry_Init* $(2)^A$, where $A = \left\lceil \frac{Access\_Count - 1}{\alpha} \right\rceil$

■ Table 3. *Expressions for computing* T_Retry_Max

that the transmission was received (R), while a 0 indicates that the transmission was not received (N). The mobile declares R/N = R if the Hamming weight of the received 5-bit word is strictly greater than 3; otherwise, it declares R/N = N.

- C/S (5 bits): A (5,1) repetition code is used to encode this flag. A 1 indicates CONTINUE or C; that is, the mobile is assigned the subsequent time slot on the same sub-channel. A 0 indicates STOP or S; that is, the mobile must read the SLA field to determine subsequent assignments on that sub-channel. The mobile station declares C/S = C if the Hamming weight of the received 5-bit word is strictly greater than 2; otherwise, it declares C/S = S.
- Channel quality feedback (2 bits): This field provides feedback on uplink channel quality to the mobile. A mobile capable of operation on multiple modulations can use this feedback to propose a different modulation for subsequent reservation based transmission opportunities.

Subchannel Assignment – The 12-bit SLA field can take the following values:

- SLA = valid coded AMI (assigns the subchannel to a mobile with that coded AMI)
- SLA = IDLE (identifies a contention opportunity)

The (12,7) code described below is used to encode this field. The all-zero codeword is used as an IDLE indicator (i.e., to indicate a contention slot).

AMI Encoding – Each mobile station is assigned a 7-bit AMI value for the duration of each transaction. The AMI assignment is initiated by an uplink or downlink transaction, whichever begins first.

The 7 bit AMI is encoded using a (12,7) code. This code is derived from a (15,11) Hamming code as follows. As an intermediate step, the (15,11) Hamming code is shortened to an (11,7) code as specified in [1]. This code is used for encoding the CPE on the IS-136 DCCH; it has a minimum Hamming distance of 3 and guarantees single error correction. However, false error correction (i.e., interpretation of one codeword as another) may occur if two or more errors occur in the channel. Two error detecting capability is provided by increasing the minimum Hamming distance of the code to 4 through the addition of a single parity bit. The resulting (12,7) code may be viewed as an extended (11,7) code.

Mobile Station Procedures – Mobile stations assume an appropriate SLF structure depending on whether they are examining feedback corresponding to a contention slot or a reserved slot. The decoding rules at the mobile station provide unequal error protection to the different flag values.

A mobile which transmits in a particular *contention slot* reads the corresponding SLF field to determine if its transmission was successful:

- On receiving an ACK (i.e., SLF/coded AMI match), it reads the SLA field on all subchannels it is capable of operating on to determine if it is granted a reservation.
- On declaring a NAK (i.e., SLF/coded AMI mismatch), it follows random access procedures for attempting another contention access.

A mobile which transmits in a particular *reserved slot* reads the corresponding SLF field to determine if its transmission was successful:

- On receiving an ACK (i.e., R/N = R), the mobile reads the C/S indicator to determine if it can transmit in the subsequent slot.
  - On decoding C/S as CONTINUE, the mobile ignores the SLA field and assumes that it has permission to transmit in the subsequent time slot associated with the same subchannel.[1]
  - C/S = STOP implies that the mobile being acknowledged must continue sniffing (reading SLA) on that subchannel for reservation-based transmission opportunities.
- On receiving a NAK (i.e., R/N = N), the mobile reads the SLA field to determine if it has been assigned the subsequent slot (i.e., it tries to match SLA with its coded AMI).[2]

Other active mobiles which are sniffing for reservations ignore the SLF field and examine the SLA field for time slot assignments. With this scheme, it is possible to reserve subchannels for some users and carry out round-robin assignments for other subchannels.

Contention Access

Contention slots are provided on the uplink PDCH in order to allow mobile stations to initiate packet data transactions. The mobile station identifies a contention opportunity by reading the PCF. If the mobile station attempts transmission in a contention slot and is negatively acknowledged by the BS, it starts a timer and waits for an AMI and/or mode assignment from the BS. If no AMI/mode assignment is received and the timer expires, the mobile station must wait for *T_Retry* idle (contention) slots before making another access attempt. The parameters used by the random access procedure are listed in Table 2.

T_Retry is uniformly distributed in the closed interval [0, *T_Retry_Max*] where *T_Retry_Max* is a function of *Access_Count*, *T_Retry_Init*, and α. The parameter

T_Retry_Max is computed using the expressions in Table 3. An access failure is declared if the mobile station is unsuccessful after *Access_Count_Max* access attempts.

Adaptive Modulation

The FC and IR RLPs rely on adaptive modulation to achieve the best throughput under delay constraints. The RLP blocks are chosen to be of fixed length and a variable integer number of blocks are packed into a MAC PDU depending on the modulation. This ensures that blocks transmitted using a particular modulation can be retransmitted even if the modulation has changed. The receiver provides periodic channel quality feedback (CQF) which indicates the maximum constellation size allowable under the prevailing channel conditions. The transmitter uses the CQF along with knowledge of the offered load in order to carry out modulation adaptation. The modulation and coding mode for the data in each time slot are indicated to the receiver through a separately coded field called the coded data field type (CDFT). This allows efficient multiplexing of IR and FC mode transactions with dynamic (slot-by-slot) modulation switching without any resulting ambiguity at the receiver.

Channel Quality Feedback

The receiver MAC layer provides CQF, which indicates the modulations that are allowable under the prevailing channel conditions. Based on this information, the transmitter chooses the modulation scheme for subsequent data transfer.

Table 4 shows the scheme for determining the maximum allowable constellation size based on the signal-to-interference-plus-noise ratio, $S/(I + N)$, estimated at the input to the decoder. The downlink adaptation threshold, θ_L, is configurable as a broadcast parameter, and $S/(I + N)$ estimation may be carried out using the technique described in [9, 10].

On the downlink, CQF is transmitted as a part of PCF and supervisory ARQ status PDUs. On the uplink, CQF is transmitted as a part of a supervisory ARQ status PDU. A valid CQF may be used along with the offered load to change the downlink modulation.

Channel conditions	CQF	Allowable modulations
$S/(I + N) < \theta_L$	00	π/4-DQPSK
$S/(I + N) >= \theta_L$	01	π/4-DQPSK, 8-PSK
–	10	Reserved
–	11	Reserved

Table 4. *CQF values on uplink and downlink. The threshold θ_L is a broadcast parameter. CQF = 10 is intended for 16-level modulation. No 16-level modulation has been specified at this time.*

Data Field Type

The DFT is a 3-bit field indicating the mode (FC or IR) and modulation (π/4-DQPSK or 8-PSK) of the data fields in each time slot, and also whether the data fields are associated with the broadcast or nonzero (i.e., mobile-specific) AMI. This field is always transmitted using π/4-DQPSK.

The mode indication allows fixed coded slots to be interspersed between IR slots. This allows, for example, expedited control/feedback frames to be transmitted in FC mode while an IR mode transaction is in progress. The modulation type indication enables slot-by-slot adaptation. The indication of mode and modulation in each time slot is also useful in order to quickly detect handshake failures and take recovery action.

The DFT values are indicated in Table 5. Only five DFT values are currently used; additional DFT values may be used for the support of FC and IR with 16-level modulation. No 16-level modulation has been specified at this time.

The DFT is encoded reliably, and soft decision decoding is recommended at both ends in order to ensure that the error rate is significantly lower than that of the data under a wide range of operating conditions. On the uplink, the 3-bit DFT field is encoded using a (6,3) code to form the CDFT. On the downlink, the 3-bit DFT is combined along with the 5-bit superframe phase (SFP), and the resulting 8-bit word is encoded using a (12,8) code to obtain the CSFP/CDFT field. While decoding, the mobile station can use its prior knowledge of SFP for each time slot in order to achieve better performance.

DFT value	Modulation	Mode	AMI type
000	π/4-DQPSK	Fixed coding	Idle (all zero)
001	π/4-DQPSK	Fixed coding	Mobile-specific
010	π/4-DQPSK	Incremental redundancy	Mobile-specific
011	8-PSK	Fixed coding	Mobile-specific
100	8-PSK	Incremental redundancy	Mobile-specific
101	Reserved		
110	Reserved		
111	Reserved		

Table 5. *Data field type values (uplink and downlink). No 16-level modulation has been specified at this time.*

Radio Link Protocol

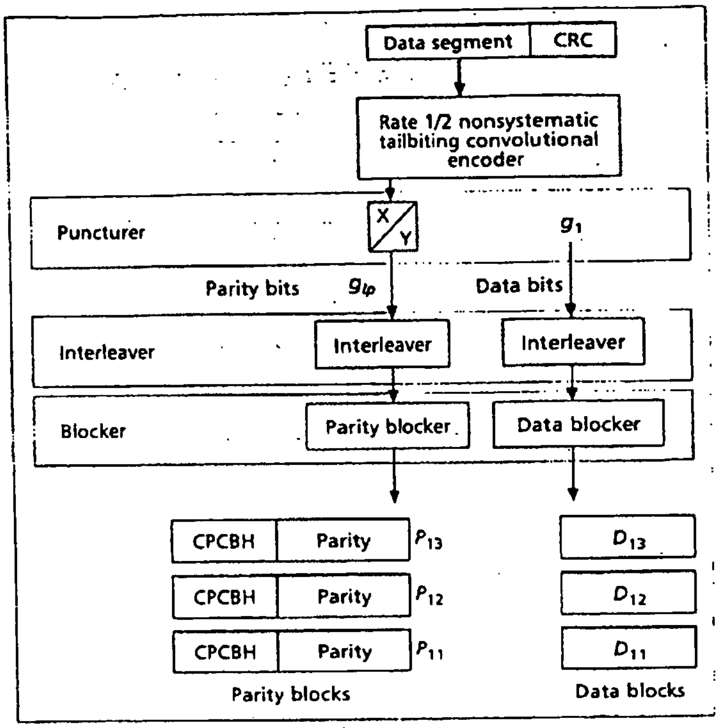
The radio resource (RR) sublayer provides data transfer and control services to LLC and GMM. It consists of three cooperating entities: the MAC entity, RRME, and BME.

The MAC entity accepts data from LLC and RRME. It supports two multiplexed logical links of different priority, one for providing expedited data delivery services (MAC logical link 0, or MLL0), and the other for normal data transfer (MAC logical link 1, or MLL1). For acknowledged data transfer, each logical link uses an RLP. The RLP for MLL1 operates in two modes: IR and FC. The RLP for MLL0 uses only FC mode. A header including a higher-layer protocol identifier (HLPI) is attached to each MAC service data unit (SDU), and the result is converted into an octet stream using standard byte-oriented HDLC framing. The octet streams for each MAC logical link are buffered independently, and are converted into RLP segments of different size depending on the mode.

For both IR and FC, the retransmission scheme is based on the TDMA circuit data RLP IS-130 [11, 12]. Thus, retransmissions are given priority over new data, and retransmissions are determined by the transmitter based on *receiver-state feedback* (bitmap feedback). Retransmissions are not based on timers. Extensions to the

[1] *The cell always sets SA to the coded AMI of the user being assigned a particular slot. Therefore, if the mobile erroneously declares a NAK when an ACK was sent, it can still obtain the assignment of the subsequent slot.*

[2] *When the BS transmits* R/N = N, *it sets* C/S = S.



■ **Figure 8.** *An IR segment encoder.*

IS-130 RLP have been defined for operation:

- At the MAC layer for packet data transactions
- With modulation adaptation
- Using the incremental redundancy mode

The RLP is initialized in IR or FC mode using the transaction initiation procedure described earlier. A BEGIN PDU is used for initializing a transaction, and subsequent data transfer is carried out through the transmission of a series of CONTINUE PDUs. Each transaction may be bounded or unbounded, and unbounded transactions may be either gracefully ended or aborted on detecting protocol violations. Supervisory ARQ Status PDUs are used to periodically provide the peer transmission controller with knowledge about the receiver state.

A transmission opportunity identified during normal protocol operation results in the transmission of one of the following:

- ARQ Status PDU
- IR or FC CONTINUE PDU

CONTINUE PDU formats for IR and FC will be described in the following sections. Seamless operation with adaptive modulation is achieved by packing fixed-size blocks within each CONTINUE PDU. Different integer numbers of these fixed-size blocks can be accommodated in a CONTINUE PDU for different modulations. In IR mode, multiple fixed-size data and parity blocks are derived from each RLP segment. In FC mode, each data block is an RLP segment.

MAC PDUs transmitted on the uplink are acknowledged via the PCF mechanism. Optionally, full or partial bitmap feedback may be provided by the BS via ARQ status PDUs. The transmitter may poll the receiver for bitmap feedback at any time. For downlink data transfer, the BS provides the mobile station with reservation opportunities to obtain bitmap feedback.

The local variables and tables maintained at the transmitter and receiver, the update procedures, and a detailed description of the protocol using the Specification and Description Language (SDL) are provided as a part of the MAC-layer specification [13].

Incremental Redundancy Mode RLP

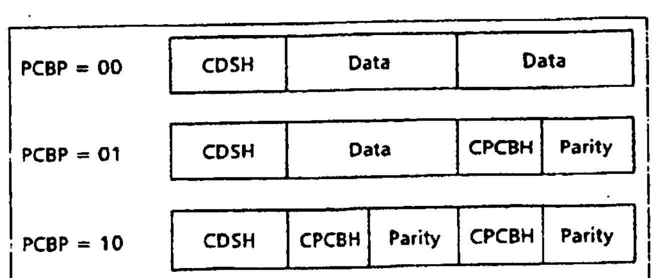
The IR RLP achieves higher throughput since redundant bits are transmitted only when necessary. It exploits the fact that the extra redundancy introduced by heavy coding is not required in most cases. IR mode places more memory requirements on the receiver, but achieves more throughput than FC mode. IR mode is to be used only for regular data transfer (i.e., MLL1), not the transfer of expedited control information (MLL0).

