(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 October 2012 (11.10.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/138089 A1

(51) International Patent Classification:
H04W 24/10 (2009.01) *H04W 72/14* (2009.01)
H04W 88/02 (2009.01)

(21) International Application Number:
PCT/KR2012/002460

(22) International Filing Date:
2 April 2012 (02.04.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10-2011-0030442 2 April 2011 (02.04.2011) KR

(71) Applicant (*for all designated States except US*): **PANTECH CO., LTD.** [KR/KR]; Pantech R&D Center, I-2 DMC, Sangam-dong, Mapo-gu, Seoul 121-270 (KR).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **AHN, Jae Hyun** [KR/KR]; Pantech Bldg., I-2 DMC, Sangam-dong, Mapo-gu, Seoul 121-270 (KR). **JUNG, Myung Cheul** [KR/KR]; Pantech Bldg., I-2 DMC, Sangam-dong, Mapo-gu, Seoul 121-270 (KR). **KWON, Ki Bum** [KR/KR]; Pantech Bldg., I-2 DMC, Sangam-dong, Mapo-gu, Seoul 121-270 (KR).

(74) Agent: **OH, Jae Eon**; Essen Patent & Law Firm, 2F. Samheung Yeoksam Bldg., 735-10 Yeoksam-dong, Gangnam-gu, Seoul 135-080 (KR).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

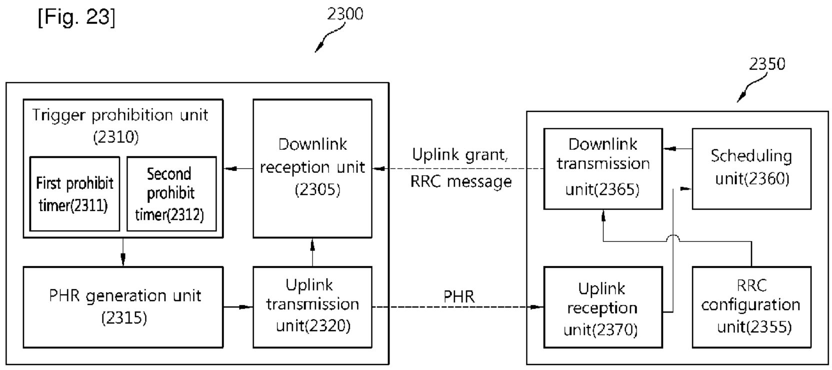
Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: APPARATUS AND METHOD FOR PERFORMING POWER HEADROOM REPORT

[Fig. 23]



(57) Abstract: Disclosed is an apparatus and method of performing power headroom report in a wireless communication system. Present invention includes for calculating power headroom (PH) of at least one serving cell which the MS supports, and generating a MAC message including the calculated PH, for generating or prohibiting triggering of report of the PH by considering a variation of pathloss with respect to the at least one serving cell and a varation of power backoff caused by other communication system which the MS supports, and by considering a time value received from a base station through a RRC message, and for transmitting the MAC message which includes the PH selectively based on trigger prohibition of the trigger prohibition unit. Thus, since interworking operation between triggering of PHR based on power backoff and triggering of PHR based on pathloss is defined, uplink power controlling can be effectively performed.

WO 2012/138089 A1

Description

Title of Invention: APPARATUS AND METHOD FOR PERFORMING POWER HEADROOM REPORT

Technical Field

[1] The present invention relates to wireless communication and, more particularly, to an apparatus and method for performing power headroom report in a wireless communication system supporting multiple component carriers.

Background Art

[2] One of methods for effectively utilizing resources of a mobile station (MS) by a base station (BS) is using power headroom (PH) information of the MS. A power control technology is an essential core technology for minimizing interference factors to effectively distribute resources and reducing battery consumption of an MS in wireless communication. When the MS provides PH information to the BS, the BS can estimate to what extent uplink maximum transmission power the MS can afford to handle (i.e., the BS can estimate uplink maximum transmission power that can be supported by the MS). Thus, the BS may provide uplink scheduling such as a transmit power control (TPC), modulation and coding scheme (MCS), bandwidth, and the like, to the MS within a range not exceeding the limit of the estimated uplink maximum transmission power.

[3] When transmissions each based on different communication schemes are concurrently made from the MS, uplink power consumption is increased in comparison to a case in which only a transmission based on a single communication scheme is made, so power management is required. Power backoff for a power management additionally reduces maximum power of uplink of the MS. Thus, PH report according to the additional maximum power reduction (MPR) is required.

Disclosure of Invention

Technical Problem

[4] The present disclosure provides an apparatus and method of performing a power headroom report (PHR) in a wireless communication system.

[5] Also, the present disclosure provides an apparatus and method of performing a power headroom report (PHR) in a wireless communication system to support multiple component carriers.

[6] Also, the present disclosure provides an apparatus and method of triggering a power headroom report (PHR) according to a change in power backoff in a wireless communication system.

[7] Also, the present disclosure provides an apparatus and method of triggering a power

headroom report (PHR) by a plurality of prohibit timers in a wireless communication system.

[8] Also, the present disclosure provides an apparatus and method of controlling intercepting of a prohibit timer in consideration of increment of power backoff (PB) with respect to a mobile station (MS) in a wireless communication system.

[9] Also, the present disclosure provides an apparatus and method of performing a power headroom report (PHR) in consideration of increment of power backoff (PB) with respect to a mobile station (MS) in a wireless communication system.

Solution to Problem

[10] According to an aspect of the present invention, there is provided a terminal (or a mobile station) performing power headroom report (PHR), including: a trigger prohibition unit configured to measure a first prohibit timer used to measure a variation of pathloss (PL) with respect to a serving cell set in the terminal, increment of power backoff (PB) with respect to the terminal or decrement of PB with respect to the terminal and prohibit triggering of PHR, generate or prohibit at least one of triggering of a first PHR based on the variation of the PL and triggering of a second PHR based on the decrement of the PB, based on a state of the first prohibit timer, or generate or prohibit triggering of a third PHR based on the increment of the PB; a downlink reception unit configured to receive an uplink grant for allocating resource used to transmit the PHR from a base station (BS); a PHR generation unit configured to generate a medium access control (MAC) message including the PHR; and an uplink transmission unit configured to transmit the MAC message to the BS.

[11] According to another aspect of the present invention, there is provided a method of performing a power headroom report (PHR) by a terminal, including: measuring a first prohibit timer used to measure a variation of pathloss (PL) with respect to a serving cell set in the terminal, increment of power backoff (PB) with respect to the terminal or decrement of PB with respect to the terminal and prohibit triggering of PHR; performing a control procedure of generating or prohibiting at least one of triggering of a first PHR based on the variation of the PL and triggering of a second PHR based on the decrement of the PB, based on a state of the first prohibit timer, or a control procedure of generating or prohibiting triggering of a third PHR based on the increment of the PB; receiving an uplink grant for allocating resource used to transmit the PHR from a base station (BS); generating a medium access control (MAC) message including the PHR; and transmitting the MAC message to the BS.

Advantageous Effects of Invention

[12] According to embodiments of the present invention, since interworking operation between triggering of a power headroom report (PHR) based on power backoff and

triggering of a PHR based on a pathloss is clearly defined, uplink power controlling can be effectively performed. Also, since the number of transmissions of PHR is appropriately adjusted, overhead can be reduced.

Brief Description of Drawings

[13] FIG. 1 illustrates a wireless communication system to which the present invention is applied.

[14] FIG. 2 is a view explaining the identical intra-band contiguous carrier aggregation in the wireless communication system to which the present invention is applied.

[15] FIG. 3 is a view explaining the identical intra-band noncontiguous carrier aggregation in the wireless communication system to which the present invention is applied.

[16] FIG. 4 is a view explaining the identical inter-band carrier aggregation in the wireless communication system to which the present invention is applied.

[17] FIG. 5 shows a linkage between downlink component carriers and uplink component carriers in the wireless communication system to which the present invention is applied.

[18] FIG. 6 shows an example of a graph surplus power over time-frequency axis according to an embodiment of the present invention.

[19] FIG. 7 is a conceptual view showing the influence of uplink scheduling of a base station on transmission power of a mobile station in the wireless communication system.

[20] FIG. 8 is a view explaining an amount of power coordination and maximum transmission power in a multi-component carrier system according to an embodiment of the present invention.

[21] FIG. 9 is a view explaining a state in which power backoff generated by 1xRTT to which the present invention is applied and a pathloss measured in an LTE receiver change over time.

[22] FIG. 10 is a view showing a change in maximum transmit power P_{CMAX} when a variation of PMPR is greater than a threshold value.

[23] FIG. 11 is a view explaining triggering of power headroom report (PHR) according to an embodiment of the present invention.

[24] FIG. 12 is a view explaining triggering of power headroom report (PHR) according to another embodiment of the present invention.

[25] FIG. 13 is a view explaining triggering of power headroom report (PHR) according to another embodiment of the present invention.

[26] FIG. 14 is a view explaining triggering of power headroom report (PHR) according to another embodiment of the present invention.

[27] FIG. 15 is a view explaining triggering of power headroom report (PHR) according to another embodiment of the present invention.

[28] FIG. 16 is a view explaining an embodiment in which PHR is triggered on the basis of a plurality of prohibit timers according to the present invention.

[29] FIG. 17 is a flow chart illustrating a method of performing PHR of a mobile station (MS) according to an embodiment of the present invention.

[30] FIG. 18 is a flow chart illustrating a method of performing PHR of a mobile station (MS) according to another embodiment of the present invention.

[31] FIG. 19 is a flow chart illustrating a method of performing PHR of a mobile station (MS) according to another embodiment of the present invention.

[32] FIG. 20 is a flow chart illustrating a method of performing PHR of a mobile station (MS) according to another embodiment of the present invention.

