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(54) METHOD OF TRANSMITTING SCHEDULING REQUESTS OVER UPLINK CHANNELS

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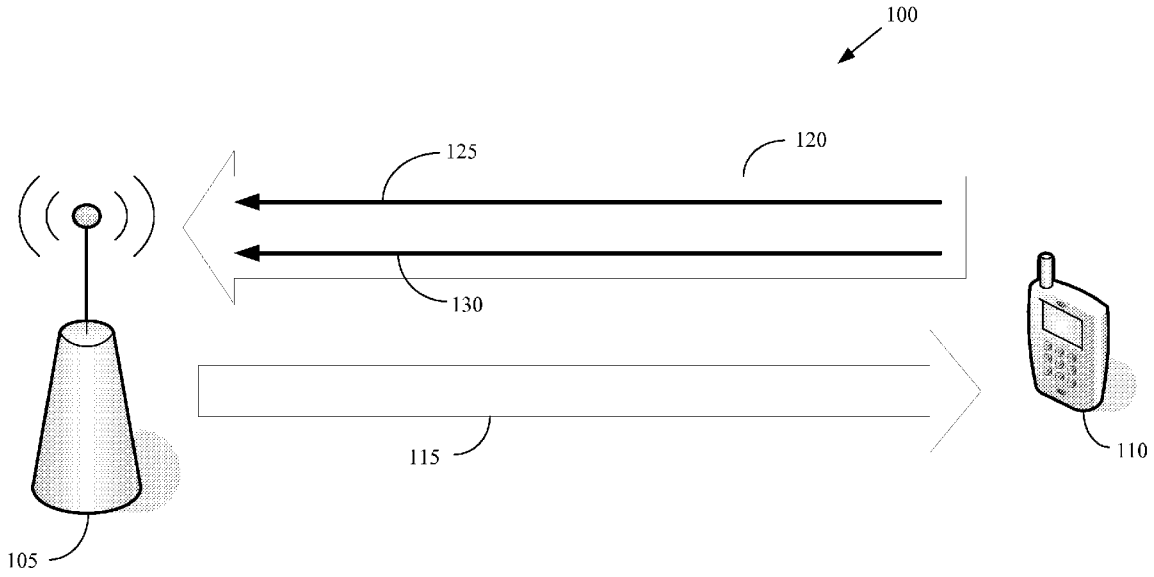
(57) **ABSTRACT**

In various embodiments of the present invention, methods are provided for transmitting scheduling requests over uplink channels. One embodiment includes determining whether a first resource for transmission of a scheduling request over an unscheduled uplink control channel is allocated concurrently with a second resource for transmission of user data over a scheduled uplink shared channel. This embodiment also includes encoding the user data and bit(s) of control information to form encoded information for transmission using the second resource. The additional bit(s) indicate whether the mobile unit is transmitting the scheduling request. Another embodiment includes determining whether a first resource for transmission of a scheduling request over an unscheduled uplink control channel is allocated concurrently with a second resource for transmission of other control information over the unscheduled uplink control channel. This embodiment includes modulating the scheduling request and the other control information into one symbol for transmission using the first resource.