Data Formats and Encoding – The byte stream derived from the upper-layer data is segmented into fixed-length RLP segments of length L. To each RLP segment, a cyclic redundancy check (CRC) sequence computed over the data is added. The data and CRC are encoded using a rate 1/2, 32-state, tailbiting, *nonsystematic*, maximal free distance convolutional encoder with octal generators (65, 57). The rate 1/2 convolutional encoder has two outputs, one of which is suitably punctured, as discussed below. Without loss of generality, the unpunctured encoder output is referred to as *data* and the punctured output as *parity*. In reality, the data output contains no redundancy and represents a one-to-one mapping to the actual data. The data bits at the output of the encoder are interleaved and segmented into D blocks of length L/D. These blocks are called *data* blocks and denoted by $D_{ij}(j = 1, 2, \ldots, D)$. Of the L parity bits at the encoder output, Dh parity bits are punctured, and the remaining parity bits are segmented into D parity blocks of equal size denoted by $P_{ij}(j = 1, 2, \ldots, D)$. Here, h is the size of the header required for each parity block. At the receiver, soft information from data and parity blocks corresponding to the same segment is combined for decoding. Figure 8 shows the mapping of data segments to data and parity blocks. Based on delay/throughput trade-offs, the parameter D was chosen to be 3. The output bits of the encoder are mapped in an interleaved manner to maximize code/time diversity.

To each parity block, a coded parity/control block header (CPCBH) is appended. For parity blocks, PCBH contains the following:

- 1-bit PCBH header type (= 1 for parity block)
- 10-bit block sequence number (BSN)

The PCBH is encoded using a punctured rate 1/2 convolutional code to obtain the CPCBH. Since parity blocks are identified through a header, the data blocks D_{ij} are assigned the same BSNs as the parity blocks, P_{ij}, for $j = 1, 2, \ldots, D$. The blocks to be transmitted in a CONTINUE PDU are determined (Table 6) as follows. Adaptive modulation is employed to achieve the best throughput under delay constraints. The protocol is designed so that a variable integer number of RLP data and/or parity



■ **Figure 9.** *The composition of an IR CONTINUE PDU (layer 1 SDU) for π/4-DQPSK.*

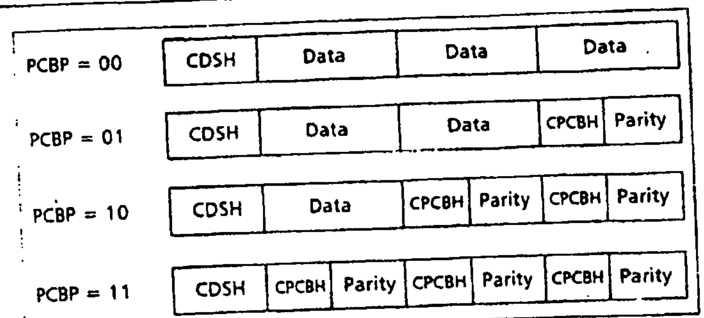
blocks may be packed into a single CONTINUE PDU, depending on the modulation. Retransmittable blocks are given priority over new RLP data blocks, and data blocks in each CONTINUE PDU are required to be in sequence. NULL blocks or END control blocks (indicating the last valid sequence number) may be inserted in place of parity blocks.

For the PDCH, two, three, or four (combinations of data and parity/control) blocks are transmitted in each CONTINUE PDU corresponding to the use of 4-, 8-, or 16-level modulation, respectively. Figures 9 and 10 show CONTINUE PDU formats as a function of the modulation type.

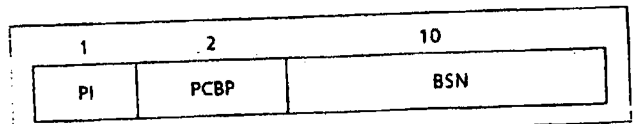
Implicit Addressing and Header Encoding – For IR, a separately coded data segment header (DSH) is transmitted along with each PDU (two, three, or four blocks). The DSH contains the following (Fig. 11):

- BSN — 10 bits (associated with the first data block in a time slot; if there are no data blocks, this field is given a default value which is ignored by the receiver)
- Poll indicator — 1 bit (to request an ARQ Status PDU)
- Parity/control block pointer (PCBP) — 2 bits (to indicate the composition of the PDU in terms of data and parity/control blocks)

Packet data channels are shared by multiple users, and each time slot must contain either an implicit or explicit address to indicate the transmitter identity and recipient of the data in both directions. The inclusion of an address on the uplink is useful for verification that the user assigned an uplink time slot was indeed the one whose transmission was received. Downlink addressing is necessary since multiple active mobiles are constantly listening for downlink transmissions, and the intended recipient must be identified. Furthermore, in order to provide protection from co-channel interference, it is desirable that the base station identity be indicated in both directions. The use of explicit addresses in each time slot requires large overhead and leads to degradation in performance. As a result, the addresses are included implicitly in the computation of CRC bits on both the uplink and downlink. Addressing is carried out using the 7-bit AMI along with a 5-bit abbreviated digital verification color code (ADVCC) as the identifier for the BS. The DSH, ADVCC, and AMI are used to compute the CRC. However, only the



■ **Figure 10.** *The composition of an IR CONTINUE PDU (layer 1 SDU) for 8-PSK.*



■ **Figure 11.** *The structure of the data segment header; the number of bits required for each field is indicated.*

13-bit DSH and 12-bit CRC are transmitted. The resulting 25-bit frame (DSH+CRC) is encoded using a punctured, tailbiting, non-systematic, 32 state, rate 1/2 convolutional code to obtain the coded DSH (CDSH).

Receiver Operation – A received RLP block is declared invalid and discarded if it corresponds to a segment which does not lie within the receiver window or to one that was already successfully decoded. The receiver stores soft information in the form of quantized Euclidean distance metrics or quantized *a posteriori* log likelihood ratios for each valid data or parity block received. The memory requirements at the receiver are larger than in the fixed coding case since the receiver must store soft information for all data or parity blocks corresponding to a segment until decoding is successful. Soft decision decoding is attempted if all data blocks corresponding to a particular segment have been received. If all data blocks have been received and the segment has not yet been decoded, the receiver attempts decoding after receiving each additional valid parity block corresponding to the segment. The receiver stores the receipt status of data or parity

Direction	RLP segment size (octets)	CRC size (bits)	RLP block size (bits)	Modulation RLPs	Number of blocks per PDU	CDSH size (bits)	PDU size (bits)	Peak triple-rate throughput (kb/s)
Downlink	37	16	104	π/4-DQPSK	2	48	256	29.6
				8-PSK	3	36	348	44.4
				16-level	4	96	512	59.2
Uplink	38	14	106	π/4-DQPSK	2	50	262	29.7
				8-PSK	3	39	357	45.6
				16-level	4	100	524	59.4
Uplink (abbreviated)	30	15	85	π/4-DQPSK	2	48	218	24
				8-PSK	3	36	327	36
				16-level	4	96	436	48

■ **Table 6.** *IR CONTINUE PDU format sizes and corresponding peak triple-rate PDCH throughput in kilobits per second. No 16-level modulation has been specified at this time.*

Direction	Modulation	Number of RLP blocks	PDU size (bits)	Rate 1/2 punctured convolutional encoder output (bits)	Peak triple-rate PDCH throughput (kb/s)
Downlink	π/4-DQPSK	2	205	256	26.4
	8-PSK	3	293	348	39.6
	16-level	4	381	512	52.8
Uplink	π/4-DQPSK	2	205	262	26.4
	8-PSK	3	293	357	39.6
	16-level	4	381	524	52.8
Uplink (abbreviated)	π/4-DQPSK	2	173	218	21.6
	8-PSK	3	245	291	32.4
	16-level	4	317	436	43.2

■ **Table 7.** *Fixed coding mode CONTINUE PDU format sizes and corresponding peak triple-rate PDCH throughput in kilobits per second. Each RLP block consists of 11 octets. No 16-level modulation has been specified at this time.*

blocks corresponding to an undecoded segment.

When a segment is successfully decoded, the receiver updates its state information. The receiver generates full or partial bitmaps using this information when it provides ARQ feedback to the transmitter. For uplink transactions, bitmap feedback is still required in order to acknowledge successfully decoded IR segments since PCF only acknowledges the receipt of blocks transmitted in the previous time slot. The bitmap consists of a primary bitmap and two optional incremental redundancy bitmaps which indicate the following:

- Primary bitmap: This bitmap indicates the acknowledgment status (ACK or NAK) for each segment. Run length coding (as specified in ITU-T T.4 [14]) is applied in order to reduce the primary bitmap size whenever compression is possible.
- IR bitmap 1: For each segment negatively acknowledged by the primary bitmap, this bitmap indicates if all data blocks corresponding to that segment have been received.
- IR bitmap 2: If IR bitmap 1 indicates that all data blocks corresponding to a particular segment have not been received, this bitmap provides additional information indicating the receipt status of each data block corresponding to that segment.

Transmitter Operation – The transmitter procedures are somewhat more complex than the receiver and more state information must be stored for each RLP block at the transmitter. The RLP delivers data in-sequence by initially sending just the RLP data blocks, D_{i1}, D_{i2} and D_{i3}, followed by sending additional RLP parity blocks, P_{ij}, $j = 1, 2, 3$ whenever the receiver fails to decode the RLP segment. The transmitter cannot discard the data and parity bits corresponding to a segment until it has received a positive acknowledgment from the receiver for the segment, hence the protocol operates by maintaining in a table, the receipt status of blocks that have been transmitted but not yet acknowledged. A block is not considered retransmittable unless it is explicitly negatively acknowledged, and sufficient time has elapsed to ensure that the status of the block is reflected in the feedback. Upon obtaining feedback from the receiver the transmitting protocol can update the table and decide on which data or parity block to schedule for transmission at the next opportunity.

Fixed Coding Mode RLP

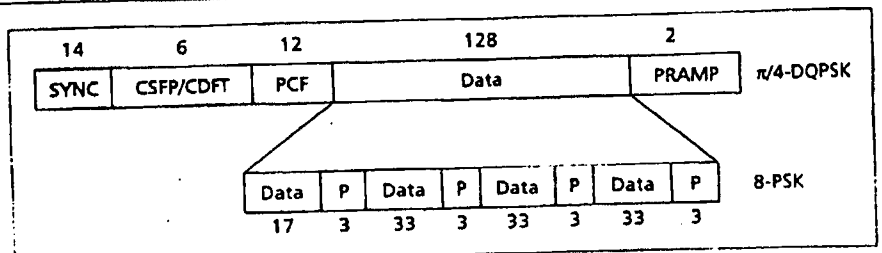
FC mode transactions are established through a BEGIN PDU handshake as described in an earlier section. In the FC mode, RLP segments (or blocks) are of fixed length (shorter than the IR mode RLP segment). The CONTINUE PDU carries 2, 3, or 4 RLP blocks depending on the use of 4-level, 8-level (Table 7), or 16-level modulation, respectively, a CONTINUE PDU Header, and a 16-bit CRC. This ensures that blocks transmitted using a particular modulation can be retransmitted even if the modulation has changed.

The PDU header consists of the following:

- 1 bit indicating that it is a CONTINUE PDU
- 1 bit identifying the logical link (i.e., MLL0 or MLL1)

Field	Size (symbols)	Function
SYNC	14	Synchronization field (see IS-136 [1]). SYNC is always modulated using π/4-DQPSK
CSFP/CDFT	6	Superframe Phase (SFP) helps mobile stations find start of superframe. Data Field Type specifies the mode and modulation for the DATA field in the time slot. CSFP/CDFT is always modulated using π/4-DQPSK.
PCF	12	Packet Channel Feedback provides subchannel feedback and subchannel assignment for the associated uplink time slots. PCF is always modulated using π/4-DQPSK.
DATA	128 (π/4-DQPSK) 116 (8-PSK)	Carries layer 1 SDU
PILOT	12 (8-PSK)	Provides phase reference for coherent demodulation of 8-PSK.
PRAMP	2	Facilitates downlink power control for adjacent time slots on same 30 kHz channel.

■ **Table 8.** *Downlink field functions and sizes.*



■ **Figure 12.** *The downlink time slot format.*

- A 1-bit poll indicator
- The 10-bit BSN of the first data block in the PDU

The PDU is encoded using a punctured, 32-state, rate 1/2, tailbiting, nonsystematic convolutional code. The puncturing (coding rate) at each modulation has been determined from the number of RLP blocks and the number of transmission symbols available for the modulation format.

Note that since the CRC bits are computed from two, three, or four RLP blocks in addition to other fields, all blocks within a PDU are lost if the PDU is not successfully decoded, and need to be recovered through retransmissions. Assigning a CRC sequence to each "small" RLP block is inefficient due to excessive overhead.

On the uplink, a CONTINUE PDU may contain an END control block which provides the last valid BSN for the transaction in lieu of a data block. This information helps the BS to schedule the required number of uplink time slot assignments in order to gracefully complete the transaction.

Implicit Addressing – Implicit addressing is carried out using the 7-bit AMI along with an 8-bit digital verification color code (DVCC) as the BS identifier. The CRC is computed using the PDU header, RLP blocks, AMI, and DVCC. Only the PDU header, RLP blocks, and CRC are provided to the convolutional encoder; the AMI and DVCC are not explicitly included.

Receiver Operation – A received RLP block is declared invalid and discarded if it does not lie within the receive window or was received previously. When a valid RLP segment is received, the receiver updates its state information. Full or partial bitmaps are generated using this information when the receiver provides ARQ feedback.

Transmitter Operation – The transmitter procedures are more complex, and more state information must be stored at the transmitter. The transmitter uses full or partial feedback information from the receiver in order to update its state information.

The data blocks to be transmitted are determined as follows. A block is not considered retransmittable unless it is explicitly NAKed, and sufficient time has elapsed to ensure that the status of the block is reflected in the feedback. Retransmittable blocks are given higher priority than new data blocks. Furthermore, the data blocks in each CONTINUE PDU are required to be in sequence. The earliest retransmittable data block is transmitted along with other retransmittable data blocks that follow in sequence. If there are no retransmittable data blocks, new data blocks within the window may be transmitted.