[33] FIG. 21 is a flow chart illustrating a method of performing PHR of a mobile station (MS) according to another embodiment of the present invention.

[34] FIG. 22 is a flow chart illustrating a method of performing PHR of a mobile station (MS) according to another embodiment of the present invention.

[35] FIG. 23 is a block diagram showing an MS and a BS performing PHR according to an embodiment of the present invention.

Mode for the Invention

[36] Exemplary embodiments of the present invention will now be described in detail with reference to the accompanying drawings. The same or similar elements are designated with the same numeral references regardless of the numerals in the drawings and their redundant description will be omitted. In describing the present invention, moreover, the detailed description will be omitted when a specific description for publicly known technologies to which the invention pertains is judged to obscure the gist of the present invention.

[37] In describing the elements of the present invention, terms such as first, second, A, B, (a), (b), etc., may be used. Such terms are used for merely discriminating the corresponding elements from other elements and the corresponding elements are not limited in their essence, sequence, or precedence by the terms. It will be understood that when an element or layer is referred to as being "on" or "connected to" another element or layer, it can be directly on or directly connected to the other element or layer, or intervening elements or layers may be present.

[38] In the present disclosure, a wireless communication network will be described, and an operation performed in the wireless communication network may be performed in a process of controlling a network and transmitting data by a system (e.g., a base station (BS)) administering the corresponding wireless communication network or may be

performed in a mobile station (MS) connected to the corresponding wireless network.

[39] FIG. 1 illustrates a wireless communication system.

[40] With reference to FIG. 1, the wireless communication system 10 is widely disposed to provide various communication services such as voice and packet data, or the like.

[41] The wireless communication system 10 includes at least one base station (BS) 11. Each BS 11 provides a communication service to particular geographical areas (which are generally called cells) 15a, 15b, and 15c. The cells may be divided into a plurality of areas (which are generally called sectors).

[42] A mobile station (MS) 12 may be fixed or mobile and may be referred to by other names such as user equipment (UE), mobile terminal (MT), user terminal (UT), subscriber station (SS), wireless device, personal digital assistant (PDA), wireless modem, handheld device, etc.

[43] The BS 11 generally refers to a fixed station that communicates with the MS 12 and may be called by other names such as evolved-node B (eNB), base transceiver system (BTS), access point (AP), etc. Cells 15a, 15b, and 15c may be construed to have a comprehensive meaning indicating partial areas covered by the BS 11, and may include various coverage areas such as a mega-cell, a macro-cell, a micro-cell, a pico-cell, a femto-cell, and the like.

[44] Hereinafter, downlink (DL) refers to communication from the BS 11 to the MS 12, and uplink (UL) refers to communication from the MS 12 to the BS 11. In downlink, a transmitter may be part of the BS 11 and a receiver may be part of the MS 12. In uplink, a transmitter may be part of the MS 12 and a receiver may be part of the BS 11.

[45] There is not limitation in multi-access schemes applied to the wireless communication. Namely, various multi-access schemes such as Code Division Multiple Access (CDMA), Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), Orthogonal Frequency Division Multiple Access (OFDMA), Single Carrier-FDMA (SC-FDMA), OFDM-FDMA, OFDM-TDMA, OFDM-CDMA, or the like, may be used. A Time Division Duplex (TDD) scheme in which transmission is made by using a different time or an Frequency Division Duplex (FDD) scheme in which transmission is made by using different frequencies may be applied to an uplink transmission and a downlink transmission.

[46] Radio interface protocol layers between the MS and the network may 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 widely known in a communication system.

[47] A physical layer, the first layer (L1), is connected to an upper medium access control (MAC) layer through a transport channel. Data is transferred between the MAC layer and the physical layer through the transport channel. Data is also transferred between

different physical layers, i.e. between physical layers of a transmitting side and a receiving side, through the physical channel. Some physical control channels are used in the PHY layer.

[48] A PDCCH (physical downlink control channel) provides an MS with information regarding a resource allocation of a PCH (paging channel) and DL-SCH (downlink shared channel) HARQ (hybrid automatic repeat request) related to the DL-SCH. The PDCCH may carry an uplink grant informing the MS about a resource allocation of uplink transmission. A PCFICH (physical control format indicator channel) informs the MS about the number of OFDM symbols used for the PDCCHs, and is transmitted at every subframe. A PHICH (physical Hybrid ARQ Indicator Channel) carries an HARQ ACK/NAK signal in response to uplink transmission. A PUCCH (Physical uplink control channel) carries uplink control information such as a CQI, an HARQ ACK/NAK signal with respect to downlink transmission, and a scheduling request. A PUSCH (physical uplink shared channel) carries a UL-SCH (uplink shared channel).

[49] The MS transmits the PUCCH or the PUSCH as follows.

[50] The MS configures the PUCCH with respect to one or more information among information regarding a precoding matrix index (PMI) or a rank indicator (RI) selected based on channel quality information (CQI) or measured space channel information, and periodically transmits the PUCCH to the BS. Also, the MS must transmit information regarding an ACK/NACK (Acknowledgement/non-acknowledgement) regarding downlink data received from the BS to the BS after a certain number of subframes upon receiving the downlink data. For example, when downlink data is received in an nth subframe, the MS transmits a PUCCH including ACK/NACK information with respect to the downlink data in (n+4) subframe. When ACK/NACK information cannot be transmitted on the PUCH allocated from the BS, or when a PUCCH for transmitting ACK/NACK is not allocated from the BS, the MS may carry and transmit ACK/NACK information in the PUSCH only when it is determined that transmission including uplink control information (UCI) information can be made in the PUSCH through CQI request information in a UL grant received from the BS.

[51] A radio data link layer, the second layer, includes a MAC layer, an Radio Link Control (RLC) layer, and a Packet Data Convergence Protocol (PDCP) layer. The MAC layer, responsible for handling mapping between a logical channel and a transport channel, selects an appropriate transport channel in order to transmit data transferred from the RLC layer, and adds required control information to a header of a MAC Protocol Data Unit (PDU). The RLC layer, an upper layer of the MAC layer, supports reliable data transmission. In order to configure data having an appropriate size fitting a radio interface, the RLC layer segments and concatenates RLC Service Data Units (SDUs) transferred from the upper layer. The RLC layer of a receiver

supports a data reassembling function in order to recover the original RLC SDUs from the received RLC PDUs. The PDCP layer is used only in a packet exchange region, and may compress a header of an IP packet to transmit packet data in a radio channel to enhance transmission efficiency of the packet data.

[52] The RRC layer, the third layer, serves to control a lower layer and exchange radio resource control information between the MS and the network. Various RRC states such as an idle mode, an RCC connected mode, or the like, are defined according to a communication state of the MS, and a transition between RRCs may be performed as necessary. In the RRC layer, various procedures related to a radio resource management, such as system information broadcast, an RRC connection management procedure, a multi-component carrier set-up procedure, a radio bearer control procedure, a security procedure, a measurement procedure, a mobility management procedure (handover), or the like.

[53] A carrier aggregation (CA) supports a plurality of carriers, which is also called a spectrum aggregation or a bandwidth aggregation. Individual unit carriers grouped through carrier aggregation are called component carriers (CCs). Each of the component carriers (CCs) is defined by bandwidth and central frequency. The carrier aggregation is introduced to support increased throughput, prevent an increase in cost otherwise caused by an introduction of a broadband radio frequency (RF) element, and guarantee compatibility with an existing system. The component carriers (CCs) may also be called serving cells.

[54] For example, when five component carriers are allocated as granularity of carrier unit having a 5 MHz bandwidth, a maximum of 25 MHz bandwidth can be supported.

[55] CCs may be divided into a primary CC (PCC) and a secondary CC (SCC) according to whether or not they are activated. The primary component carrier is a carrier which is constantly activated, and the secondary component carrier is a carrier activated or deactivated according to particular conditions. Here, activation refers to a state in which traffic data is transmitted or received or a state in which traffic data is in a standby state, namely, is ready to be transmitted or received. Deactivation refers to a state in which traffic data cannot be transmitted or received and only measurement or transmission or reception of minimum information is available. The MS may use only one primary component carrier or one or more secondary component carriers along with a primary component carrier. The MS may be allocated the primary component carrier and/or the secondary component carrier from the BS.

[56] The carrier aggregation may be divided into an intra-band contiguous carrier aggregation as shown in FIG. 2, an intra-band non-contiguous carrier aggregation as shown in FIG. 3, and an inter-band carrier aggregation as shown in FIG. 4.

[57] First, with reference to FIG. 2, the intra-band carrier aggregation (CA) is made

among continuous component carriers in the identical band. For example, CC#1, CC#2, CC#3, …, CC#N, aggregated CCs, are all adjacent to each other.

[58] With reference to FIG. 3, an intra-band non-contiguous CA is made among discontinuous CCs. For example, CC#1 and CC#2, aggregated CCs, are spaced apart by a particular frequency.

[59] With reference to FIG. 4, an inter-band CA is made as one or more CCs are aggregated in different frequency bands when a plurality of CCs exist. For example, CC#1, an aggregated CC, exists in band #1, CC#2, an aggregated CC, exists in band #2.

[60] The number of aggregated carriers may be configured to be different for downlink and uplink. An aggregation in which the number of downlink component carriers is equal to the number of uplink component carriers is called a symmetric aggregation, and an aggregation in which the number of downlink component carriers is different from the number of uplink component carriers is called an asymmetric aggregation.

[61] Sizes of component carriers (i.e., bandwidths) may vary. For example, when five component carriers are used to configure a 70MHz band, the five carriers may be configured as follows: 5MHz CC (carrier #0) + 20MHz CC (carrier #1) + 20MHz CC (carrier #2) + 20MHz CC (carrier #3) + 5MHz CC (carrier #4).

[62] Hereinafter, a multi-carrier system refers to a system supporting carrier aggregation. In the multi-carrier system, a contiguous carrier aggregation and/or a non-contiguous carrier aggregation may be used, or either the symmetrical aggregation or the asymmetrical aggregation may be used.