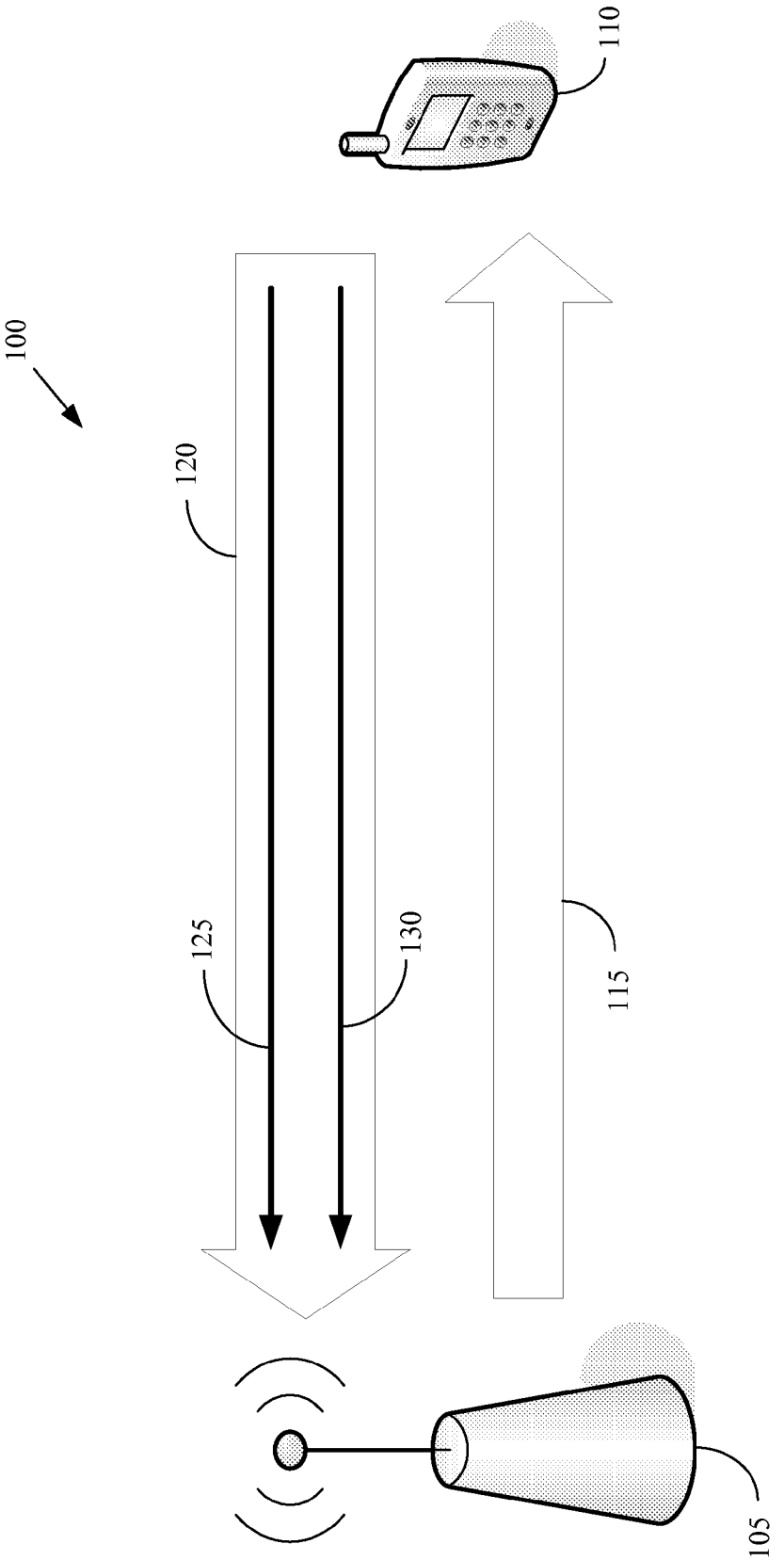



Figure 1

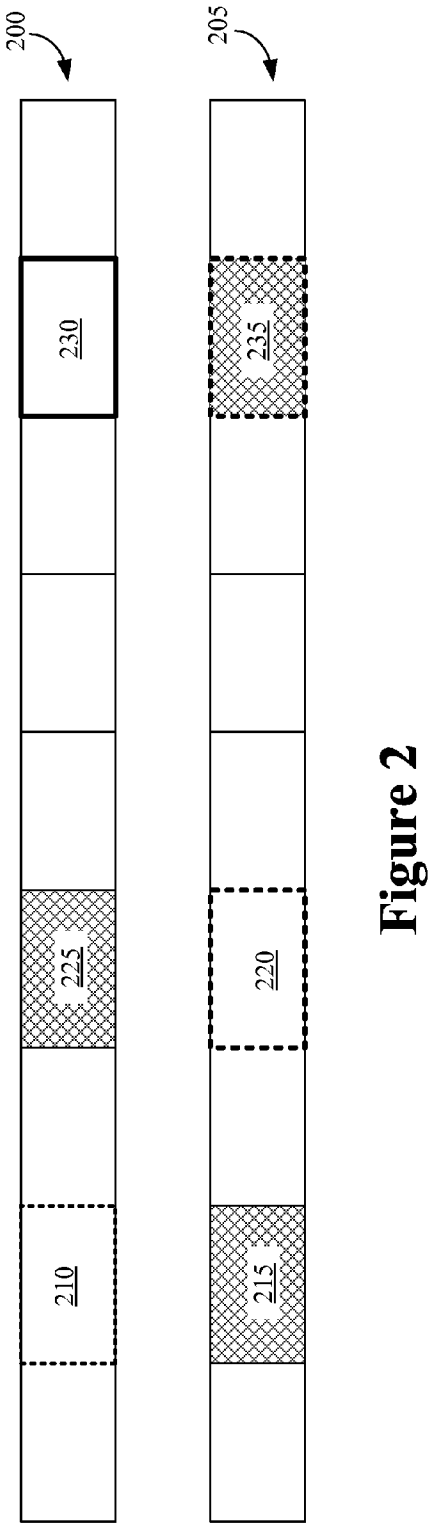



Figure 2

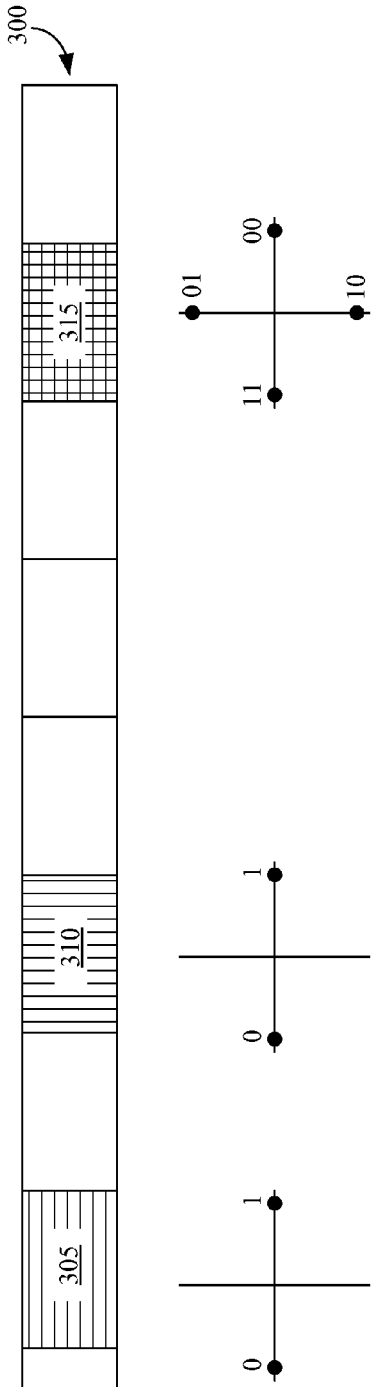



Figure 3

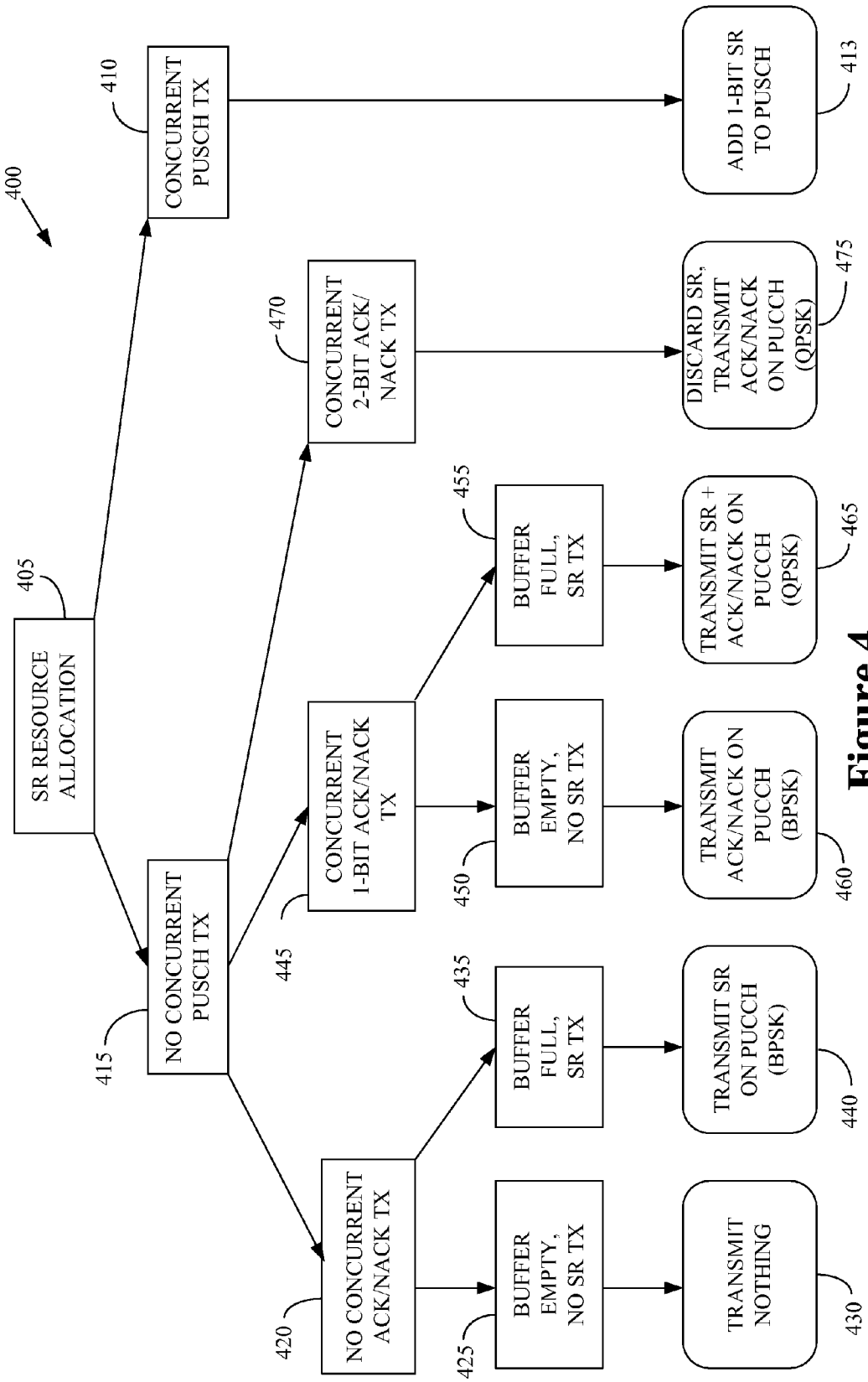



Figure 4

# METHOD OF TRANSMITTING SCHEDULING REQUESTS OVER UPLINK CHANNELS

## BACKGROUND OF THE INVENTION

**[0001]** 1. Field of the Invention

**[0002]** This invention relates generally to communication systems, and, more particularly, to wireless communication systems.

**[0003]** 2. Description of the Related Art

**[0004]** The coverage area of a wireless communication system is typically divided into a number of cells or sectors, which may be grouped into one or more networks. Base stations provide wireless connectivity to the cells or sectors within the wireless communication system. Alternatively, wireless connectivity may be provided by access points, base station routers, access networks, and the like. Mobile units located in each cell may access the wireless communications system by establishing a wireless communication link, often referred to as an air interface, with the base station associated with the cell or sector. The mobile units may also be referred to using terms such as access terminal, user equipment, subscriber station, and the like. The mobile units may include devices such as mobile telephones, personal data assistants, smart phones, Global Positioning System devices, wireless network interface cards, desktop or laptop computers, and the like.