Radio Link Protocol End Procedures

For uplink transactions, the mobile station is required to commit to the end of the transaction if the buffer backlog is smaller than a threshold. This allows the BS to dynamically schedule uplink reservation opportunities without wasting any slots.

While initiating a transaction, the mobile station indicates the length of the transaction in the BEGIN PDU through the transaction size (TS) field, which can take the following values:

- TS = 0 indicates that the transaction ends with the BEGIN PDU.
- TS = 1, 2, ..., 62 indicates that there are TS data blocks in the transaction.
- TS = 63 indicates that the transaction is unbounded.

In cases where the BEGIN PDU indicates an unbounded transaction, an explicit END control block must be transmitted when nearing the end of the transaction (i.e., when the amount of data in the transmit buffer falls below a threshold). The transmitter commits to the end of the transaction by providing the last valid sequence number for the transaction within the END block. For FC transactions, the END block is identified by an escape sequence and transmitted with other data blocks as part of a CONTINUE PDU. For IR transactions, the END block is identified by the PCBH and may be transmitted along with other data/parity blocks as part of a CONTINUE PDU. The END block is acknowledged through the end block received (EBR) indicator in the ARQ Status PDU. The transmitter and receiver continue retransmission procedures for recovering data only up to and including the last sequence number. Any new data that arrives in the transmit buffer requires the initiation of another transaction.

Radio Link Protocol Partial Recovery and Error Handling

In both modes of operation, the transmitter and receiver can detect anomalies in protocol operation and trigger recovery action. Recovery occurs by aborting the current transaction and starting another one as necessary.

The transmitter RLP may abort the current transaction at any time by transmitting a BEGIN PDU to initiate a new transaction. Events such as the acknowledgment of previously acknowledged data, acknowledgment of data not yet transmitted, and excessive number of retransmission attempts are flagged as protocol anomalies by the transmitter RLP. If the number of anomalies that occur within a sliding time window exceeds a predetermined threshold, the transaction is aborted.

The receiver RLP may trigger a transaction abort by sending an ARQ Status PDU with a null bitmap or an abort indication. Events such as the receipt of data outside the receiver window or the receipt of multiple copies of the same data are flagged as protocol anomalies by the receiver RLP. If the number of anomalies that occur within a sliding time window exceeds a predetermined threshold, the transaction is aborted.

The transaction is also aborted if a long period of inactivity is detected at either the transmitter or receiver.

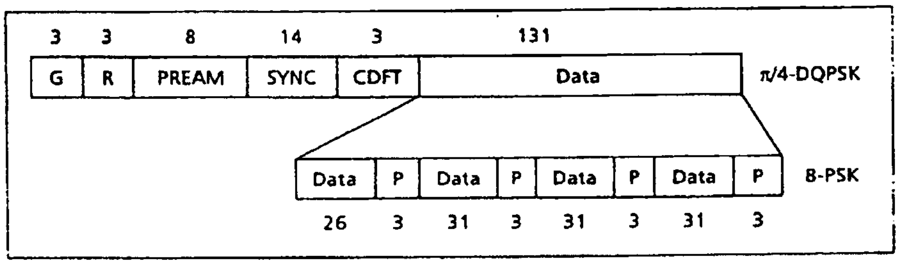
Time Slot Formats

The 30 kHz spectrum usage, symbol rate, and TDMA format (six time slots every 40 ms) are maintained as in the IS-136 standard [1] in order to minimize impact on existing infrastructure. However, the time slot contains new fields that are required for PDCH functions.

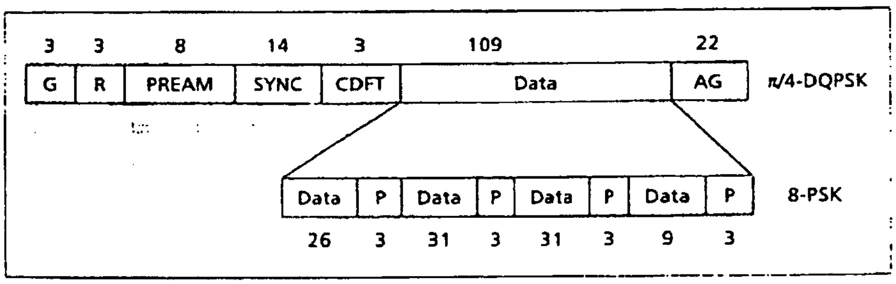
Downlink Time Slot Format

Field	Size (symbols)	Function
G	3	Guard field (see IS-136 [1]). Guard is always modulated using π/4-DQPSK.
R	3	Ramp field (see IS-136 [1]) allows mobile stations to increase transmit power. Ramp is always modulated using π/4-DQPSK.
PREAM	8	Preamble (see IS-136 [1])
SYNC	14	Synchronization field (see IS-136 [1]). SYNC is always modulated using π/4-DQPSK
CDFT	3	Data Field Type specifies the mode and modulation for the DATA field in the time slot. CSFP/CDFT is always modulated using π/4-DQPSK.
DATA	131 (π/4-DQPSK) 119 (8-PSK)	Carries Layer 1 Service Data Unit.
PILOT	12 (8-PSK)	Provides phase reference for coherent demodulation of 8-PSK.

■ **Table 9.** *Uplink field sizes and functions.*



■ **Figure 13.** *The uplink time slot format.*



■ **Figure 14.** *The plink abbreviated time slot.*

The downlink time slot formats for π/4-DQPSK and coherent 8-PSK are shown in Fig. 12. The slot format is identical for both the IR and FC modes. The shaded fields are always modulated using π/4-DQPSK. The different field sizes and functions are summarized in Table 8.

Uplink Time Slot Format

The uplink time slot formats for π/4-DQPSK and coherent 8-PSK are shown in Fig. 13. The shaded fields are always modulated using π/4-DQPSK, and the slot format is identical for both the IR and FC modes. The different field sizes and functions are summarized in Table 9.

Uplink Abbreviated Time Slot Format

Abbreviated uplink time slot formats are defined for packet data service deployments in large cells. The only difference from the regular uplink time slot format is that an abbreviated guard (AG) field of size 22 symbols is defined at the end of the time slot (Fig. 14). The DATA field contains only 109 symbols in the π/4-DQPSK case and 97 symbols in the case of coherent 8-PSK. The G, R, PREAM, SYNC, and CDFT field sizes are maintained as in the uplink time slot case, and these fields are modulated using π/4-DQPSK.

Summary

This article has described the specification of a high-data-rate packet data service for the North American digital TDMA cellular standard, TIA/EIA IS-136 [1]. Details of the RLP, MAC, and physical layers are provided. The specification has the following features:
- Upper layers (L3 and above) consistent with GPRS
- Aggregation of multiple time slots
- Flexible allocation of uplink and downlink bandwidth
- Adaptive modulation
- Incremental redundancy and fixed coding modes

The standard is likely to be approved by the time this article is published. Implementations are expected in early 2000.

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E-6

A SELECTIVE REPEAT ARQ SYSTEM

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1. INTRODUCTION Automatic Repeat Request (ARQ) has proven an effective means of data transmission error control on telecommunications channels, and currently enjoys widespread commercial application. Stop and wait ARQ, due to its simplicity, is the most commonly used technique on terrestrial circuits. For circuits where the (round trip propagation delay x data rate) product is a significant fraction of the block length, such as satellite circuits at voice-band data rates or terrestrial long lines at group band data rates, the throughput efficiency of stop and wait ARQ suffers badly. Selective Repeat ARQ, being insensitive to transmission delay, permits efficient error control transmission on these circuits.

A summary of ARQ techniques has been made by Gatfield[1]; in which he derives generalized efficiency expressions for several ARQ techniques, including Selective Repeat. This paper describes a particular Selective Repeat ARQ design[2], derives efficiency equations, and compares calculated performance versus the measured performance of the hardware implementation over simulated channels.

2. DESCRIPTION The Selective Repeat ARQ (SRQ) described herein is a full duplex device, intended for operation in the configuration shown in Figure 1. When the data terminal (DTE) employs its own stop and wait ARQ, it must effectively be disabled, to avoid waiting the full round trip delay between block transmissions. The Transmit Interface Adapter recognizes the terminal block format, and immediately responds to each block from the DTE transmitter with an ACK. The result is a nearly continuous flow of data provided by the Transmit Interface Adapter to the Error Control Transmitter. The Receive Interface Adapter accepts the continuous data stream from the Error Control Receiver and re-assembles it into DTE data blocks for the terminal receiver. The adapters must be compatible with the complete DTE communications protocol. DTEs without resident error control, which provide a serial synchronous data stream, can be directly connected to the Basic Error Control System.

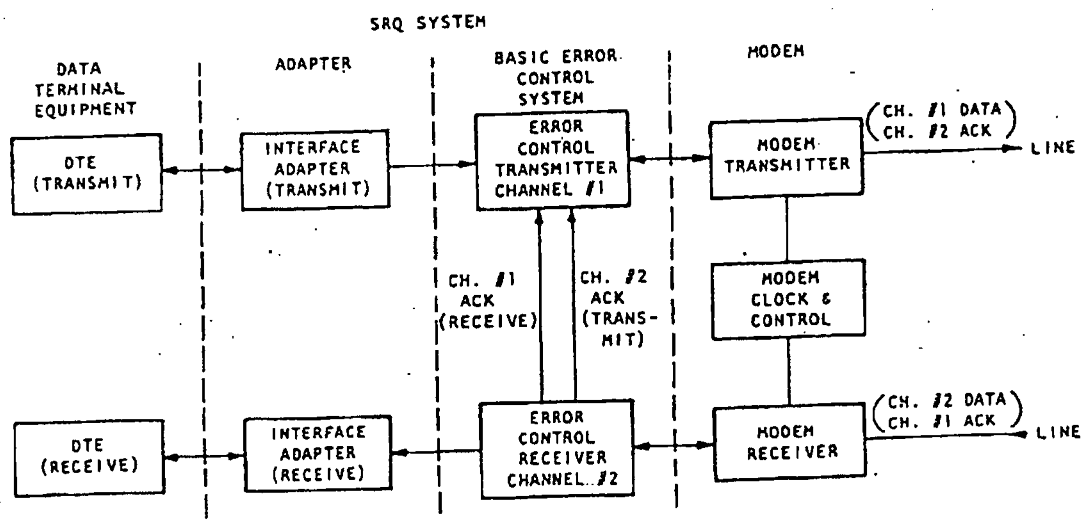

Figure 1. Selective Repeat ARQ System

2.1 Transmitter The Error Control Transmitter accepts serial synchronous data from the adapter, and formats it into 512 bit blocks, (which bear no relation in length to the DTE block structure), as shown in Figure 2. Successive blocks are transmitted without pause for acknowledgment. The block address and data

BLOCK ADDRESS (7 BITS)	DATA (473 OR 475 BITS)	ACK/NAK ADDRESS (5 OR 7 BITS)	ACK/NAK WORDS (3 BITS)	HOUSE-KEEPING (3 BITS)	CYCLIC CHECK (19 BITS)

Figure 2. Block Structure

This pape- ... upon work performed under the sponsorship of the International Telecommunication Satellite Organ'. Any opinions expressed are not necessarily those of INTELSAT.

portion of each transmitted block is also stored in the transmit queue memory, as illustrated in the transmitter block diagram in Figure 3. When the remote Error Control Receiver receives a block, an ACK or NAK decision is made based on the error detection process, and this ACK/NAK decision is address labeled and returned to the local site in the return channel data blocks. ACK'ed blocks are discarded from the queue. A NAK'ed block is retrieved from the queue, retransmitted, and retained in the queue until it is finally ACK'ed. The throughput efficiency of the SRQ results from the fact that blocks are continuously being transmitted without pause for acknowledgment, and that only errored blocks are retransmitted.

Each transmitted data block is labeled with a 7 bit (modulo 128) block address, provided by the block address counter through gate C1 at the beginning of each new block of data accepted from the DTE. This address, which is incremented by 1 for each new block, identifies the order in which the blocks must be reassembled at the receiver. When a new block is to be transmitted, gate C2 accepts the block address and data from gate C1 and passes it to gate C3. Here the ACK/NAK decisions from the return channel receiver, along with identifying address, and housekeeping bits are added in composing the block. The block address and new data from gate C2 are also fed to the transmit queue memory for retention.

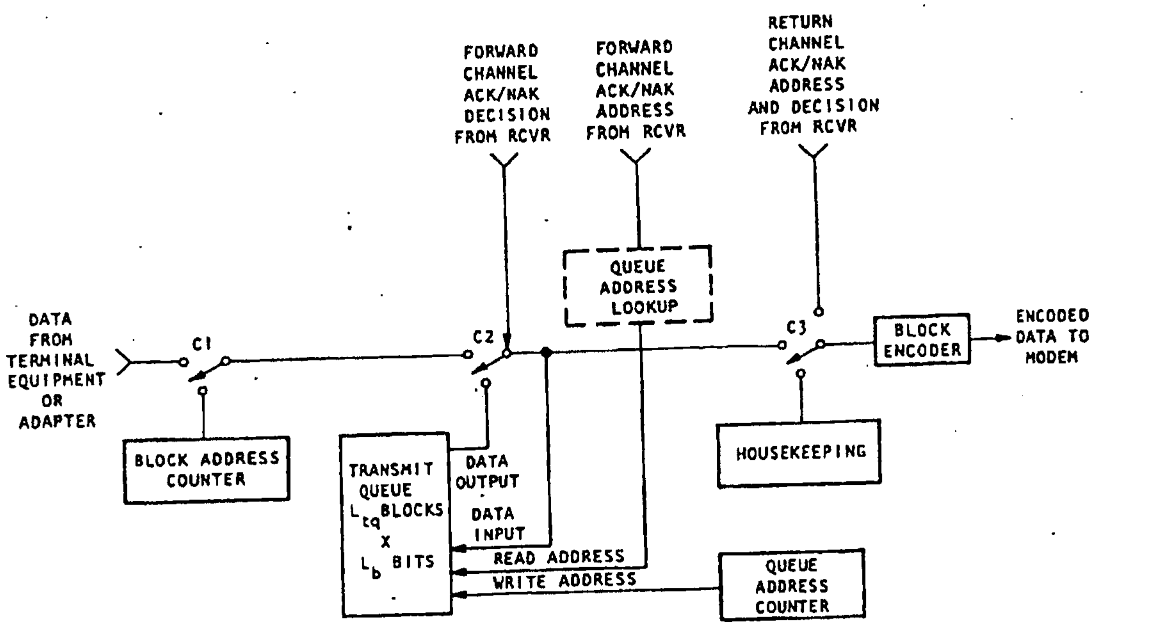

Figure 3. Error Control Transmitter (Local Site)

The transmit queue has the capacity to store L_{tq} blocks, each L_b bits in length, where

$$L_b = (\text{BLOCK ADDRESS LENGTH}) + (\text{DATA LENGTH})$$

and

$$L_{tq} \geq \frac{R \times (D_p + D_c)}{L_B}$$

R = data rate in bits per second
D_p = maximum round trip delay in seconds
D_c = total delay in seconds, of the SRQ circuitry
L_B = total block length in bits

The transmit queue write address is provided by the queue address counter, a modulo L_{tq} counter which is incremented once for every block transmitted.