[63] FIG. 5 illustrates a linkage between downlink component carriers and uplink component carriers in the multi-carrier system.

[64] With reference to FIG. 5, downlink component carriers (DL CC) D1, D2, and D3 are aggregated in downlink, and uplink component carriers (UL CC) U1, U2, and U3 are aggregated in uplink. Here, Di is an index (i=1, 2, 3) of the DL CC, and Ui is an index of UL CC. At least one DL CC is a primary component carrier (PCC), and the other remaining DLCC are secondary component carriers (SCC). Similarly, at least one UL CC is a PCC, and the other remaining UL CCs are SCCs. For example, D1 and U1 are PCCs, and D2, U2, D3, and U3 are SCCs.

[65] In an FDD system, the DL CCs and the UL CCs are configured to be connected by 1:1, and in this case, D1 is configured to be connected to U1, D2 to U2, and D3 to U3, in a one-to-one manner. The MS configures the linkage between the DL CCs and the UL CCs through system information transmitted by a logical channel BCCH or an MS-dedicated RRC message transmitted by a DCCH. Each linkage may be configured to be cell-specific or may MS-specific.

[66] FIG. 5 illustrates only the 1:1 linkage between the DL CCs and the UL CCs, but, of

course, a linkage of 1:n or a linkage of n:1 may be established. Also, the index of the component carriers may not be consistent with order of CCs or the position of a frequency band of corresponding CCs.

[67] Power headroom (PH) will now be described.

[68] Power headroom (PH) refers to extra power which can be additionally used in addition to power currently used for uplink transmission by the MS. For example, it is assumed that maximum transmission power, transmission power within an allowable range, of the MS is 10W. It is also assumed that the MS currently uses 9W in a frequency band of 10 MHz. The MS can additionally use 1W, so PH is 1W.

[69] Here, when the BS allocates a frequency band of 20 MHz to the MS, power of 9x2=18W is required. However, since the maximum power of the MS is 10W, if power of 20 MHz is allocated to the MS, the MS cannot use the entirety of the frequency band or power may be insufficient so the BS cannot properly receive a signal from the MS. Thus, in order to solve this problem the MS reports the BS that power headroom is 1W, so that the BS can perform scheduling within the range of power headroom. Such a report is called a power headroom report (PHR).

[70] Reported PH may be given as shown in Table 1 below.

[71] Table 1

[Table 1]

Reported value	Measured quantity value (dB)
POWER_HEADROOM_0	$-23 \le PH < -22$
POWER_HEADROOM_1	$-22 \le PH < -21$
POWER_HEADROOM_2	$-21 \le PH < -20$
POWER_HEADROOM_3	$-20 \le PH < -19$
POWER_HEADROOM_4	$-19 \le PH < -18$
POWER_HEADROOM_5	$-18 \le PH < -17$
...	...
POWER_HEADROOM_57	$34 \le PH < 35$
POWER_HEADROOM_58	$35 \le PH < 36$
POWER_HEADROOM_59	$36 \le PH < 37$
POWER_HEADROOM_60	$37 \le PH < 38$
POWER_HEADROOM_61	$38 \le PH < 39$
POWER_HEADROOM_62	$39 \le PH < 40$
POWER_HEADROOM_63	$PH \ge 40$

[72] With reference to Table 1, power headroom (PH) is within a range from -23dB to +40dB. When 6 bits are used to express PH, indexes of $2^6=64$ can be expressed, so PH is classified into a total of 64 levels. For example, when bits expressing PH is 0 (namely, it is 000000 when expressed by 6 bits), it means that PH is $-23 \le P_{PH} \le -22$dB.

[73] Since the PH is frequently changed, periodic PHR scheme may be used. According to the periodic PHR scheme, when a periodic timer expires, the MS triggers the PHR, and when the PH is reported, the MS retarts the periodic timer.

[74] Also, when a pass loss (PL) estimate value measured by the MS is changed by more than a certain reference value, the PHR may be triggered. The PL estimate value is measured by the MS based on a reference symbol received power (RSRP).

[75] The PH (P_{PH}) is defined as the difference between maximum transmission power P_{CMAX} configured in the MS as represented by Equation 1 and power $P_{estimated}$ estimated regarding uplink transmission, and it is expressed as dB.

[76] [Equation 1]

[77]
$$P_{PH}=P_{CMAX}-P_{estimated}[dB]$$

[78] Power headroom (P_{PH}) may also be called remaining power or surplus power. Namely, a remainder value, excluding $P_{estimated}$, the sum of transmission power used by each CC, in the maximum transmission power of the MS configured by the BS, is P_{PH}.

[79] For example, $P_{estimated}$ is equal to power P_{PUSCH} estimated regarding transmission of physical uplink shared channel (PUSCH). Thus, in this case, P_{PH} can be obtained by Equation 2 shown below:

[80] [Equation 2]

[81]
$$P_{PH}=P_{CMAX}-P_{PUSCH}[dB]$$

[82] In another example, $P_{estimated}$ is equal to the sum of power P_{PUSCH} estimated regarding transmission of the PUSCH and power P_{PUCCH} estimated regarding transmission of physical uplink control channel (PUCCH). Thus, in this case, power headroom (PH) can be obtained by Equation 3 shown below:

[83] [Equation 3]

[84]
$$P_{PH}=P_{CMAX}-P_{PUCCH}-P_{PUSCH}[dB]$$

[85] The PH according to Equation 3 can be expressed on time and frequency axes in a graph as shown in FIG. 6. In FIG. 6, PH with respect to one CC is shown.

[86] With reference to FIG. 6, the configured maximum transmission power P_{CMAX} of the MS includes P_{PH} (605), P_{PUSCH} (610) and P_{PUCCH} (615). Namely, the remainder, excluding P_{PUSCH}(610) and P_{PUCCH}(615), in P_{CMAX} is defined as P_{PH} (605). Each power is calculated by transmission time interval (TTI).

[87] A main serving cell is the only serving cell retaining a UL PCC for transmitting the PUCCH. Thus, a sub-serving cell cannot transmit the PUCCH, PH is determined as expressed by Equation 2, and a parameter and an operation with respect to the PHR method determined by Equation 3 are not defined.

[88] Meanwhile, in the main serving cell, operation and parameters with respect to a PHR method determined by Equation 3 may be defined. When MS receives an uplink grant from the BS so it should transmit the PUSCH and simultaneously transmits the PUCCH in the same subframe according to a determined rule in the main serving cell, the MS calculates all the PHs according to Equation 2 and Equation 3 at a point in time at which the PHR is triggered, and transmits the same to the BS.

[89] In the multi-component carrier system, PH can be individually defined regarding a plurality of configured CCs, and FIG. 7 shows a graph in which PH is expressed on time and frequency axes.

[90] No matter whether it is a single component carrier system or it is a multi-component carrier system, the maximum transmission power configured in the MS is affected by maximum power reduction (MPR) of the MS. MPR refers to reducing the maximum transmission power configured in the MS within a certain allowed range, and an amount of power reduced by the MPR may be called a maximum power reduction (MPR) amount.

[91] FIG. 7 is a conceptual view showing the influence of uplink scheduling of the BS on transmission power of the MS in a wireless communication system.

[92] With reference to FIG. 7, the MS receives an uplink grant allowing uplink data transmission from the BS at time (or subframe) t0 through a PDCCH. Thus, the MS should calculate an amount of transmission power according to the uplink grant at t0.

[93] First, at time t0, the MS calculates first transmission power 725 in consideration of a PUSCH power offset value 700 and a transmission power control (TPC) value 705 received from the BS and an 'a' value (received from the BS), a weight, to a pathloss (PL) 710 between the BS and the MS. The first transmission power (1st Tx Power) 725 is largely according to a parameter affected by a path environment between the BS and the MS and a parameter determined by a policy of a network. In addition, the MS calculates a second transmission power (2nd Tx Power) 730 in consideration of a scheduling parameter 715 indicating a QPSK modulation scheme and an allocation of ten resource blocks (RBs). The second transmission power 730 is transmission power changing through uplink scheduling of the BS.

[94] Thus, the MS can calculate final uplink transmission power by adding the first transmission power 725 and the second transmission power 730. Here, the final uplink transmission power cannot exceed the configured maximum transmission power (P_{CMAX}) of the MS. In the example of FIG. 7, since the final transmission power is smaller

than P_{CMAX} value at the time t0, so the uplink information according to configured parameter can be transmitted. Also, there is power headroom (PH) 720, an extra with respect to transmission power, which can be additionally configured. The PH 720 is transmitted by the MS to the BS according to a rule defined in the wireless communication system.

[95] At time t1, the BS changes into a scheduling parameter 750 indicating a 16QAM modulation scheme and allocation of 50 resource blocks in consideration of transmission power which can be additionally configured for the MS through information of PH 720. The MS re configures second transmission power 765 according to the scheduling parameter 750. A first transmission power 760 at time t1 is determined in consideration of a PUSCH power offset value 735, a TPC value 740, and an 'a' value (received from the BS), a weight, to a PL 745 between the BS and the MS, and here, it is assumed that the first transmission power 760 is equal to the first transmission power 725 at time t0.

[96] At time t1, P_{CMAX} is changed into a value close to P_{CMAX_L}, while the sum of the second transmission power 765 and the first transmission power 760 requested by the scheduling parameter 750 exceeds P_{CMAX}. Namely, a PH estimated value error 755 by P_{CMAX_H}-P_{CMAX} occurs. In this manner, when scheduling is performed on the uplink resource based only on PH information, the MS cannot configure uplink transmission power expected by the BS, generating performance degradation. When the CC aggregation scheme is used, the PH estimated value error 755 is further increased. Thus, the MS should reduce the configured maximum transmission power.