**[0005]** The wireless communication link typically includes one or more downlink (or forward link) channels for transmitting information from the base station to the mobile unit and one or more uplink (or reverse link) channels for transmitting information from the mobile unit to the base station. The uplink and downlink channels include data channels for transmitting data traffic, signaling or control channels to carry control information that is used to decode the data channels, paging channels for locating mobile units, broadcast channels for broadcasting information to multiple mobile units, multicast channels for broadcasting information to a subset of mobile units that have subscribed to the multicast service, and the like. The channels may be shared by multiple mobile units or dedicated to one mobile unit at a time. Channels can be defined using different time slots (e.g., Time Division Multiple Access or TDMA), frequencies (e.g., Frequency Division Multiple Access or FDMA), code sequences (e.g., Code Division Multiple Access or CDMA), orthogonal subcarrier frequencies or tones in a carrier frequency band (e.g., Orthogonal Frequency Division Multiplexing or OFDM), or combinations thereof.

**[0006]** Each base station typically provides wireless connectivity to more than one mobile unit. Consequently, air interface resources are shared between the multiple mobile units. For example, mobile units may share one or more uplink channels to a base station. When a mobile unit has information to transmit over the uplink channel, such as a data burst, the mobile unit transmits a scheduling request to request access to the uplink channel. The mobile unit then waits to transmit information over the uplink channel until after receiving an access grant from the base station. The access grant typically indicates the resources that have been allocated to the mobile unit to transmit the information, such as a timeslot, a channel code, a frequency or tone, and the like. The mobile unit relinquishes the channel once the data burst has been transmitted. Base stations that implement these so-

collisions between different mobile units attempting to transmit over the same uplink channel. The base station may also schedule access to the air interface resources to take advantage of fluctuations in channel conditions.

**[0007]** In next generation wireless systems like the Universal Mobile Telecommunication System (UMTS) Long-Term Evolution, mobile units are required to transmit certain types of control messages in a portion of the uplink and downlink data that is transmitted in an unscheduled mode that is distinct from a scheduled mode that may be used to transmit other portions of the user and control data that are scheduled explicitly by the base station system. For example, systems like UMTS-LTE implement physically different channels for scheduled user and control data (e.g., the physical uplink shared channel or PUSCH) and unscheduled control data (e.g., the physical uplink control channel or PUCCH) that are transmitted in different frequency bands or sub-bands and may make use of different modulation and coding schemes. Time and frequency resources may be pre-allocated to both the scheduled and unscheduled channels. However, due to constraints on the peak-to-average power of the transmitter, the UMTS-LTE standards specify that information cannot be transmitted concurrently on the scheduled and unscheduled channels by the same mobile unit. For example, when a mobile unit is scheduled to transmit data via the PUSCH in a specific timeslot, it may not send control data concurrently via the PUCCH. The mobile units can transmit via the scheduled PUSCH only when explicitly signaled by the scheduler from the base station system, but the mobile units can use the PUCCH at regular pre-allocated time intervals.

**[0008]** Three types of control information are typically transmitted over unscheduled uplink data channels such as the PUCCH defined in UMTS-LTE. Acknowledgement and/or Non-Acknowledgement (ACK/NAK) messages may be transmitted over the uplink in response to receiving downlink data from a base station. An ACK message is transmitted to acknowledge successful reception of each downlink block of data is acknowledged on correct reception and a NACK message is sent if a failure is detected during the reception. The NACK messages may trigger a retransmission of the unsuccessfully received data. Channel Quality Information (CQI) that indicates the quality of signals received on the downlink is transmitted over the uplink at predetermined periodic intervals. Mobile units may also transmit scheduling requests over the uplink in order to request resources in the scheduled data channels such as the PUSCH. For example, a mobile unit may transmit a scheduling request when its transmit buffer is filled.

**[0009]** Timing of the uplink control data transmissions must be known to both the base station and the mobile units. In conventional wireless communication systems, the ACK/NACK messages are transmitted over the scheduled uplink channel a selected amount of time after the associated downlink transmission. Both the mobile unit and the base station know the value of the delay between reception of a downlink data block and transmission of the ACK/NACK over the uplink. The CQI is transmitted at regular intervals using a pre-allocated resource. For example, the CQI may be transmitted in predetermined time slots using a predetermined group of subcarriers and code sequence. Thus, the base station knows when the mobile unit will be transmitting CQI over the uplink. Uplink channel resources are also pre-allo-

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