The distant receiver error checks each received block, and ACK's or NAK's appropriately on each return channel block. Consider transmitting new data block B_i, and storing it in queue location $i_{(modulo\ L_{tq})}$. On a maximum round trip delay channel, its acknowledgment is returned to the transmitter just before new data block $B_{i+L_{tq}}$ must be transmitted. If B_i was ACK'ed, transmit queue location $i_{(mod\ L_{tq})}$ is cleared, and a new data block can be transmitted and stored in that location. If B_i was NAK'ed, however, gate C2 selects the queue as the data source, and block B_i is retransmitted and retained in location $i_{(mod\ L_{tq})}$. The queue read address, $i_{(mod\ L_{tq})}$ is derived from the ACK/NAK address returned with the ACK/NAK decision from the distant site. New data block $B_{i+L_{tq}}$ is held up during the retransmission, and is then transmitted and stored in queue location $(i+1)_{(mod\ L_{tq})}$, assuming that block B_{i+1} was ACK'ed. Thus, the transmit queue stores, in order of (re)transmission, all blocks that have yet to be acknowledged.

Two alternative means of address labeling ACK/NAK return decisions have been utilized. In Mode A the remote receiver strips the block address off each block received, and uses it to identify the returned ACK/NAK decision for that block. This scheme requires that the transmitter store in a lookup memory, for each block transmitted, the queue location of that block. When the block address accompanying the ACK/NAK decision is returned, the lookup memory provides the queue read address to access the block for retransmission if necessary. In Mode B, a modulo L_{tq} counter in the remote receiver counts received blocks. If, during the initial SRQ synchronization process, this counter and the transmit queue address counter are both initialized to the same state, then the receiver counter address is the transmit queue address for each received block. When this address is used to identify the return ACK/NAK information, it can be used directly at the local site to address the transmit queue and access the desired block. Mode B is simpler to implement, and as will be shown, results in somewhat superior throughput performance. The possible risk of Mode B is that if the receiver counter loses synchronization with the transmit queue address counter, data loss or a hangup state could occur. Suitable safeguards have been incorporated in the design, however, making Mode B the favored one.

Three housekeeping bits are added to each block transmitted by gate C3. These status bits identify system initialization, fill block, and block resynchronization transmissions and communicate alarm conditions to the remote site. (Fill blocks are transmitted when no DTE data is available, or under certain "wait" conditions when the receiver cannot handle new data. These blocks must be labeled so that they may be identified and discarded by the receiver.)

Choice of the block length involves trading off fixed overhead versus the number of bits that must be retransmitted in the event of error. The block address, (7 bits), ACK/NAK address and word (8 bits), housekeeping (3 bits), and to a great extent the error check bits (19 bits) must be regarded as fixed overhead.

Ignoring second order effects, the total overhead per block is

$$\frac{O_T}{L_B} = \frac{O_F + L_B \cdot P\ (\text{error block})}{L_B}$$

where

O_F = fixed overhead = 37 bits

L_B = block length

and for randomly distributed errors

$P\ (\text{error block}) = 1-(1-P_b)^{L_B}$

$P_b = P\ (\text{bit error})$

Block length was chosen to minimize O_T/L_B for bit error rates in the $1\text{x}10^{-4}$ range. Calculating L_B,

$$\frac{d}{dL_B}\left[O_F\ L_B^{-1} + 1-(1-P_b)^{L_B}\right] = 0$$

$$-\ O_F\ L_B^{-2} - (1-P_b)^{L_B} \log_e (1-P_b) = 0$$

Substituting $P_b = 1\text{x}10^{-4}$ and solving for L_B, optimum block length is just over 628 bits. Since a block length of 2^n bits is convenient from an implementation standpoint, a block length of 512 bits was chosen.

The SRQ is designed to handle a maximum round trip delay, D_p, of 800 ms at a data rate R, or 9600 bits per second. The SRQ circuit delay is four 512 bit blocks. The transmit queue length, L_{tq}, chosen is 20 blocks.

The error control is a 511 bit word BCH code, with an added odd parity bit to achieve a 512 bit block. The BCH remainder, 18 bits in length, is inverted prior to transmission, making an all zeros or all ones word invalid (ignoring the odd parity bit). The minimum distance of the code is 6, so all combinations of 5 or less errors in a block are detected. Burst errors of 19 or fewer bits are also handled.

2.2 Receiver *At the receiver, blocks are not necessarily accepted in the same order as that in which they arrived at the transmitter. Consider again the case where block B_i contains an error in the first transmission. The order in which blocks are accepted at the receiver is;

$$B_{i-2},\ B_{i-1},\ \text{Reject},\ B_{i+1},\ ---,\ B_{i+L_{tq-1}},\ B_i,\ B_{i+L_{tq}},\ ---$$

The receiver must reorder the blocks correctly before they can be released. This necessitates address labeling each new block transmitted, and a receiver storage, the receive queue (see Figure 4), in which blocks can be reassembled in numerical order prior to release. The ability of the receive queue to continue handling good blocks while waiting for the repeat of an errored block is the key feature is SRQ. The only throughput loss results from retransmitting errored blocks; there is no waiting period following receipt of an errored block, and no correctly received blocks are retransmitted.

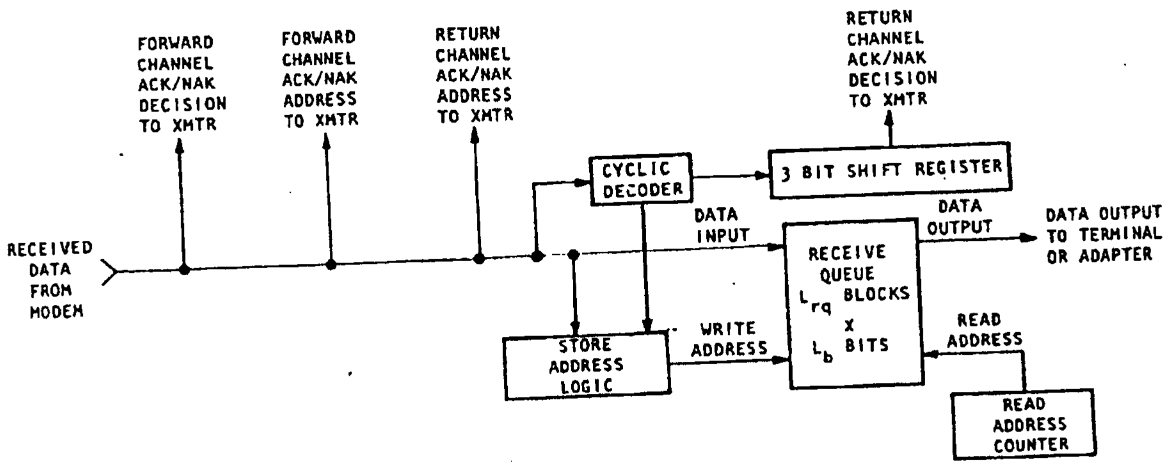

Figure 4. Error Control Receiver (Local Site)

In theory, the receive queue must be infinite, to allow it to continue handling new data blocks regardless of how many retransmissions are required to get an errored block through. When a receive queue of finite length reaches capacity while awaiting accepting of an errored block, the receiver must NAK further new data blocks that cannot be allocated to the queue, and data release must be suspended until the errored block, which has advanced to the front of the queue, is received correctly. When the previously errored block is finally accepted, data release from the queue can resume, and new data blocks can again be accepted.

The choice of a receive queue length of forty blocks, (n=2), results in an efficiency degradation of less than 5% at a bit error rate of 1×10^{-3}, according to the efficiency expression developed in Section 3. At bit error rates of 1×10^{-4} and above, the "wait" contribution to efficiency loss is negligible.

The ACK/NAK decisions made by the receiver cyclic decoder are stored in a three bit shift register. The contents of this register are transmitted back to the distant site as the ACK/NAK word, (see Figure 2). This triple redundancy in ACK/NAK transmission minimizes the effect of reverse channel error rate on forward channel throughput./

3. TRANSMISSION EFFICIENCY In an ARQ system each received block is checked for errors and initially classified as either a good block or an error block. Good blocks are tested further and additionally classified as a block available for release to the data terminal, an unrequested (thus unnecessary) repeat of a block previously accepted for release, or a wait block. Wait blocks are good blocks that must be NAK'ed because the receiver queue is full. Total blocks received are simply the good blocks plus error blocks. Efficiency of an ARQ system is measured as the ratio of blocks released to total blocks weighted by block efficiency.

$$E = \frac{\text{Blocks Released}}{\text{Total Blocks}} \times \frac{\text{Message Bits/block}}{\text{Total Bits/block}}$$

which can also be expressed as

$$E = \frac{\text{Good blocks-Unrequested Repeats-Wait blocks}}{\text{Total Blocks}} \ (K/N)$$

$$= [P\ (\text{good block})\ - P\ (\text{unrequested repeat})\ - P\ (\text{wait block})]\ K/N \qquad (1)$$

In the analysis that follows, random errors are assumed. The block length is 512 bits; thus, the probability of an error block, B, is

$$P\ (\text{error block}) = 1-(1-P_b)^{512} = B$$

where P_b is the bit error rate.

Therefore, the probability of a good block is

$$P\ (\text{good block}) = 1-B$$

3.1 Unrequested Repeats — As mentioned previously, ACK/NAK information about each received block is included in three return blocks. This feature affects the probability of an unrequested repeat. In addition, the required event for an unrequested repeat is dependent upon the operating mode.

Mode A — An unrequested repeat requires that a good block be received. The initial return block must be rejected by the distant receiver followed by an error in either or both directions during the next two block periods. (The reason errors occurring in the forward direction are included is because valid block numbers are not available to label the return ACK/NAK in Mode A when a block is rejected).

$$P(\text{unnecessary repeat}) = P(\text{good})\cdot P(\text{error})\cdot(1-P(\text{good})^2)^2$$

$$= 4B^3-8B^4+5B^5-B^6$$

Mode B — An unnecessary repeat requires that a good block be received and that three consecutive return blocks be rejected by the distant receiver.

$$P(\text{unnecessary repeat}) = P(\text{good})\cdot P(\text{error})^2 = (1-B)B^3$$

3.2 Wait Blocks — If a block must be repeated three or more times, there is a possibility some subsequent blocks will have to be NAK'ed, although received without errors, because the 40 block receive queue has filled. These blocks are referred to as "wait" blocks.

The round trip delay is assumed to be 20* blocks; therefore, when a block is NAK'ed, it will be received again 20 blocks later. The transmitter increments the block number counter (modulo 128) each time a new data block is transmitted. Whenever a block is retransmitted, the block number counter is not incremented.

Figure 5 is the event sequence for a block received in error three times and accepted on its fourth arrival. It depicts the block number received, whether it is an accepted, rejected (error block) or wait block and the receiver queue allocation. For simplification, Block #1 is shown as being rejected three times. The 19 blocks arriving in sequence positions $W_1 - W_{19}$ could possibly be NAK'ed because the queue has filled.

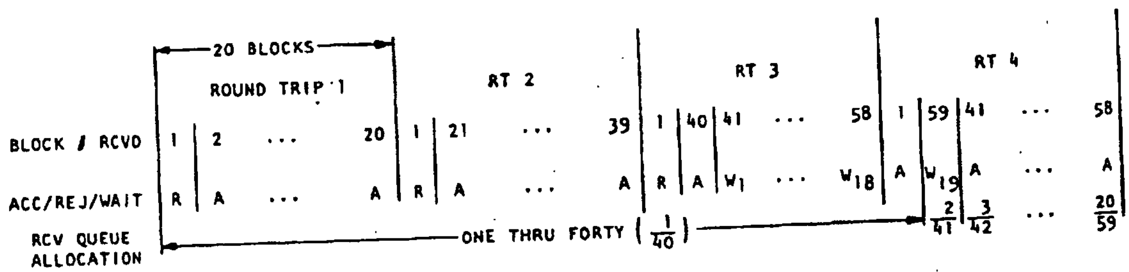

Figure 5. Event Sequence for a 19 Block Wait Period

For the queue to be full when a block arrives at position W_1 requires that (1) a block be received in error three times and accepted on the fourth arrival, (2) there are no repeated blocks in the other 39 sequence positions, and (3) that the present block is good. The probability of a repeated block is

$$P(\text{repeated block}) = B + P(\text{unnecessary repeat}) = P_r \quad (2)$$

Therefore, the probability that a block arriving in position W_1 given that we are in event sequence position W_1 is

$$P(\text{wait in } W_1/W_1) = P(3\text{ rej, 1 good})\cdot P(\text{block \# = 41})\cdot P(\text{good}) \quad (3)$$

$$= B^3(1-B)(1-P_r)^{40}(1-B)$$

A block arriving in the second wait position can have a block number of 40 or 41 in excess of the block being rejected three times.

$$P(\text{wait in } W_2/W_2) = P(3\text{ rej, 1 good})[(1-P_r)^{41}+40\ P_r(1-P_r)^{40}]P(\text{good}) \quad (4)$$

*The maximum allowable delay.