[97] The range of maximum transmit power of the MS in consideration of the MPR is expressed by Equation 4 shown below:

[98] [Equation 4]

[99]
$$P_{CMAX\_L} \leq P_{CMAX} \leq P_{CMAX\_H}$$

[100] Here, P_{CMAX} is maximum transmit power configured in the MS, P_{CMAX_L} is a minimum value of P_{CMAX}, and P_{CMAX_H} is a maximum value of P_{CMAX}. Specifically, P_{CMAX_L} and P_{CMAX_H} are calculated by Equation 5 and Equation 6, respectively, shown below:

[101] [Equation 5]

[102]
$$P_{CMAX\_L} = MIN[P_{EMAX} - \Delta T_C, P_{powerclass} - MPR - AMPR - \Delta T_C]$$

[103] [Equation 6]

[104]
$$P_{CMAX\_H} = MIN[P_{EMAX}, P_{powerclass}]$$

[105] Here, MIN[a,b] is a smaller value among a and b, P_{EMAX} is maximum power determined by RRC signaling of the BS, and $\triangle T_C$ is power amount applied when there is

an uplink transmission at the edge of a band, which has 1.5dB or 0dB according to a band. $P_{powerclass}$ is a power value according to several power classes defined to support specifications of various terminals in a system. In general, the LTE system supports power class 3, and $P_{powerclass}$ by power class 3 is 23dBm. MPR is a maximum power reduction amount, and AMPR (Additional MPR) is an additional maximum power reduction amount signaled by the BS.

[106] The MPR may be configured to have a particular range or as a particular constant. The MPR may be defined by an MS or by CC. Also, the MPR may be configured to have a certain range or as a constant within each CC unit. Also, the MPR may be configured to have a range or as a constant according to whether or not PUSCH resource allocation of each CC is continuous or discontinuous. Also, the MPR may be configured to have a range or as a constant according to whether or not a PUCCH exists.

[107] FIG. 8 is a view explaining a maximum power reduction amount and maximum transmit power of an MS in a multi-component carrier system according to an embodiment of the present invention. For the sake of explanation, it is assumed that only one ULCC is allocated to an MS.

[108] With reference to FIG. 8, when it is assumed that $\triangle T_C$=0, a maximum value (P_{CMAX_H}) of maximum transmit power (P_{CMAX}) may be 23dBm corresponding to power class 3. A minimum value (P_{CMAX_L}) of the maximum transmit power (P_{CMAX}) may be a value obtained by subtracting a maximum power reduction amount (MPR) 800 and an AMPR 805 from the maximum value (P_{CMAX_H}). Namely, the MS reduces the minimum value (P_{CMAX_L}) of the maximum transmit power (P_{CMAX}) by using the MPR 800 and the AMPR 805. The maximum transmit power (P_{CMAX}) is determined between the maximum value (P_{CMAX_H}) and the minimum value (P_{CMAX_L}).

[109] Meanwhile, an uplink transmit power 830 is the sum of power 815 determined by a bandwidth (BW), Modulation and Coding Scheme (MCS), and RB, a pathloss (PL) 820, and a PUSCH TPSs 825. A PH 810 is obtained by subtracting the uplink transmit power 830 from the maximum transmit power (P_{CMAX}).

[110] In FIG. 8, only a single UL CC is explained, but when a plurality of UL CCs are allocated, maximum transmission power may be given by an MS, rather than by UL CC, and maximum transmission power by an MS may be given as the sum of each maximum transmission power with respect to all the UL CCs.

[111] In calculating maximum transmit power, P_{EMAX}, $\triangle T_C$, $P_{powerclass}$, and the AMPR may be information the BS knows or may be able to know. However, the BS cannot know the MPR, so it cannot accurately know maximum transmit power according to the MPR. When the MS reports PH to the BS, the BS can merely estimate an approximate range of the maximum transmit power through the PH. Since the BS performs

uncertain uplink scheduling within the estimated maximum transmit power, in the worst-case scenario, the BS may perform scheduling with a modulation/channel bandwidth/RB requesting transmit power greater than the maximum transmit power with respect to the MS.

[112] As mentioned above, the PHR report is used to provide information regarding a difference between estimated power with respect to an uplink data transmission for each activated serving cell and nominal maximum transmit power of the MS. Also, the PHR procedure is used to provide information regarding a difference between estimated power with respect to an uplink data transmission and a PUCCH transmission with respect to a primary serving cell and the nominal maximum transmit power of the MS.

[113] In order for the PHR to be triggered, trigger conditions must be satisfied. The trigger conditions are also called an event. Parameters related to trigger conditions include a pathloss variation, a power backoff variation, and various timers. These parameters may be associated to define trigger conditions or may define trigger conditions independently.

[114] 1. Power backoff

[115] Power backoff refers to maximum power reduction (MPR) additionally generated by power management in uplink. When transmissions each based on different communication schemes are concurrently made from the MS, uplink power consumption is increased in comparison to a case in which only a transmission based on a single communication scheme is made, so power management is required. Power management is required, for example, for concurrent transmissions based on a packet switching scheme and a circuit switching scheme, for concurrent transmission of non-voice data and voice data, for concurrent transmissions of LTE-based data and 1x-Evolution-Data Optimized (EVDO) or 1x-Radio Transmission Technology (RTT)-based data, or in case of considering an Specific Absorption Rate (SAR). Power backoff is also called a PMPR (or P-MPR).

[116] Power backoff is a variable for determining maximum transmission power P_{CMAX} configured in the MS. For example, when power backoff is taken into consideration, Equation 5 may be amended as expressed by Equation 7 shown below:

[117] [Equation 7]

[118] $$P_{CMAX\_L}=MIN[P_{EMAX}-\Delta T_C, P_{powerclass}-MAX[MPR+AMPR, PMPR]-\Delta T_C]$$

[119] With reference to Equation 7, PMPR is a power backoff value. P_{CMAX_L} is determined by a greater value among MPR+AMPR and PMPR. Namely, MPR+AMPR and PMPR are not compatible, and MPR may be independently performed only by PMPR itself. For example, when PMPR>MPR+AMPR in Equation 7, PMPR itself is identified with

MPR in Equation 5.

[120] In another example, when power backoff is considered, Equation 5 may be amended as expressed by Equation 8 shown below:

[121] [Equation 8]

[122] $$P_{CMAX\_L}=MIN[P_{EMAX}-\Delta T_C, P_{powerclass}-MPR-AMPR-PMPR-\Delta T_C]$$

[123] According to Equation 8, P_{CMAX_L} is calcualted by all of MPR, AMPR, and PMPR. Namely, MPR, AMPR, and PMPR are compatible and affect P_{CMAX_L} together. PMPR in Equation 8 is an additional MPR generated by power management, which is different from the pure MPR defined in Equation 5.

[124] When the defintion of the PMPR value according to Equation 7 and that of the PMPR value according to Equation 8 are compared, the PMPR in Equation 7 refers to the power backoff value itself generated by the 1xRTT, and as for the PMPR in Equation 8, the power backoff value generated by the 1xRTT and the pure MPR value defined in Equation 5 are compared, and when it is larger, the PMPR in Equation 8 is defined as the difference value.

[125] For example, when a value of pure MPR defined in Equation 5 is 8dB and a power backoff value expected by 1xRTT is 7dB, the PMPR value defined by Equation 7 is 7dB and the PMPR value defined by Equation 8 is 0dB. The PMPR value defined by Equation 8 is 0dB because there is no influence when it is small.

[126] In another example, when the value of pure MPR is 8dB and the power backoff value by 1xRTT is 10dB, the PMPR value defined by Equation 7 is 10dB and the PMPR value defined by Equation 8 is 2dB (=10dB-8dB).

[127] As shown in Equation 7 and Equation 8, the maximum transmit power P_{CMAX} is changed by power backoff. When the maximum transmit power P_{CMAX} is changed, PH is resultantly changed. Namely, power backoff affects the change in PH, and the power backoff variation is used to define trigger conditions together with a pathloss variation. Namely, triggering of PHR may be generated on the basis of power backoff or may be generated on the basis of a pathloss. For example, the trigger conditions may include a case in which a variation of power backoff is greater than a threshold value of power backoff, and here, there may be a case in which increment of power backoff is greater than the threshold value of power backoff and a case in which decrement of power backoff is greater than the threshold value of power backoff. Also, the trigger conditions may include a case in which a variation of a pathloss is greater than a threshold value of the pathloss.

[128] Power backoff and a pathloss have difference in terms of characteristics.

[129] FIG. 9 is a view explaining a state in which power backoff generated by 1xRTT and a pathloss measured in the LTE receiver change over time.

[130] Here, 1xRTT refers to a circuit-based communication system, which includes CDMA2000, WCDMA communication, or the like. Namely, the 1xRTT may include a communication system which is different from an LTE system.

[131] With reference to FIG. 9, power backoff by 1xRTT occurs irrespective of a change in channels. Also, pathloss slowly changes in units of 200 ms, but a change in power backoff by 1xRTT changes relatively rapidly in units of 20 ms.

[132] Meanwhile, the maximum power reduction (MPR) is generated by an MS according to a resource allocation scheme or modulation in an LTE uplink grant. Thus, with respect to uplink grant for which resource allocation scheme or modulation is the same, the MPR may be applied equally. However, power backoff by the 1xRTT occurs separately from the LTE uplink grant, and it changes rapidly according to whether or not a 1xRTT data transmission is made concurrently with an LTE transmission.

[133] When the maximum transmit power P_{CMAX} is changed due to power backoff, PH is changed accordingly. In this case, since the PH due to power backoff is rapidly changed, if PHR is transmitted whenever PH is changed, the frequent transmission of PHR may act as overhead. In addition, the PHR may also be generated by a different cause such as pathloss, or the like, as well as by power backoff, increasing overhead. Thus, in order to effectively perform uplink power controlling, a method of appropriately triggering a PHR according to a change in power backoff is required. To this end, trigger conditions having a different format from that of the trigger conditions defined based on pathloss should be defined. Also, a definite procedure with respect to an operation when the trigger conditions based on pathloss interwork with the trigger conditions having a different format is required.

[134] FIG. 10 is a view showing a change in the maximum transmit power P_{CMAX} when a variation of PMPR is greater than a threshold value.

[135] When the value of PMPR is changed during a power backoff process, the P_{CMAX} value is changed to interfere with uplink scheduling performed by the BS. The case in which the PMPR is changed during a power backoff process includes a case in which the PMPR is increased (S1010) and a case in which the PMPR is reduced (S1020).

[136] In particular, in the case in which the PMPR is increased, power scaling down phenomenon occurs in an uplink transmission of the MS, which is, thus, especially problematic. Here, power scaling down phenomenon refers to a phenomenon in which as the P_{CMAX} value is reduced according to an increase in the value of PMPR, the BS erroneously estimates the P_{CMAX} value and performs uplink scheduling, so transmission power requested by the MS is greater than the P_{CMAX} value but the actual transmission power of the MS is reduced within the P_{CMAX} value.

[137] When the power scaling down phenomenon occurs in the uplink transmission of the MS due to the erroneous scheduling of the BS, a reception end (or a receiver) of the BS

will receive power smaller than reception power previously estimated by the BS in scheduling, so performance of uplink may be degraded.

[138] When the PMPR is reduced (S1020), a problem arises in that transmission power retained by the MS is not sufficiently utilized. Uplink scheduling is ineffective, but it does not cause a severe performance degradation like the power scaling down phenomenon does.

[139] Thus, when the PMPR is increased, in order to effectively perform PHR, the PHR trigger conditions are required to be adjusted such that the PHR trigger according to the increase in the PMPR can be properly transferred at a corresponding timing. PHR is required to be performed by discriminating the case in which the PMPR is increased from the case in which the PMPR is reduced.

[140] Hereinafter, the case (S1010) in which the PMPR value is increased by more than a threshold value and PHR is performed is called a PHR based on power backoff according to an increase in the PMPR, and the case (S1020) in which the PMPR value is reduced by more than a threshold value and PHR is performed is called a PHR based on power backoff according to a reduction in the PMPR. Here, the threshold value when the PMPR value is increased and the threshold value when the PMPR value is reduced may be equal or different. Hereinafter, it is assumed that the threshold value when the PMPR value is increased and the threshold value when the PMPR value is reduced are equal, and they will be referred to simply as a threshold value. Thus, an absolute value of the increment or decrement of the PMPR, namely, the variation of the PMPR, is compared with the threshold value.

[141] 2. Timer

[142] A timer is an element defining the trigger conditions. It controls trigger of PHR together with a pathloss variation and a power backoff variation. The timer includes a periodic PHR timer (referred to as a 'periodic timer', hereinafter) and a prohibition PHR timer (referred to as a 'prohibit timer', hereinafter). The periodic timer is controlled to allow the PHR to be periodically triggered. The prohibit timer prohibits triggering of the PHR.

[143] The periodic timer may start (or may be driven) or restart (or may be re-driven) when uplink resource for a new transmission is allocated to the MS at a current transmission time interval (TTI) or when allocated uplink resource can accommodate a PHR MAC control element including a subheader as a result of logical channel priority. Or, the periodic timer may restart when triggering of PHR based on any one of a pathloss and power backoff occurs. After the periodic timer starts or restarts, when a certain period of time has lapsed, the periodic timer expires.

[144] A value of the periodic timer and the prohibit timer may be expressed in number of subframes. For example, when a value of the periodic timer is 10, it corresponds to ten

subframes. Accordingly, PHR is triggered at every ten subframes in the MS. Meanwhile, when a value of the prohibit timer is 10, triggering of PHR is prohibited during the ten subframes. When the ten subframes have lapsed so the prohibit timer expires, then, a chance of triggering PHR is obtained.

[145] Configuration of the periodic timer and the prohibit timer may be controlled by the RRC layer. For example, the BS may transmit an RRC message such as a MAC-MainConfig information element in Table 2. Table 2 shows a case in which two prohibit timers are provided.

[146] Table 2

[Table 2]

```
MAC-MainConfig ::=        SEQUENCE {
   .
   .
   .

   phr-Config                 CHOICE {
   release                    NULL,
   setup                      SEQUENCE {
      periodicPHR-Timer          ENUMERATED {sf10, sf20, sf50, sf100, sf200,
                                             sf500, sf1000, infinity},
      primary prohibitPHR-Timer ENUMERATED {sf0, sf10, sf20, sf50, sf100,
                                                 sf200, sf500, sf1000},
   secondary prohibitPHR-Timer ENUMERATED {sf0, sf30, sf60, sf100, sf150,
                                                 sf200, sf500, sf1000},
      dl-PathlossChange          ENUMERATED {dB1, dB3, dB6, infinity}
      }
   }                                    OPTIONAL, -- Need ON
   .
   .
   .
}
```

[147]

[148] With reference to Table 2, the RRC message includes a periodic timer (periodicPHR-Timer) value and a prohibit timer value. The prohibit timer includes two types of timers, namely, a primary prohibit PHR timer and a secondary prohibit PHR timer. Or, the timers may also be called a first prohibit timer and a second prohibit timer. The value sfn of the prohibit timer means that the prohibit timer operates during n number of subframes.

[149] The first prohibit timer may prohibit triggering of PHR based on every cause excluding triggering of PHR based on power backoff according to an increase in the PMPR. For example, the first prohibit timer prohibits triggering of PHR based on a pathloss, as well as triggering of PHR based on power backoff. In this case, however, the first prohibit timer cannot prohibit triggering of PHR based on power backoff according to an increase in the PMPR. As described above, when the PMPR is increased, when the PMPR is increased, there is a possibility in which performance is degraded due to power scaling down phenomenon, so the increase in power backoff

has high priority with respect to the PHR. Meanwhile, the second prohibit timer prohibits only triggering of PHR based on power backoff. For example, among triggering of PHR based on power backoff, the second prohibit timer prohibits triggering of PHR based on power backoff according to an increase in the PMPR and triggering of PHR based on power backoff according to a reduction in the PMPR. Here, however, it does not prohibit triggering of PHR based on pathloss.

[150] Thus, when the first prohibit timer has not expired while the second prohibit timer has expired, PHR based on power backoff according to an increase in the PMPR may be triggered, but PHR based on power backoff according to a reduction in the PMPR or PHR based on pathloss is not triggered. Meanwhile, when the first prohibit timer has expired while the second prohibit timer has not expired, PHR based on power backoff according to the increase or reduction in the PMPR is not triggered but PHR based on pathloss may be triggered. In this case, triggering of PHR based on power backoff according to the reduction in the PMPR may be performed only when both the first prohibit timer and the second prohibit timer have expired.

[151] A timing at which the first prohibit timer and the second prohibit timer restart after they have expired may be different contingently.

[152] For example, when a PHR based on a certain cause is transmitted, both the first prohibit timer and the second prohibit timer restart. For example, a transmission of a PHR based on a pathloss makes even the second prohibit timer, as well as the first prohibit timer restart. Meanwhile, a transmission of PHR based on power backoff according to an increase or reduction in the PMPR may make only the second prohibit timer restart but not the first prohibit timer.

[153] In another example, the PHR based on a particular cause may make a particular prohibit timer restart. For example, a transmission of PHR based on pathloss makes only the first prohibit timer restart, and a transmission of PHR based on power backoff according to an increase or reduction in the PMPR makes only the second prohibit timer restart.

[154] In another example, PHR based on a particular cause may make the particular prohibit timer. For example, a transmission of PHR based on a pathloss makes only the first prohibit timer restart and a transmission of the PHR based on power backoff according to an increase or reduction in the PMPR makes only the second prohibit timer restart.

[155] In another example, a transmission of PHR based on a pathloss makes both the first prohibit timer and second prohibit timer restart and a transmission of the PHR based on power backoff according to an increase or reduction in the PMPR may make both the first prohibit timer and the second prohibit timer restart.

[156] In another example, a transmission of PHR based on a pathloss makes only the first

prohibit timer restart and a transmission of the PHR based on power backoff according to an increase or reduction in the PMPR may make both the first prohibit timer and the second prohibit timer restart.

[157] In Table 2, it is described that two types of prohibit timers are provided, but this is merely illustrative and three or more prohibit timers may be provided. In this case, two different prohibit timers may be prohibited by a single prohibit timer.

[158] Meanwhile, in another example, in order to control configuration of the periodic timer and the prohibit timer by the RRC layer, the BS may transmit an RRC message such as MAC-MainConfig information element of Table 3. Table 3 shows a case in which a single prohibit timer is provided.

[159] Table 3

[Table 3]

```
MAC-MainConfig ::=        SEQUENCE {
    .
    .
    .

    phr-Config                   CHOICE {
    release                      NULL,
    setup                     SEQUENCE {
       periodicPHR-Timer            ENUMERATED {sf10, sf20, sf50, sf100, sf200,
                                              sf500, sf1000, infinity},
       prohibitPHR-Timer            ENUMERATED {sf0, sf10, sf20, sf50, sf100,
                                                 sf200, sf500, sf1000},
       dl-PathlossChange            ENUMERATED {dB1, dB3, dB6, infinity}
       }
    }                                   OPTIONAL, -- Need ON
    .
    .
    .
}
```

[160]

[161] With reference to Table 3, the RRC message includes a periodic timer value and a prohibit timer value. A single prohibit timer is provided and is able to prohibit triggering of PHR based on every cause excluding PHR based on power backoff according to an increase in the PMPR. Namely, the prohibit timer prohibits both triggering of PHR based on power backoff according to a reduction in the PMPR and triggering of PHR based on pathloss, excluding PHR based on power backoff according to an increase in the PMPR. When n number of subframes have lapsed by sfn, the prohibit timer expires, and when a PHR based on a certain cause is transmitted, the prohibit timer restarts. When the prohibit timer restarts although it has not expired yet, it is called reconfiguration the prohibit timer. Reconfiguration and restarting are different in that a start point is before the prohibit timer expires or after the prohibit timer expires, and when the prohibit timer is reset or restarts, time at which the prohibit timer expires is the same.