Therefore, the probability of a wait given a block received in error three times and good on its fourth arrival is

$$P(\text{wait}/3\text{ rej, }1\text{ good}) = \sum_{i=1}^{19} P(W_i)P(\text{wait}/W_i) \tag{5}$$

$$\text{where } P(W_i) = \frac{1}{\text{Sequence length}} = \frac{1}{62}$$

$$= \sum_{i=1}^{19} \frac{1}{62} \sum_{j=0}^{i-1} \binom{38+i}{j} P_r^{\,j}(1-P_r)^{39+i-j}(1-B) \tag{6}$$

In the event a block is rejected four times, RT 1 to 3 are shown in Figure 5, and RT 4 to 6 are as shown in Figure 6. For this case, there are 38 sequence positions where blocks could be rejected because the queue has filled. Since a block may arrive in error any number of times and since the number of wait positions increases by 19 for each additional block 1 rejection, the following relationships hold.

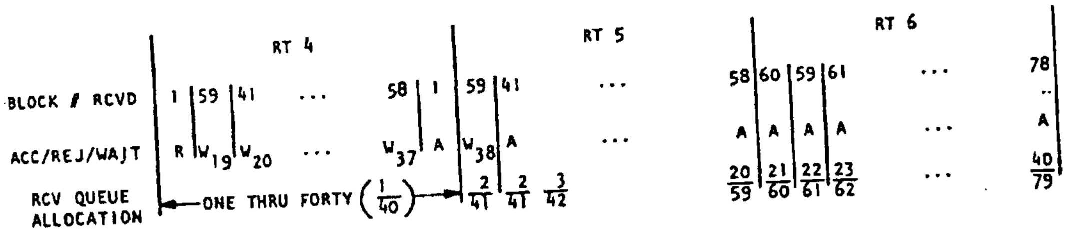

Figure 6. Event Sequence for a 38 Block Wait Period

$$P(\text{wait}) = P(\text{wait}/3\text{ rej, }1\text{ good})\cdot P(3\text{ rej, }1\text{ good}) + P(\text{wait}/4\text{ rej, }1\text{ good})\cdot P(4\text{ rej, }1\text{ good}) + \ldots + P(\text{wait}/\ell\text{ rej, }1\text{ good})\cdot P(\ell\text{ rej, }1\text{ good}) \tag{7}$$

where

$$P(\text{wait}/\ell\text{ rej, }1\text{ good}) = \sum_{i=1}^{(\ell-2)19} \frac{1}{(20\ell+2)} \sum_{j=0}^{i-1} \binom{38+i}{j} P_r^{\,j}(1-P_r)^{39+i-j}(1-B) \tag{8}$$

and

$$P(\ell\text{ rej, }1\text{ good}) = B^{\ell}(1-B) \tag{9}$$

Substituting 8 and 9 into 7, the probability of a wait becomes

$$P(\text{wait}) = \sum_{\ell=3}^{\infty} B^{\ell}(1-B)^2 \sum_{i=1}^{(\ell-2)19} \frac{1}{(20\ell+2)} \sum_{j=0}^{i-1} \binom{38+i}{j} P_r^{\,j}(1-P_r)^{39+i-j} \tag{10}$$

3.3 General Efficiency Expression Substituting the expression for P(unnecessary repeat) and P(wait) into equation 1, we obtain

Mode A

$$E = (K/N)\left[1-B-4B^3+8B^4-5B^5+B^6-\sum_{\ell=3}^{\infty} B^{\ell}(1-B)^2 \sum_{i=1}^{(\ell-2)19} \frac{1}{(20\ell+2)} \sum_{j=0}^{i-1} \binom{38+i}{j} P_r^{\,j}(1-P_r)^{39+i-j}\right] \tag{11}$$

where $P_r = B+4B^3-8B^4+5B^5-B^6$

Mode B

$$E = (K/N)\left[1-B-B^2(1-B)-\sum_{\ell=3}^{\infty} B^{\ell}(1-B)^2 \sum_{i=1}^{(\ell-2)19} \frac{1}{(20\ell+2)} \sum_{j=0}^{i-1} \binom{38+i}{j} P_r^{\,j}(1-P_r)^{39+i-j}\right] \tag{12}$$

where $P_r = B^3(1-B)+B$

4. TEST RESULTS Laboratory testing was performed on the system to confirm that actual and calculated performances were in close agreement. This testing consisted of injecting random errors in the digital data path. The results are shown in Figures 7 and 8 for Modes A and B respectively. The solid curve represents calculated performance and the indicated points are measured performance data. Inspection shows that indeed the system performs as expected in terms of efficiency vs. random error rate.

Testing over a combined terrestrial and satellite circuit at 9600 bps is presently under way. The test circuit is marginal for operation at 9600 bps and the bit error rate varies widely. While insufficient data has been collected to properly relate transmission efficiency with bit error rate, an average of 87% efficiency has been obtained for 40 hours of operation. Data on the residual error rate, interruptions in operation requiring operator intervention, and other performance measures is also being collected.

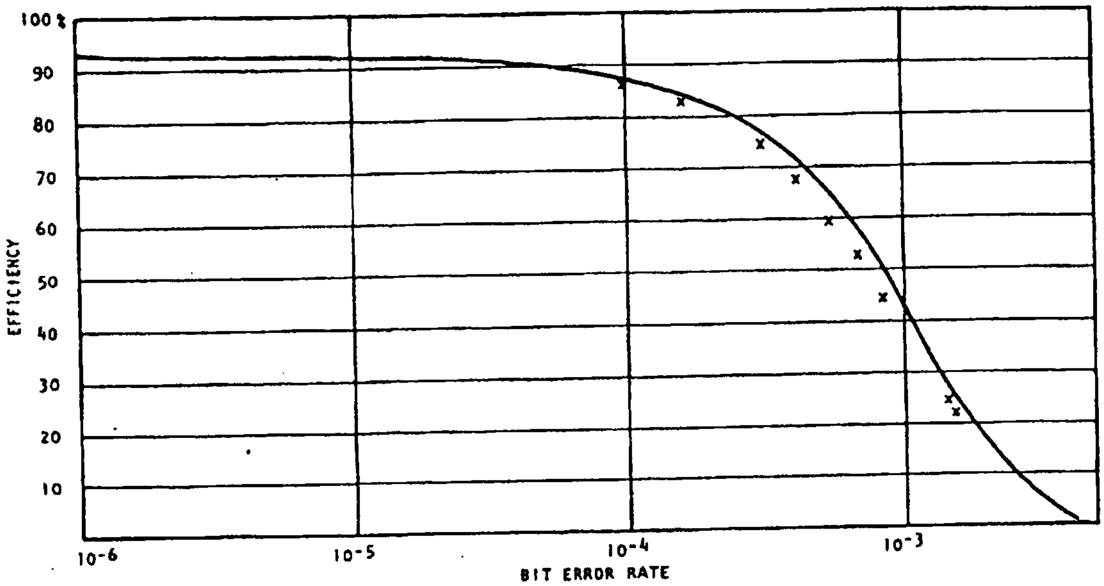

Figure 7. Efficiency Curve, Mode A

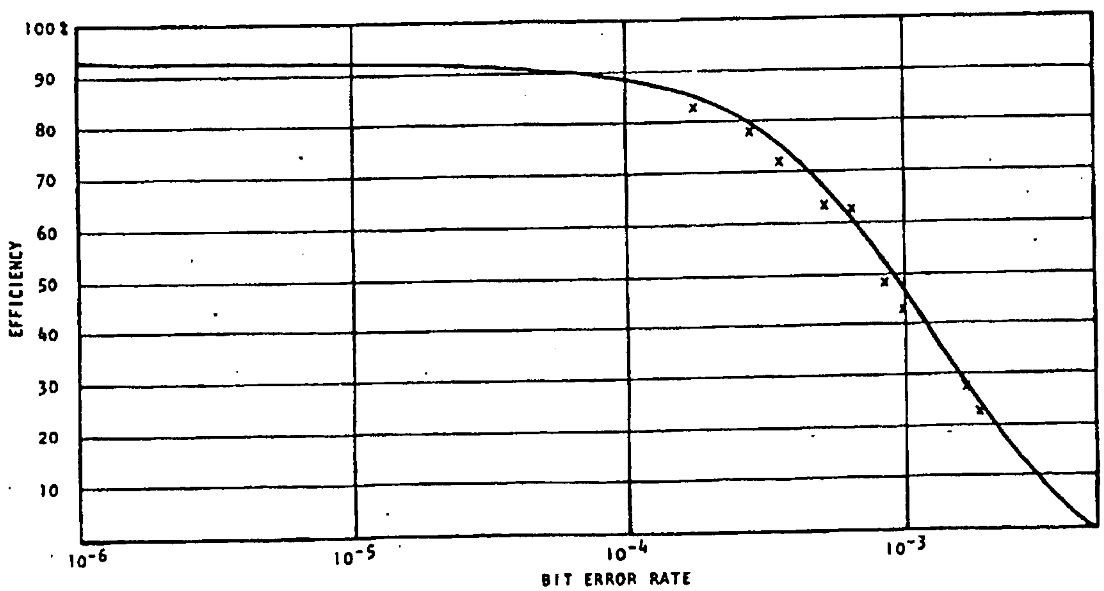

Figure 8. Efficiency Curve, Mode B

REFERENCES

(1) A. G. Gatfield "ARQ Error Control on the Satellite Channel" IEEE International Communications Conf. Record - 1974, pp. 22B-1 - 22B-5.

(2) The Selective Repeat ARQ described herein was developed under contract with COMSAT Laboratories for

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TSG-RAN Working Group 2 (Radio L2 and Radio L3) ***R2-001701***
Sophia Antipolis, France, 21-15 August 2000

Agenda item: 4.1
Source: Siemens
Title: Technical report 25.835 on Hybrid ARQ Type II/III, V0.0.2
Document for: Decision

3G TR 25.835 V0.0.21(2000-08

Technical Repo

3rd Generation Partnership Project
Technical Specification Group Radio Access Network
Report on Hybrid ARQ Type II/II
(Release 2000

Keywords
<keyword[, keyword]>

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Contents

Foreword

This Technical Specification 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;

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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.

1 Scope

This technical report captures the results of the work on the work item "Hybrid ARQ Type II/III". This includes technical solutions and their comparison. The report covers impacts on all RAN WGs.

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.

[<seq>] <doctype> <#>[([up to and including]{yyyy[-mm]|V<a[.b[.c]]>}[onwards])]: "<Title>".

[1] 3G TS 25.123: "Example 1, using sequence field".

[2] 3G TR 29.456 (V3.1.0): "Example 2, using fixed text".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the [following] terms and definitions [given in ... and the following] apply.

Definition format

<defined term>: *<definition>*.

example: text used to clarify abstract rules by applying them literally.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

Symbol format

<symbol> <Explanation>

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

Abbreviation format

<ACRONYM> <Explanation>

4 Background and Introduction

Release 2000 3G TR 25.835 V0.0.21(2000-08)3GTR 25.835 V0.0.21(2000-08)3G TR ab.cde V0.0.0(2000-07)

5 Overview of Hybrid ARQ Type II/III

5.1 General Mechanism

There are different variants of hybrid ARQ methods. The terms hybrid ARQ type I, type II, and type III are used according to the following definition:

Type I hybrid ARQ

The ARQ method used in current 3GPP specifications is referred to as HARQ type I. In this basic HARQ type I the CRC is added and the data is encoded with a forward error correction (FEC) code. In the receiver the FEC code is decoded and the quality of the packet is checked (CRC check). If there are errors in the packet, a retransmission of the packet (RLC-PDU) is requested. The erroneous packet is discarded and retransmissions use the same coding as the first transmission.

Type II hybrid ARQ

The type II HARQ is a so-called Incremental Redundancy ARQ scheme. This means that an RLC-PDU that is to be retransmitted is not discarded but is combined with some incremental redundancy information provided by the transmitter for subsequent decoding.

For type II HARQ the retransmissions are typically not identical with the original transmission. The retransmitted part carries additional redundancy information for error correction purposes. This additional redundancy is combined with the previously received packet and the resulting code word with a higher coding gain is decoded. In hybrid ARQ type II, the retransmitted amount of redundancy is different for each retransmission, and retransmissions can in general only be decoded after combination with previous transmissions.

Type II hybrid ARQ requires that when RLC-PDU are transferred their sequence numbers are signalled with a better error protection than the data part of the RLC-PDU. This is because several versions of the RLC-PDU may need to be combined in the physical layer before it can be decoded and any identifier contained within the RLC-PDU detected.

Type III hybrid ARQ

Like type II hybrid ARQ, type III hybrid ARQ also belongs to the incremental redundancy ARQ schemes. This means that retransmissions concerning one RLC-PDU are not discarded but kept at the receiver for combination with additional information before decoding.

With type II hybrid ARQ, retransmissions containing additional incremental code bits sent for a RLC-PDU, which was initially received with errors, are in general not self decodable. In situations where the transmitted RLC-PDU can be severely damaged, for example, due to interference, it is desirable to have a scheme where any additional information sent is self decodable. In type III HARQ each retransmission is self-decodable. Thus, the data can be recovered from the retransmitted packet without combining if it is transmitted with sufficient quality

Type III places similar requirements on the signalling protocol for external RLC-PDU identification and on the physical layer as type II hybrid ARQ.

Two subcases of hybrid ARQ type III can be distinguished:

- with multiple redundancy versions
  Different versions of a RLC-PDU are created. Different puncture bits are used in each version. If transmission of the first fails then the second version is sent. Transmission of further versions or repeat transmissions of the already transmitted versions may be made and combined.