[162] 3. Triggering PHR

[163] A PHR is triggered when trigger conditions are met. As mentioned above, elements defining the trigger conditions include a power backoff variation (increment or decrement), a pathloss variation, and a timer. These elements are associated to define trigger conditions. The PHR is basically triggered under the conditions in which the power backoff decrement is greater than a threshold value, the periodic timer has expired, or a pathloss variation is greater than a threshold value and the prohibit timer has expired. Exceptionally, the PHR is triggered under the conditions in which power backoff increment is greater than a threshold value. Hereinafter, the trigger conditions for triggering a PHR will be described, and a case in which a single prohibit timer is provided as shown in Table 3 and a plurality of prohibit timers are provided as shown in Table 2 will be described. In particular, on the assumption that a single prohibit timer is provided, a case in which a PHR based on power backoff according to an increase in the PMPR is transmitted and the prohibit timer restarts, in otherwise case, and a case in which only expired prohibit timer restarts will be described.

[164] Also, a case in which the periodic timer expires forms the same conditions as that of the case in which a variation of pathloss is greater than a pathloss threshold value. Thus, the substituting of the case in which the periodic timer expires to the case in which the pathloss variation is greater than the pathloss threshold value obtains the same result.

[165] (1) In case in which a single prohibit timer is provided, and the prohibit timer does not restart after the PHR based on power backoff according to an increase in the PMPR is performed.

[166] For example, the PHR may be triggered when the periodic timer expires.

[167] In another example, the PHR may be triggered when the prohibit timer expires and when the periodic timer expires or the pathloss variation is greater than the pathloss threshold value.

[168] In another example, the PHR may be triggered when the prohibit timer expires and power backoff decrement is greater than the power backoff threshold value.

[169] In another example, the PHR may be triggered when power backoff increment is greater than the power backoff threshold value. In this case, the PHR may be triggered although the prohibit timer has not expired yet.

[170] FIG. 11 is a view explaining triggering of power headroom report (PHR) according to an embodiment of the present invention. FIG. 11 shows a case in which a single prohibit timer is provided, and the prohibit timer does not restart after the PHR based on power backoff according to an increase in the PMPR is performed.

[171] With reference to FIG. 11, PHR triggering based on pathloss (PH) (or PHR triggering by PH) and PHR triggering based on power backoff (PB) (or PHR triggering

by PB) are controlled by the single prohibit timer. The PHR triggering by PB includes PHR triggering by PB according to an increase in the PMPR (or PHR triggering by PMPR up) and PHR triggering by PB according to a reduction in the PMPR (or PHR triggering by PMPR down). Based on the passage of time, points in time B1 to B5 at which the decrement of power backoff is greater than the power backoff threshold value relatively frequently occurs in comparison to points in time A1, A2, and A3 at which the variation of pathloss is greater than the pathloss threshold value.

[172] In principle, two trigger conditions should be met to trigger PHR. First, a condition 1 of PHR triggering is met when the periodic timer expires, when the variation of pathloss is greater than the pathloss threshold value, or when the decrement of power backoff is greater than power backoff threshold value.

[173] A condition 2 of PHR triggering is met when the prohibit timer expires. When both condition 1 and condition 2 are met, PHR is triggered and a transmission of the PHR is made.

[174] However, exceptionally, when the increment of power backoff is greater than the power backoff threshold value, although the prohibit timer has not expired yet, the PHR is triggered. This is a condition 3. When the condition 3 is met, the trigger condition is met although the condition 1 and the condition 2 are not met. The reason is because, if the increment of power backoff is greater than the power backoff threshold value, a power scaling down phenomenon occurs to degrade performance. After the PHR was transmitted as the trigger conditions were met, although not much time has lapsed since then, the PHR is transmitted again in order to prevent the power scaling down phenomenon.

[175] At a point in time A1, the periodic timer has expired or the variation of pathloss is greater than the pathloss threshold value (PHR triggering by PL), so the condition 1 is met, but since the prohibit timer has not expired yet, the condition 2 is not met. Similarly, at points in time B1 and B2, decrement of power backoff is greater than the threshold value of power backoff so the condition 1 is met, but since the prohibit timer has not expired yet, the condition 2 is not met. Accordingly, PHR is not triggered at points in time A1, B1, and B2.

[176] Next, at a point in time A2, both condition 1 and condition 2 are met, so the PHR is triggered and a transmission of the PHR (PHR Tx) occurs. Since the condition 1 and the condition 2 were met so transmission of the PHR has occurred, the prohibit timer restarts at this point in time. At a point in time B3 at which the prohibit timer has not expired after it restarted, the condition 1 is met and the condition 2 is not met, so PHR is not triggered.

[177] However, at a point in time C1, the increment of power backoff is greater than the threshold value of power backoff, satisfying the condition 3. When the condition 3 is

met, even before the prohibit timer expires (namely, although the condition 2 is not met), the PHR is triggered (PHR triggering by PMPR up) and a transmission of the PHR (PHR Tx) occurs. However, when the condition 3 is met so the PHR is triggered, the prohibit timer is not reset or does not restart.

[178] After the prohibit timer expires, at a point in time B4, both the condition 1 and the condition 2 are met so PHR is triggered and transmission of the PHR occurs. Since the conditions 1 and 2 are met and the transmission of the PHR occurs, the prohibit timer restarts at this point of time.

[179] At points in time A3 and B5, the condition 1 is met while the condition 2 is not met, so the prohibit timer prohibits the PHR from being triggered.

[180] However, at a point in time C2, since the condition 3 is met, although the condition 2 is not met, the PHR is triggered and a transmission of the PHR (PHR Tx) occurs. Like the point in time C1, at the point in time C2, the condition 3 is met and the PHR is triggered, the prohibit timer is not reset or does not restart.

[181] Like the point in time C3, at the points in time C1 and C2, the condition 3 is met and the PHR is triggered, and a transmission of the PHR occurs. Since the condition 3 is met and the PHR is triggered, the prohibit timer is not reset or does not restart. Thus, starting of the prohibit timer does not take place.

[182] In this manner, when the single prohibit timer controls triggering of the PHR due to several causes at a time, overhead otherwise resulting from frequent PHR can be minimized and process of triggering PHR can be clarified. Also, it helps inform the BS about a transition of a change according to an increase in the PMPR. Since the transmission of PHR (PHR Tx) according to a change in the increase in the PMPR does not cause the prohibit timer to restart, triggering of PHR by the periodic timer or the variation of pathloss is prevented from being prohibited by the prohibit timer unintentionally. In FIG. 11, it is described that triggering of PHR and transmission of PHR concurrently occur for the sake of explanation, but this is merely illustrative and triggering of PHR and transmission of PHR may occur at different points in time.

[183] (2) In case in which a single prohibit timer is provided and the prohibit timer is reset or restarts after PHR based on power backoff according to an increase in PMPR is performed.

[184] For example, PHR may be triggered when the periodic timer expires.

[185] In another example, PHR may be triggered when the prohibit timer expires and the periodic timer expires or a pathloss variation is greater than a pathloss threshold value.

[186] In another example, PHR may be triggered when the prohibit timer expires and power backoff decrement is greater than a power backoff threshold value.

[187] In another example, PHR may be triggered when power backoff increment is greater than the power backoff threshold value. In this case, although the prohibit timer has not

expired yet, PHR can be triggered.

[188] FIG. 12 is a view explaining triggering of power headroom report (PHR) according to another embodiment of the present invention. FIG. 12 shows a case in which only a single prohibit timer is provided and the prohibit timer is reset or restarts after PHR based on power backoff according to an increase in the PMPR is performed.

[189] With reference to FIG. 12, triggering of PHR as the periodic timer expires or based on pathloss (PHR triggering by PL) and triggering of PHR based on power backoff are controlled by a single prohibit timer. The PHR triggering by PB includes PHR triggering by PB according to an increase in the PMPR (PHR triggering by PMPR up) and PHR triggering by PB according to a reduction in the PMPR (PHR triggering by PMPR down). Based on the passage of time, points in time B1 to B6 at which the decrement of power backoff is greater than the power backoff threshold value relatively frequently occurs in comparison to points in time A1, A2, and A3 at which the variation of pathloss is greater than the pathloss threshold value.

[190] In principle, two trigger conditions should be met to trigger PHR. First, a condition 1 of PHR triggering is met when the periodic timer expires, when the variation of pathloss is greater than the pathloss threshold value, or when the decrement of power backoff is greater than power backoff threshold value. A condition 2 of PHR triggering is met when the prohibit timer expires. When both condition 1 and condition 2 are met, PHR is triggered and a transmission of the PHR is made.

[191] However, exceptionally, when the increment of power backoff is greater than the power backoff threshold value to meet the condition 3 of triggering of PHR, although the prohibit timer has not expired yet, the PHR is triggered. This is to prevent a degradation of performance due to a power scaling down phenomenon occurring when the increment of power backoff is greater than the power backoff threshold value.

[192] When the example of FIG. 12 is compared with the example of FIG. 11, the fact that triggering and transmission of PHR occur according to the condition 1 to condition 3 is the same, while the fact that when the condition 3 is met and PHR is transmitted, the prohibit timer is reset or restarts is different.

[193] At a point in time A1, the periodic timer has expired or the variation of pathloss is greater than the pathloss threshold value, so the condition 1 is met, but since the prohibit timer has not expired yet, the condition 2 is not met. Similarly, at points in time B1 and B2, decrement of power backoff is greater than the threshold value of power backoff so the condition 1 is met, but since the prohibit timer has not expired yet, the condition 2 is not met. Accordingly, PHR is not triggered at points in time A1, B1, and B2.

[194] Next, at a point in time A2, both condition 1 and condition 2 are met, so the PHR is triggered and a transmission of the PHR occurs. Since transmission of the PHR has

occurred, the prohibit timer restarts at this point in time. At a point in time B3 at which the prohibit timer has not expired after it restarted, the condition 1 is met and the condition 2 is not met, so PHR is not triggered.

[195] At a point in time C1, the increment of power backoff is greater than the threshold value of power backoff, satisfying the condition 3. When the condition 3 is met, even before the prohibit timer expires (namely, although the condition 2 is not met), the PHR is triggered (PHR triggering by PMPR down) and a transmission of the PHR (PHR Tx) occurs. Unlike the embodiment of FIG. 11, in the embodiment of FIG. 12, even when the condition 3 is met so the PHR is triggered, the prohibit timer is reset or restarts.

[196] At a point in time B4, the condition 1 is met, but since the prohibit timer which restarted at the point in time C1 has not expired yet, the condition 2 is not met so PHR is not triggered.

[197] At a point in time B5, both the condition 1 and the condition 2 are met so PHR is triggered (PHR triggering by PMPR down) and transmission of the PHR occurs. Since the transmission of the PHR occurs, the prohibit timer restarts at this point of time.

[198] At points in time A3 and B6, the condition 1 is met while the condition 2 is not met, so the prohibit timer prohibits the PHR from being triggered.

[199] In this manner, when the single prohibit timer controls triggering of the PHR due to several causes at a time, overhead otherwise resulting from frequent PHR can be minimized and process of triggering PHR can be clarified. In particular, since the PHR according to the condition 3 is transmitted and the prohibit timer restarts, overhead can be further reduced. Also, since the reconfiguration operation of the prohibit timer has consistency win relation to the transmission of PHR (PHR Tx), the operation of the prohibit timer is prevented from being complicated. Also, in FIG. 12, it is described that triggering of PHR and transmission of PHR concurrently occur for the sake of explanation, but this is merely illustrative and triggering of PHR and transmission of PHR may occur at different points in time.

[200] (3) In case in which a single prohibit timer is provided and when PHR based on power backoff according to an increase in the PMPR is performed, only the prohibit timer which has expired restarts.

[201] For example, PHR may be triggered when the periodic timer expires.

[202] In another example, PHR may be triggered when the prohibit timer expires and the periodic timer expires or a pathloss variation is greater than a pathloss threshold value.

[203] In another example, PHR may be triggered when the prohibit timer expires and power backoff decrement is greater than a power backoff threshold value.

[204] In another example, PHR may be triggered when power backoff increment is greater than the power backoff threshold value, although the prohibit timer has not expired yet.

.

[205] FIG. 13 is a view explaining triggering of power headroom report (PHR) according to another embodiment of the present invention. In FIG. 13, a single prohibit timer is provided, and when PHR based on power backoff according to an increase in the PMPR is performed, only the prohibit timer which has expired restarts.

[206] With reference to FIG 13, triggering of PHR based on expiration of the periodic timer or pathloss (PHR triggering by PL) and triggering of PHR based on power backoff (PHR triggering by PB) are controlled by a single prohibit timer.

[207] The condition 1 to condition 3, as conditions under which PHR is triggered, are the same as those of the cases (1) and (2). In principle, when both the condition 1 and the condition 2 are met, PHR is triggered, and exceptionally, when only the condition 3 is met, PHR is triggered.

[208] When the example of FIG. 13 is compared with the examples of FIG. 11 and FIG. 12, the fact that triggering and transmission of PHR occur according to the condition 1 to condition 3 is the same, while the fact that when the condition 3 is met and PHR is transmitted, only the prohibit timer which has expired restarts is different.

[209] At a point in time A1, the periodic timer has expired or the variation of pathloss is greater than the pathloss threshold value, so the condition 1 is met, but since the prohibit timer has not expired yet, the condition 2 is not met. Similarly, at points in time B1 and B2, decrement of power backoff is greater than the threshold value of power backoff so the condition 1 is met, but since the prohibit timer has not expired yet, the condition 2 is not met. Accordingly, PHR is not triggered at points in time A1, B1, and B2.

[210] Next, at a point in time A2, both condition 1 and condition 2 are met, so the PHR is triggered and a transmission of the PHR (PHR Tx) occurs. Since the condition 1 and the condition 2 are met and transmission of the PHR has occurred, the prohibit timer restarts at this point in time. At a point in time B3 at which the prohibit timer has not expired after it restarted, the condition 1 is met and the condition 2 is not met, so PHR is not triggered.

[211] At a point in time C1, the condition 3 is met, so although the condition 2 is not met, the PHR is triggered (PHR triggering by PMPR up) and a transmission of the PHR (PHR Tx) occurs. Unlike the embodiment of FIG. 12, in the embodiment of FIG. 13, the condition 3 is met, but since the prohibit timer has not expired yet, the prohibit timer does not restart.

[212] At a point in time B5, both the condition 1 and the condition 2 are met so PHR is triggered (PHR triggering by PMPR down) and transmission of the PHR (PHR Tx) occurs. Since the transmission of the PHR occurs, the prohibit timer restarts at this point of time.

[213] At a point in time C2, the condition 3 is met, so although the condition 2 is not met, PHR is triggered and a transmission of PHR occurs. Unlike the point in time C1, in the case of the point in time C2, the prohibit timer has expired, so the prohibit timer does not restart.

[214] At a point in time B6, the condition 1 is met while the condition 2 is not met, so the prohibit timer prohibits the PHR from being triggered.

[215] In this manner, when the single prohibit timer controls triggering of the PHR due to several causes at a time, overhead otherwise resulting from frequent PHR can be minimized and process of triggering PHR can be clarified. In particular, since the PHR according to the condition 3 is transmitted and the prohibit timer restarts, overhead can be further reduced. Since the transmission of PHR (PHR Tx) according to a change in the increase in the PMPR does not cause the prohibit timer to restart, triggering of PHR by the periodic timer or the variation of pathloss is prevented from being prohibited by the prohibit timer unintentionally. Also, in FIG. 13, it is described that triggering of PHR and transmission of PHR concurrently occur for the sake of explanation, but this is merely illustrative and triggering of PHR and transmission of PHR may occur at different points in time.

[216] (4) In case in which a plurality of prohibit timers are provided

[217] As shown in Table 2, a plurality of prohibit timers may be provided. A technical concept regarding an operation of cooperatively operating two prohibit timers, namely, first and second prohibit timers, to prohibit PHR triggering may also be applied to a case in which three or more prohibit timers are provided, in the same manner.

[218] For example, PHR may be triggered when the periodic timer expires.

[219] In another example, the PHR may be triggered when the first prohibit timer expires and when the periodic timer expires or the pathloss variation is greater than the pathloss threshold value.

[220] In another example, the PHR may be triggered when the first or second prohibit timer expires and power backoff decrement is greater than the power backoff threshold value.

[221] In another example, the PHR may be triggered when the second prohibit timer expires and power backoff increment is greater than the power backoff threshold value

[222] To sum up, the first prohibit timer prohibits triggering when the periodic timer expires or when the pathloss variation is greater than the pathloss threshold value and triggering when the power backoff decrement is greater than the power backoff threshold value. Also, the second prohibit timer prohibits triggering when the power backoff increment is greater than the power backoff threshold value and triggering when the power backoff decrement is greater than the power backoff threshold value.

[223] The value of the first prohibit timer and that of the second prohibit timer may be

equal or different. When the value of the first prohibit timer and that of the second prohibit timer are different, the value of the first prohibit timer may be greater or smaller than the value of the second prohibit timer.

[224] Meanwhile, In case in which PHR is triggered and transmitted when the periodic timer expires or the pathloss variation is greater than the pathloss threshold value, both the first and second prohibit timers may restart or only the first prohibit timer may restart. Hereinafter, the case in which both the first prohibit timer and the second prohibit timer restart will be described with reference to FIG. 14 and the case in which only the first prohibit timer restarts will be described with reference to FIG. 15. Meanwhile, in both the cases of FIGS. 14 and 15, in case in which PHR is triggered and transmitted when the power backoff increment is greater than the power backoff threshold value and when the power backoff decrement is greater than the power backoff threshold value, only the second prohibit timer restarts.

[225] FIG. 14 is a view explaining triggering of power headroom report (PHR) according to another embodiment of the present invention. FIG. 14 shows a case in which two prohibit timers are provided, and when PHR is triggered and transmitted in case in which the periodic timer expires or a pathloss variation is greater than the pathloss threshold value, the first and second prohibit timers are reset or restart together.

[226] With reference to FIG. 14, triggering of PHR based on expiration of the periodic timer and pathloss (PHR triggering by PL) and triggering of PHR based on power backoff (PHR triggering by PB) are controlled by two prohibit timers.

[227] The PHR triggering by PB includes PHR triggering by PB according to an increase in the PMPR (or PHR triggering by PMPR up) and PHR triggering by PB according to a reduction in the PMPR (or PHR triggering by PMPR down).

[228] In principle, two trigger conditions should be met to trigger PHR. First, the condition 1 of PHR triggering is met when the periodic timer expires, when the variation of pathloss is greater than the pathloss threshold value, or when the decrement of power backoff is greater than power backoff threshold value.

[229] Whether or not the condition 2 is met may be differently interpreted according to what is the cause of trigger. Namely, with respect to PHR triggering based on the expiration of the periodic timer or pathloss, the condition 2 is that the first prohibit timer should expire, while with respect to PHR triggering based on power backoff according to a reduction in the PMPR, the condition 2 is that both the first and second prohibit timers should expire.