- with one redundancy version
  In this subcase of HARQ type III, the same FEC coding is used for each retransmission, similar to the operation of HARQ type I. However, the erroneous packets are stored in the receiver and combined with retransmissions of the packet. This is a kind of incremental redundancy coding scheme in the form of a repetition code.

6 Hybrid ARQ Type II/III in UTRAN Layer 2 and Layer 3

6.1 Protocol Architecture

This section gives a general overview of function split for HARQ type II/III in the UE, the Node B, the Controlling or Drift RNC, and the Serving RNC in the UL and DL direction.

The following major functions are shown in table 1 and table 2:

- TX buffering: The buffering of data which should be (re)transmitted at the transmitting side.
- Parameter setting for Redundancy Version selection: It is selected with which redundancy version a certain (re-)transmission of a PDU is done.
- RX soft decision buffering for combining: Buffering of the received initial and retransmitted data for the combining at the receiver side.
- RX buffering for RLC-SDU reassembly: Buffering of the RLC-PDUs to reassemble them to RLC-SDUs.
- Combining of retransmissions: Combining of the initially transmitted and retransmitted data for error correction.

	UE	Node B	CRNC / DRNC	SRNC
TX buffering	RLC	-	-	-
Parameter setting for Redundancy Version selection	RLC	-	-	-
RX soft decision buffering for combining	-	Layer 1	-	-
RX buffering for RLC-SDU reassembly	-	-	-	RLC
Combining of retransmissions	-	Layer 1	-	-

Table 1: Function split for hybrid ARQ type II/III in the UE, NodeB, CRNC/DRNC, and SRNC in UL direction

	UE	Node B	CRNC / DRNC	SRNC
TX buffering	-	-	-	RLC
Parameter setting for Redundancy Version selection	-	-	-	RLC
RX soft decision buffering for combining	Layer 1	-	-	-
RX buffering for RLC-SDU reassembly	RLC	-	-	-
Combining of retransmissions	Layer 1	-	-	-

Table 2:-Function split for hybrid ARQ type II/III in the UE, NodeB, CRNC/DRNC, and SRNC in DL direction

To perform the HARQ type II / III operation the physical layer requires additional side information, e.g. sequence number, redundancy version, and logical channel identification. The setting of these parameters should be under control of RLC. A coordinated data flow of user data and side information from RLC to MAC and L1 is required (see

figure 1). The physical layer can encode the data and the side information separately, and map them on one or possibly even different physical channels. At the receiver the buffering and recombining of the data is performed.

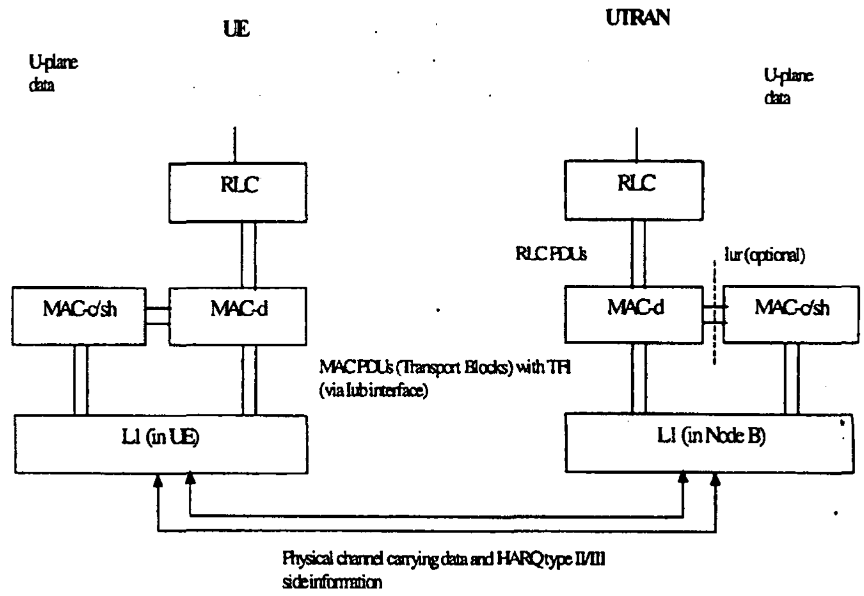

Figure 1 Protocol stack overview for hybrid ARQ type II/III.

Dotted lines visualise the transport of necessary side information for hybrid ARQ type II/III operation between RLC and the Physical Layer. Solid lines show the transport of user data.

Two different models for handling the additional requirements for hybrid ARQ type II/III in Layer 2 and Layer 3 have been proposed and are described in this report.

Case A: One logical channel is used for the transfer of user data and side information between RLC and MAC, and one transport channel is used for the transfer of user data and side information between MAC and physical layer.

Case B: Two separate logical channels are used for the transfer of user data and side information between RLC and MAC, and two separate transport channels are used for the transfer of user data and side information between MAC and physical layer.

6.2 Usage of logical channels and transport channels

6.2.1 Usage of logical channels and transport channels with Case A

The necessary side information for hybrid ARQ type II/III operation is included in the same logical channel as the RLC PDU data. This logical channel can be mapped to the following transport channels:

a) DTCH can be mapped onto the DCH.

b) DTCH can be mapped onto the DSCH

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c) DTCH can be mapped onto the DSCH, but with transmission of side information over DPCH

d) DTCH can be mapped onto the USCH

As already possible in release 99, a second logical channel can be used for RLC control PDUs. The use of this second logical channel is independent from the hybrid ARQ type II/III operation.

6.2.2 Usage of logical channels and transport channels with Case B

The hybrid ARQ user data and side information can be produced onto two PDUs, respectively. User data and side information can be transmitted to MAC-d as following cases;

a) DTCH can be mapped onto the DCH.

b) DTCH can be mapped onto the DSCH

c) DTCH can be mapped onto the DCH and DSCH

The HARQ user data and side information are produced as each RLC PDU and are mapped onto two signals. Since RLC and MAC-d are located in a RNC, the co-ordination between both signals is a kind of implement issue(for example, using an indicator between HARQ user data and side information).

6.32 Usage of transport channels and physical channels

6.3.1 Usage of transport channels and physical channels with Case A

The hybrid ARQ user data and side information can be transmitted on the dedicated or shared channels. Following cases can be considered.

a) DCH can be mapped onto the DPCH

b) DSCH can be mapped onto the PDSCH

c) DSCH can be mapped onto the PDSCH + DPCH

d) USCH can be mapped onto the PUSCH

ad a) ,b), and d) The HARQ user data and side information is mapped onto the same Physical Channel. Since one physical channel is always generated by a common processing chain in Layer 1, no special co-ordination of the user data and the side information at the physical layer is needed, as long as the MAC and RLC layer ensure a synchronised delivery of user data and side information to the Layer 1.

ad c) The hybrid ARQ type II/III user data can be mapped on a different physical channels than the side information. This scenario is especially interesting for the transmission of the user data over the downlink shared channel, while the side information is transmitted over a more reliable dedicated channel. The use of two independent physical channels requires special attention for the co-ordination of the transmissions on both channels, because the data flow through MAC and Layer 1 may be different. This is the case for the simultaneous use of DCH and DSCH, which may be influenced by variable and unknown delays, e.g. transmission over the Iur interface and scheduling in MAC-c/sh of the controlling RNC.

6.3.2 Usage of transport channels and physical channels with Case B

The hybrid ARQ user data and side information can be transmitted on the dedicated or shared channels. Following cases can be considered.

a) DCH can be mapped onto the DPCH

b) DSCH can be mapped onto the PDSCH

c) DCH and DSCH can be mapped onto the DPCH and PDSCH, respectively

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ad a) and b) The HARQ user data and side information are mapped onto the same Physical Channel(s). Since one physical channel is always generated by a common processing chain in Layer 1, no special co-ordination of the user data and the side information at the physical layer is needed, as long as the MAC ensures a synchronised delivery of one(or two) signal(s) to the Layer 1.

ad c) The HARQ user data and side information can be separated at MAC and be mapped onto two different transport channels(i.e. DSCH and DCH). When there are both MAC-d and MAC-c/sh in one RNC, the synchronisation between DSCH and DCH can be done according to the scheduling result of MAC-c/sh. Each transport channel can be mapped onto the related physical channel (i.e. DSCH onto PDSCH, DCH onto DPCH).

6.43 Examples of Interlayer Procedures

~~6.3.1 Data Transfer on Uplink~~

~~6.3.2 Data Transfer on Downlink~~

6.4.1 Examples of Interlayer Procedures for Case A

6.4.1.1 Data Transfer on Uplink

Following Figure is a modification of "Data Transfer on USCH" as specified in [2]. Additional detail of the data transfer in the user plane is shown . The shaded area of the Figure corresponds to a single uplink transmission

MAC-Data-REQ → USCH:Data → MAC-Data-IND

and is equally valid for usage on other transport channels, e.g. DCH.

If the transmission on the Uu interface is corrupted, the physical layer on the receiving side needs to retrieve the Hybrid ARQ parameter list of the corrupted data in order to perform Type II operation. Therefore, it is needed that the parameter values be stronger encoded on the physical layer than the associated data. Subsequent retransmissions send incremental redundancy to the already transferred data. Which redundancy version of the data is sent is indicated through the redundancy version parameter ("Red.Vers.") which is signalled together with all the transmissions. Each time an incremental redundancy version of the data is received, the physical layer attempts to decode the concatenated versions of all previous transmissions.

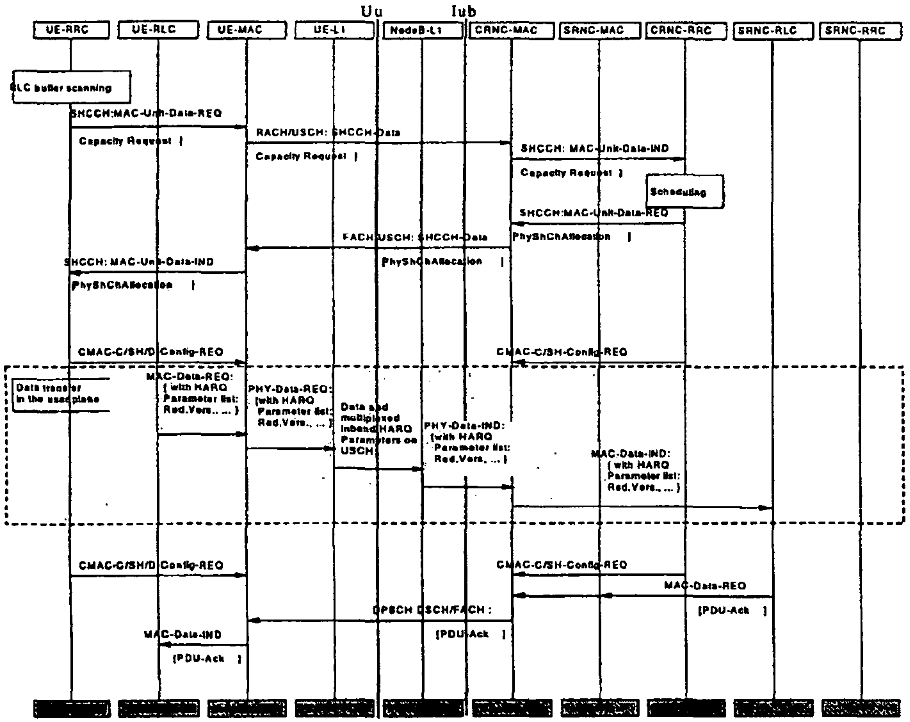

Figure 2 Example procedure for uplink data transfer using hybrid ARQ type II/III on USCH.

The relevant part in the shaded area is equally valid for usage on other transport channel, e.g. DCH.

6.4.1.2 Data Transfer on Downlink

The following figure is a modification of the "Data Transfer on DSCH" as specified in [2]. Additional detail of the data transfer in the user plane is shown. The shaded area of the figure corresponds to a single downlink transmission

MAC-Data-IND ← DSCH:Data ← MAC-Data-REQ

and is equally valid for usage on other transport channel, e.g. DCH.

In case of corrupted transmission on the Uu interface, the same procedure which was already described for the uplink case (in section 6.3.1) applies.

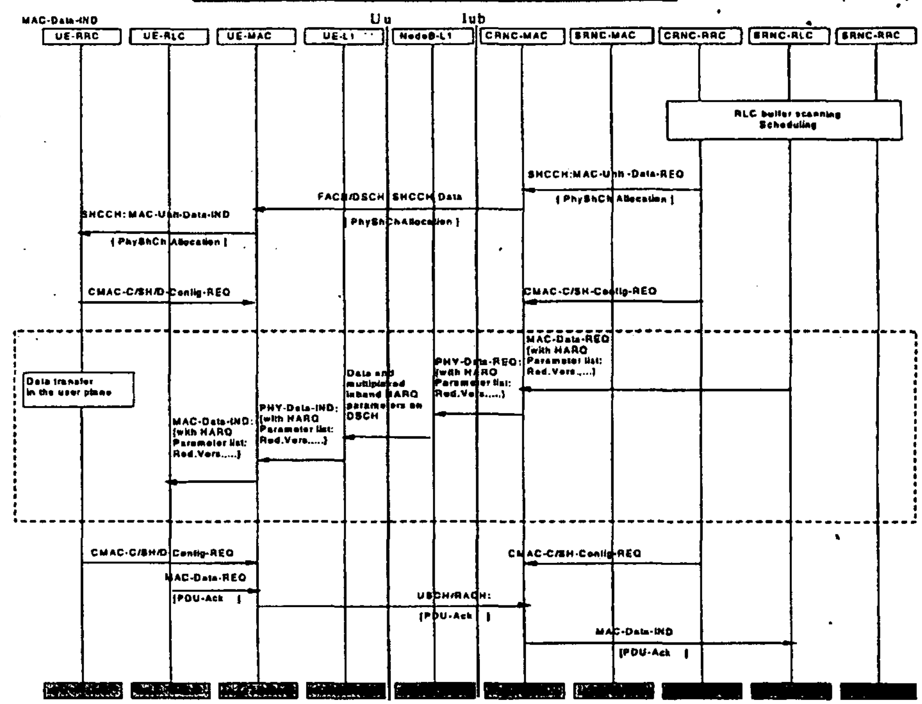

Figure 3 Example procedure for downlink data transfer using hybrid ARQ type II/III on DSCH in TDD mode.

The relevant part in the shaded area is equally valid for usage on other transport channel, e.g. DCH.

6.4.1.3 Data Transfer on Downlink with DCH+DSCH

Several ways for operating hybrid ARQ type II/III with user data transmission over a downlink shared channel while transmitting the side information necessary for combining at the receiver (e.g. sequence number, redundancy version) over a more reliable dedicated physical channel are possible.

It is important to assure that the user data and the corresponding side information are transmitted synchronously over both channels to allow correct decoding at the receiver. Due to the different handling of dedicated and shared channels in the MAC layer, this synchronisation is difficult to achieve by using different logical channels.

Also, additional problems arise if the controlling RNC is not equal to the serving RNC, because the Iur interface with high transmission delays has to be involved. In the case of an involved Iur interface, it is suggested not to split data and side information on different channels.

A similar synchronisation problem on downlink shared channels and dedicated physical channels was already solved in release 99 for the TFCI transmission using logical split of TFCI-word for the transport format on the DSCH. With small extensions, this mechanism could also be used to support the hybrid ARQ type II/III case.

The following text and figure have been copied from 25.303V3.4.0. In the figure, three legends have been added to mark the important details which can be used to transfer side information for hybrid ARQ type II/III on the dedicated physical channel.

In the figure, the parameter "HARQ type II/III side information" has been added to the existing procedure at the appropriate places to show how a transmission of hybrid ARQ type II/III encoded data using this mechanism could work.

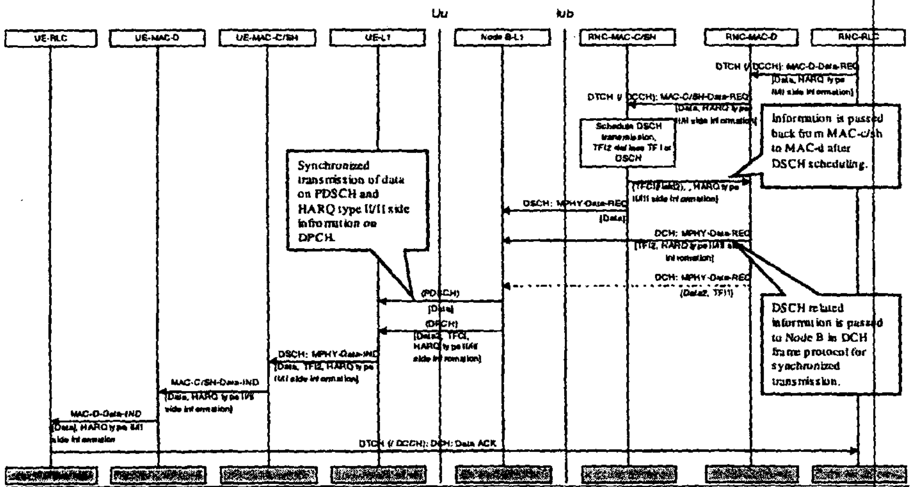

Figure 4 Data flow for Acknowledged-mode data transmission on DSCH using logical split of TFCI-word and split transmission of hybrid ARQ type II/III data and side information.

6.4.2 Examples of Interlayer Procedures for Case B

Following some flowcharts about the HARQ type II/III scheme for case B scheme

The basic scheme is as follows:

- When RLC receives the data, RLC processes the data based on release 99 specification and produces a new PDU including the side information about data PDU, i.e. RLC PDU sequence number, RLC PDU version based on previous signalling.
- Both data PDU and a new PDU including side information, which are produced in RLC, are transmitted to MAC-d.
- DTCH(s) including the side information and data PDU is(are) mapped to DCH transport channel through MAC-d or(and) DSCH transport channel through MAC-d and MAC-c/sh.
- Data PDU and side information are transmitted to a receiver through DPCH or(and) PDSCH.

In this document, each scheme in following cases is explained, when CRNC and SRNC are existed in a system.

Case 1) HARQ user data and side information are transmitted to receiver using one physical channel, DPCH.

Case 2) HARQ user data and side information are transmitted to receiver using one physical channel, PDSCH.

Case 3) HARQ user data and side information are separately transmitted to receiver using two physical channels, DPCH and PDSCH.

These cases are explained at following sections.

6.4.2.1 HARQ user data and side information are transmitted to receiver using one physical channel, DPCH

Case 1

This case can be applied to downlink and uplink HARQ type II/III.

The flowchart for downlink in Case 1

Figure 5 shows a flowchart when the proposed scheme supports downlink.

In this case, RLC produces two signals whose primitive form is one, MAC-DATA-REQ. One of the produced signals includes the HARQ user data and the other includes the side information of the associated HARQ user data.

As shown in figure 5, the flowchart is similar to Release 99.

The difference is as follows:

- When RLC produces data signal, RLC produces two signals, one including HARQ user data and the other including side information.
- Both produced signals are transmitted to Node B through MAC-d.
- When layer 1 of UE receives the data and separates it to HARQ user data part and side information part, the HARQ user data part is stored at buffer of layer 1 and the side information part is transmitted to MAC-d as primitive PHY-DATA-IND. In this point, data indicator, which is a parameter to indicate the relation between HARQ user data and side information, is added to the primitive, PHY-DATA-IND.
- When RLC receives the side information part with data indicator, RLC sends the side information and data indicator to RRC. This operation is done because there is no direct connection between RLC and layer 1.
- RRC sends the received information to Layer 1.

The flowchart for uplink in Case 1

Figure 6 shows a flowchart when the proposed scheme supports uplink.

In this case, the basic functions are same as one of section 2.1.1.

The differences are follows:

- The transmitter and receiver is changed, that is, in section 2.1.1, the transmitter and receiver are UTRAN and UE, respectively. By the way, in this section, they are opposite.
- In receiver, UTRAN, the received data is transmitted from Node B to upper layer through Iub.

6.4.2.2 HARQ user data and side information are transmitted to receiver using one physical channel, PDSCH

As shown in figure 7, this case can be applied to downlink HARQ type II/III.

In this case, the basic functions are same as one of (case 1).

The differences between (case 1) and (case 2) are as follows:

- When MAC-d received data and side information, they are transmitted from MAC-d to MAC-c/sh for using the DSCH.
- The TFI information about DSCH including HARQ user data and side information is transmitted from MAC-c/ to MAC-d according to Release 99.

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6.4.2.3 HARQ user data and side information are separately transmitted to receiver using two physical channels, DPCH and PDSCH

As shown in figure 8, this case can be applied to downlink HARQ type II/III.

In this case, the basic function is similar with one of (case 1).

The differences between (case 1) and (case 3) are as follows:

- When MAC-d received data and side information, the data is transmitted to MAC-c/sh and the side information waits for the response(i.e. TFI of DSCH) of MAC-c/sh.
- Data is transmitted from MAC-c/sh to Node B through PHY-DATA-REQ primitive.
- "The TFI about DSCH and TFI about DCH and side Information" are transmitted from MAC-d to Node B through PHY-DARQ-REQ primitive.
- The HARQ user data and side information are transmitted to UE through PDSCH and DPCH, respectively.

Examples

Following some call flows about some HARQ schemes

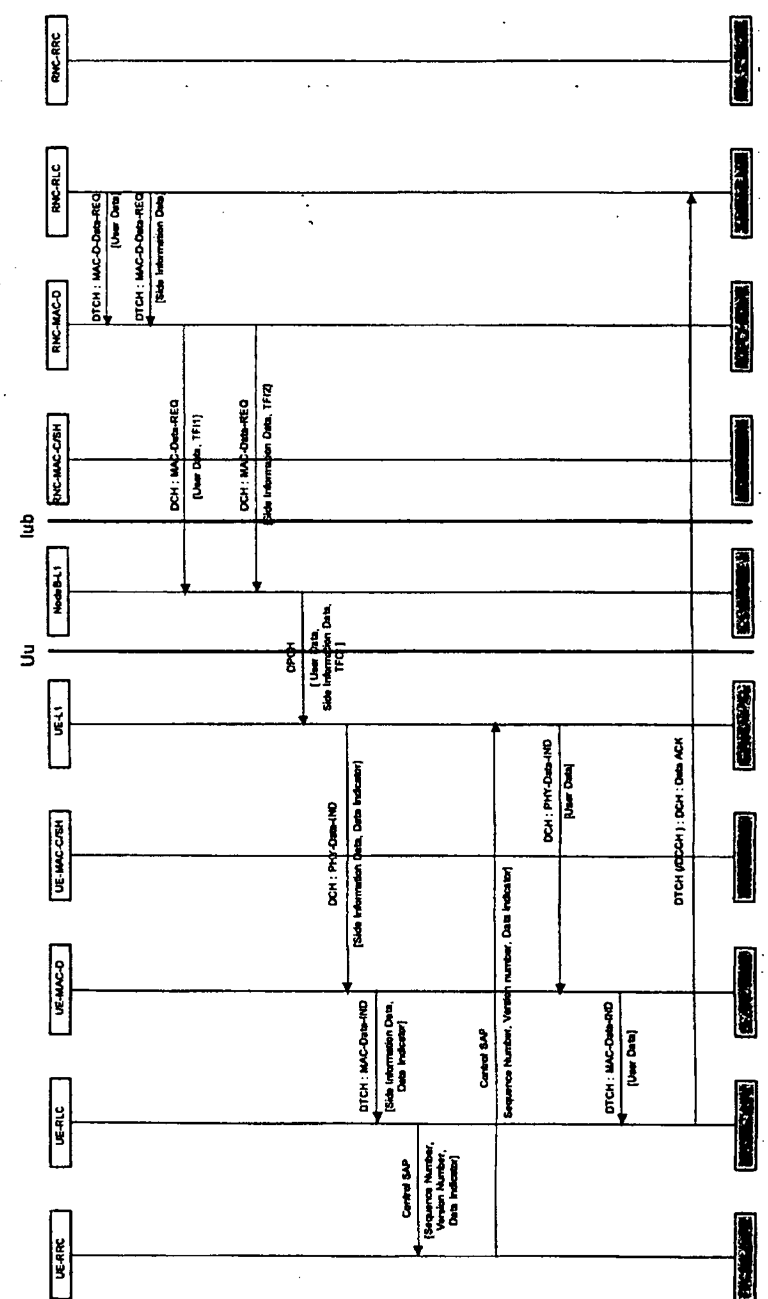

Figure 6 Example downlink procedure when HARQ user data and side information are transmitted to receiver using a one physical channel, DPCH

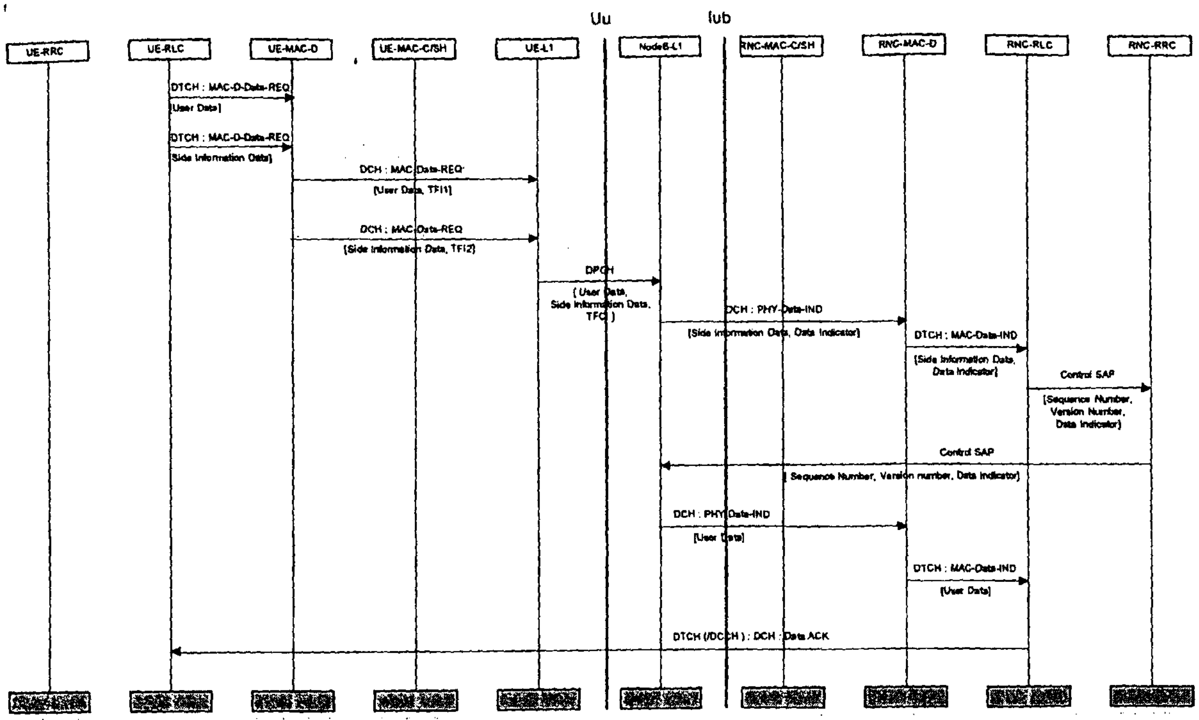

Figure 6 Example uplink procedure when HARQ user data and side information are transmitted to receiver using a one physical channel, DPCH.

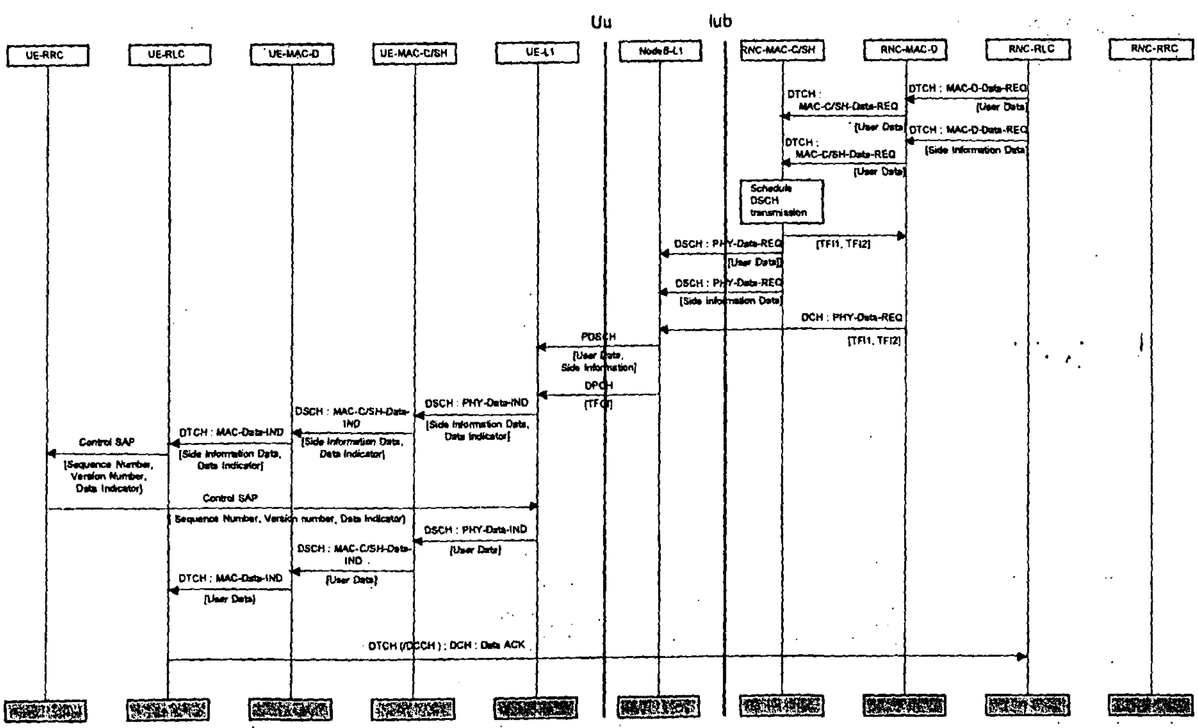

Figure 7 Example downlink procedure when HARQ user data and side information are transmitted to receiver using a one physical channel, PDSCH.

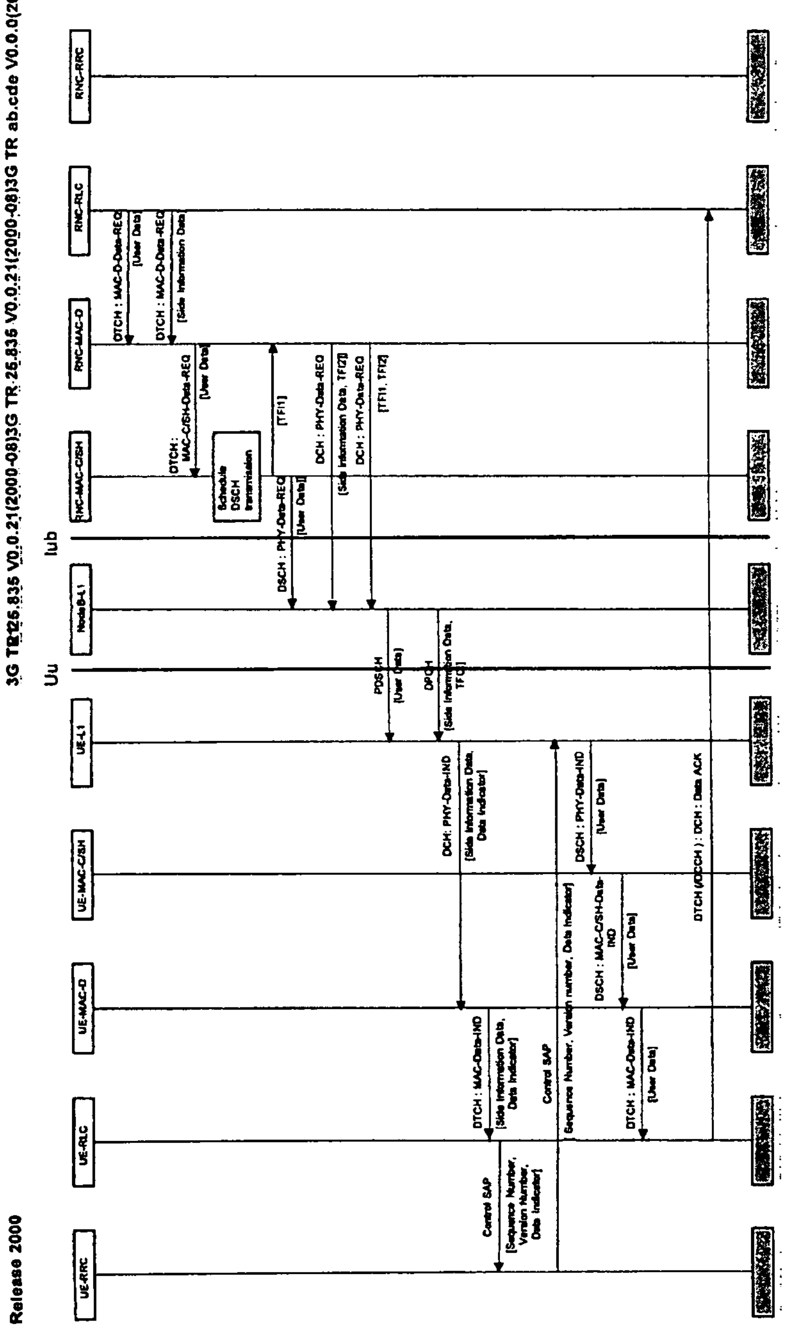

Figure 8 Example downlink procedure when HARQ user data and side information are separately transmitted to receiver using two physical channels, DPCH and PDSCH.

6.54 Services provided by~~Interface to~~ the Physical Layer

6.54.1 Functions of Layer 1

The main functions of the physical layer are listed in [1]. The following additional functions have to be performed for hybrid ARQ type II/III operation:

- redundancy selection, buffering, and combining for hybrid ARQ type II/III data
- encoding/decoding, transmission, and error detection on hybrid ARQ type II/III side information

6.54.2 Interface to Layer 1

6.5.2.1 Interface to Layer 1 for Case A

According to the function split shown in section 6.1, major parts of the functionality for hybrid ARQ type II/III have to be performed in the physical layer. This requires some changes to the interface between MAC and the physical layer, because in addition to the user data, hybrid ARQ type II/III side information for the redundancy selection and to allow combining of retransmissions at the receiver has to be passed from MAC to Layer 1.

The interface between MAC and Layer 1 is described by primitives in [1]. On the transmitting side, data transfer from MAC to Layer 1 is handled by the PHY-DATA-REQ primitive, which passes a TFI (Transport Format Indicator) and a TBS (Transport Block Set) as parameters.

On the receiving side, the PHY-DATA-IND primitive passes the received data with the parameters TFI, TBS, and CRC result from the Layer 1 to the MAC. No indication primitives from MAC to the physical layer are available on the receiving side. This implies, that all necessary side information for hybrid ARQ type II/III operation, i.e. the PDU sequence number and the redundancy version, have to be passed to Layer 1 already on the transmitting side, if major changes to the interface between MAC and physical layer are not desired.

The following extension to the primitives from Release 99 allow hybrid ARQ type II/III operation under these assumptions:

- To the PHY-DATA-REQ primitive on the transmitting side, the parameters of the required side information for hybrid ARQ type II/III are added. If the transport block set contains more than one Transport block , the side information parameters should be submitted for each TB. Therefore, lists for each parameter with one entry per transport block are required. These are:
  - List of PDU sequence number
  - List of Redundancy version
  - List of Logical channel identification equal to the C/T field of the MAC header, if more than one logical channel is mapped on the hybrid ARQ type II/III coded transport channel.
- To the PHY-DATA-IND primitive on the receiving side, for basic operation no parameters have to be added.

  Additional error checking and performance improvements may be possible, if the following parameters are added to the PHY-DATA-IND (ffs):
  - List of PDU sequence number
  - List of Redundancy version
  - List of Logical channel identification equal to the C/T field of the MAC header, if more than one logical channel is mapped on the hybrid ARQ type II/III coded transport channel.

6.5.2.2 Interface to Layer 1 for Case B

In this case, the HARQ user data and side information are separately transmitted from MAC to Layer 1.

On the transmitting side, data transfer from MAC to Layer 1 is handled by the PHY-DATA-REQ primitive, which passes a TFI (Transport Format Indicator) and a TBS (Transport Block Set) as parameters. The HARQ user data and side information are transmitted from MAC to Layer 1 with same primitive format, PHY-DATA-REQ.

On the receiving side, the PHY-DATA-IND primitive passes the received data with the parameters TFI, TBS, and CRC result from the Layer 1 to the MAC. If PHY-DATA-IND includes the side information which is produced by transmitter, an additional information is also inserted at the primitive, PHY-DATA-IND. The role of additional information is to indicate the relation between HARQ user data and side information.

The following extension to the primitives from Release 99 allow hybrid ARQ type II/III operation under these assumptions:

- To the PHY-DATA-REQ primitive on the transmitting side, the parameters of the primitive is as same as one which is defined at Release 99.
- To the PHY-DATA-IND primitive on the receiving side, the parameter for hybrid ARQ type II/III is added. There is:
  - Data indicator which is a parameter to indicator the relation between HARQ user data and side information

6.65 MAC Protocol

6.6.1 MAC Protocol for Case A

No major changes to the MAC protocol have been identified. In case of multiple logical channels mapped on one hybrid ARQ type II/III transport channel, the logical channel identification as contained in the C/T field has to be passed to Layer 1 on the transmitting side to allow separation of data flows form different RLC engines in Layer 1.

6.6.2 MAC Protocol for Case B

No major changes to the MAC protocol have been identified. Some additional functionality can be needed. The details of this additional functionality are ffs.

6.76 RLC Protocol

6.7.1 RLC Protocol for Case A

For the adaptation of the RLC protocol to hybrid ARQ type II/III operation, no major changes have been identified. The RLC PDU format should be the same as for Release 99.

The sequence numbers are handled in the same way as for Release 99.

For the setting of the redundancy version different algorithms can be considered. One of the solution is to increment the redundancy version for each retransmission of a PDU, and to start from the beginning when the highest possible redundancy version has been send. However, other solutions to select the redundancy version may also be possible.

Some additional functionality for the selection of the redundancy version for each hybrid ARQ type II/III PDU is needed. The details of this selection are ffs.

6.7.2 RLC Protocol for Case B

No major changes to the RLC protocol have been identified.

Some additional functionality as following will be needed.

- Produce about a new PDU for side information of HARQ type II/III

The details of this additional functionality are ffs.

6.87 RRC Protocol

6.8.1 RRC Protocol for Case A

Some additional parameters for the configuration of hybrid ARQ type II/III will be required. No need for new procedures or modifications of the existing procedures has been identified. The details of the additional parameters are ffs.

6.8.2 RRC Protocol for Case B

No major changes to the RRC protocol have been identified.

Some additional functionality as following will be needed.

- Configuration RLC protocol for hybrid ARQ type II/III operation.
- Configuration RLC protocol for producing new PDU including side information of hybrid ARQ type II/III
- Support the interface RRC protocol and RLC protocol for hybrid ARQ type II/III operation
- Support the interface RRC protocol and Physical layer for hybrid ARQ type II/III operation

The details of this additional functionality are ffs.

7 Physical Layer impacts

7.1 Overview of physical layer mechanisms

7.2 Performance evaluation

7.3 Impacts to UE and Node B complexity

One important aspect to consider is the complexity of introducing HARQ into Release -00. When considering specification changes, the easy way to create HARQ functionality would be to add it on top of the existing RLC ARQ protocol. In this case ACKs are communicated between UE and RNC RLCs, and soft combining is done on L1. However, RLC level round trip delay (ca 120 ms) and polling period (ca 80 ms) for ACKs makes the buffer memory requirement in UE L1 considerable.

The number of symbols to be buffered in L1 receiver can be estimated roughly as follows:

$$buffer = \left(coded\ bits_{RCL\ PDU} \times failed\ PDUs\ in\ TTI \times (latency_{retransmit} + latency_{NACK})\right)$$

where it is assumed for the sake of clarity that an integer number of RLC PDUs fit into one L1 TTI. The latencies are also considered as multiples of a TTI. For HARQ with soft combining all retransmissions are combined and stored in the same location as the first transmitted symbol, so the number of retransmissions does not directly reflect on the buffering need. Type II HARQ is sending smaller blocks than type I with soft combining, but in practice one has to reserve room for a whole symbol in the receiver for assembling the incremental information; thus type I and type II buffering does not differ a lot if the lowest encoding rate is the same.

In practical cases, with a total latency around 200 ms, there is a need to buffer several tens of ksymbols of soft symbol decisions in the receiver. Depending on how many bits are used to represent a soft symbol in the decoding stage this memory requirement becomes a multiple of the soft symbol memory usage.

8 Impacts on UTRAN Interfaces

8.1 Impacts on Iub

8.2 Impacts on Iur

9 Specification Impacts

History

Document history		
Date	**Version**	**Comment**
July 2000	0.0.0	First draft
August 2000	0.0.1	Table of Contents and Scope added after decision at RAN2#14
August 2000	0.0.2	The text from the e-mail discussion between RAN2#14 and RAN2#15 was added.
Editor for 3G TR 25.835 is:		
Armin Sitte Siemens AG Tel. : +49 30 386 29077 Fax : +49 30 386 25548 Email : Armin.Sitte@icn.siemens.de Reinhard Köhn Siemens AG Tel. : +49 30 386 29041 Fax : +49 30 386 25548 Email : Reinhard.Koehn@icn.siemens.de		
This document is written in Microsoft Word version.		