[230] Exceptionally, when the increment of power backoff is greater than the power backoff threshold value, the condition for PHR triggering is met. This is called the condition 3.

[231] When a single prohibit timer is provided, when the condition 3 is met, PHR is

triggered and transmitted without being prohibited by the prohibit timer. However, when two prohibit timers are provided, the condition 2 is determined such that that the second prohibit timer should be met although the condition 3 is met.

[232] To sum up, in case in which two prohibit timers are provided, when the condition 1 is met, PHR is triggered when the condition 2 is also met, and also, when the condition 3 is met, PHR is triggered when the condition 2 is met.

[233] Whether or not the trigger conditions are met at each point in time is determined as follows.

[234] First, at a point in time A1, the periodic timer has expired or the variation of pathloss is greater than the pathloss threshold value, so the condition 1 is met, but since the first prohibit timer has not expired yet, the condition 2 is not met. Similarly, at points in time B1 and B2, decrement of power backoff is greater than the threshold value of power backoff so the condition 1 is met, but since the first or second prohibit timer has not expired yet, the condition 2 is not met. Also, at a point in time C1, the increment of power backoff is greater than the power backoff threshold value, satisfying the condition 3, but since the second prohibit timer has not expired yet, the condition 2 is not met. Accordingly, PHR is not triggered at points in time A1, B1, B2, and C1.

[235] Next, at a point in time B3, a decrement of power backoff is greater than the power backoff threshold value, satisfying the condition 1, and since both the first and second prohibit timers have expired, the condition 2 is met, so PHR is triggered (PHR triggering by PMPR down) and a transmission of PHR (PHR Tx) occurs. When the decrement of power backoff is greater than the power backoff threshold value, the first prohibit timer does not restart and only the second prohibit timer restarts.

[236] At a point in time C2, the condition 3 is met, but the second prohibit timer has not expired yet after it restarted, the condition 2 is not met, and thus, PHR is not triggered.

[237] At a point in time A2, the periodic timer has expired or a variation of pathloss is greater than the pathloss threshold value, satisfying the condition 1, and since the first prohibit timer has expired, the condition 2 is also met. Thus, PHR is triggered (PHR triggering by PL) and a transmission of PHR (PHR Tx) occurs. Since the transmission of PHR has occurred because the variation of pathloss is greater than the pathloss threshold value, the first prohibit timer which has already expired restarts, and the second prohibit timer which has not expired yet is reset to restart.

[238] At a point in time B4, the first and second prohibit timers have not expired yet after they restarted, the condition 1 is met but the condition 2 is not met, so PHR is not triggered.

[239] At a point in time A3, since the first prohibit timer has not expired yet after it restarted, the condition 1 is met but the condition 2 is not met, so PHR is not triggered.

[240] At a point in time C3, since the second prohibit timer has expired, the condition 2 is

met irrespective of the first prohibit timer. Since both the condition 3 and condition 2 are met, PHR is triggered (PHR triggering by PMPR up) and a transmission of PHR (PHR Tx) occurs. The second prohibit timer restarts. However, the first prohibit timer is not reset or does not restart.

[241] At a point in time A4, the periodic timer expires and the variation of pathloss is greater than the pathloss threshold value, satisfying the condition 1, and since the first prohibit timer has expired, the condition 2 is also met. Thus, since the transmission of PHR has occurred because the periodic timer expired and the variation of the pathloss was greater than the pathloss threshold value, both the first and second prohibit timers which have already expired restart.

[242] In FIG. 14, it is described that the value of the second prohibit timer is smaller than that of the first prohibit timer, but this is merely illustrative and the value of the second prohibit timer may be greater than that of the first prohibit timer.

[243] FIG. 15 is a view explaining triggering of power headroom report (PHR) according to another embodiment of the present invention. FIG. 15 shows a case in which two prohibit timers are provided, and only the first prohibit timer restarts according to a transmission of PHR triggered when the periodic timer expires or when a pathloss variation is greater than the pathloss threshold value. Also, only the second prohibit timer restarts according to a transmission of a PHR triggered according to the increment or decrement of power backoff.

[244] With reference to FIG. 15, the condition 1, the condition 2, and the condition 3 for triggering PHR are determined by the same method as described above with reference to FIGL 14. Here, however, the case of FIG. 15 is different from the case of FIG. 14, in that the first prohibit timer and the second prohibit timer restart or are reset by a different cause.

[245] Whether or not the trigger conditions are met at each point in time is determined as follows.

[246] First, at a point in time A1, the periodic timer has expired or the variation of pathloss is greater than the pathloss threshold value, so the condition 1 is met, but since the first prohibit timer has not expired yet, the condition 2 is not met. Similarly, at points in time B1 and B2, decrement of power backoff is greater than the threshold value of power backoff so the condition 1 is met, but since the first or second prohibit timer has not expired yet, the condition 2 is not met. Also, at a point in time C1, the increment of power backoff is greater than the power backoff threshold value, satisfying the condition 3, but since the second prohibit timer has not expired yet, the condition 2 is not met. Accordingly, PHR is not triggered at points in time A1, B1, B2, and C1.

[247] Next, at a point in time B3, a decrement of power backoff is greater than the power backoff threshold value, satisfying the condition 1, and since both the first and second

prohibit timers have expired, the condition 2 is met, so PHR is triggered (PHR triggering by PMPR down) and a transmission of PHR (PHR Tx) occurs. When the transmission of PHR occurs, only the second prohibit timer restarts.

[248] At a point in time A2, since the first prohibit timer has expired, both the condition 1 and the condition 2 are met, so PHR is triggered (PHR triggering by PL) and a transmission of PHR occurs PHR Tx). Unlike the embodiment of FIG. 14, when the PHR transmission occurs because the periodic timer expired and the variation of pathloss was greater than the pathloss threshold value, only the first prohibit timer which has already expired restarts and the second prohibit timer which has not expired yet is not reset or does not restart.

[249] At a point in time C2, the second prohibit timer has not expired yet, so the condition 2 is not met, and at a point in time A3, the first prohibit timer has not expired yet, so the condition 2 is not met, and at a point in time B4, the first prohibit timer has not expired yet, so the condition 2 is not met. Thus, PHR is not triggered at points in time C2, A3, and B4.

[250] At a point in time C3, the increment of power backoff is greater than the power backoff threshold value, satisfying the condition 3, and since the second first prohibit timer has not expired yet, so the condition 2 is not met has expired, the condition 2 is also met. Thus, PHR based on power backoff is triggered (PHR triggering by PMPR up) and a transmission of PHR occurs (PHR Tx). And, only the second prohibit timer restarts. However, the first prohibit timer is still reset does not restart.

[251] At a point in time B5, the second prohibit timer has not expired yet, so the condition 2 is not met, and thus, PHR is not triggered.

[252] At a point in time A4, the periodic timer has expired or the variation of pathloss is greater than the pathloss threshold value, satisfying the condition 1, and since the first prohibit timer has expired, the condition 2 is met. Thus, the MS triggers PHR and transmits the PHR to the BS. At this time, only the first prohibit timer restarts. The second prohibit timer does not restart yet.

[253] In FIG. 15, it is described that the value of the second prohibit timer is smaller than that of the first prohibit timer, but this is merely illustrative and the value of the second prohibit timer may be greater than that of the first prohibit timer.

[254] As described above with reference to FIGS. 14 and 15, when the plurality of prohibit timers are provided, triggering of PHR according to the periodic timer or the variation of pathloss can be prevented from being prohibited unintentionally by the transmission of the PHR (PHR Tx) based on power backoff. The unintentional prohibition refers to a situation in which starting of the first prohibit timer is affected by the transmission of the corresponding PHR (PHR Tx), so triggering of PHR by the periodic timer or the variation of pathloss is prohibited. Besides, unnecessary transmission of PHR (PHR

Tx) due to backoff through the second prohibit timer can be prevented.

[255] As described above with reference to FIGS. 11 to 15, the timing of triggering of PHR varies according to i) whether or not a single prohibit timer is provided or a plurality of prohibit timers are provided, and ii) whether or not restart or reset points in time of the plurality of prohibit timers are associated or independent according to trigger factors. In short, the points in time at which PHR is triggered include A2, B4, C1, and C2 in FIG. 11, A2, B5, and C1 in FIG. 12, A2, B4, C1, and C2 in FIG. 13, A2, A4, B3, and C3 in FIG. 14, and A2, A4, B3, and C3 in FIG. 15.

[256] In this manner, when a single prohibit timer is provided, the periodic timer expires, the variation of pathloss is greater than the pathloss threshold value, of the decrement of power backoff is greater than the power backoff threshold value. Thus, although the condition 1 for triggering PHR is met, if the condition 2 is not met, PHR is not triggered. Namely, the condition 2 is determined in consideration of the prohibit timer, so the PHR is dependent upon the operation scheme of the prohibit timer. However, when the increment of power backoff is greater than the power backoff threshold value, the condition 3 is met, so PHR is triggered irrespective of the operation scheme of the prohibit timer.

[257] Meanwhile, when two prohibit timers are provided, when the condition 3, as well as the condition 1, is met, the condition 2 should be met. Namely, the first prohibit timer or the second prohibit timer is considered in every case, so PHR is dependent upon the operation scheme of the prohibit timers.

[258] FIG. 16 is a view explaining an embodiment in which PHR is triggered on the basis of a plurality of prohibit timers according to the present invention. FIG. 16 shows an example in which after PHR based on power backoff according to an increase in the PMPR is performed, a prohibit timer does not restart. In this case, PHR is triggered under the condition that a PHR available state is maintained for a certain period of time (trigger time (or Time To Trigger: TTT)). Maintaining the PHR available state for TTT is applied only to triggering PHR when a decrement of power backoff is greater than the power backoff threshold value. Namely, the corresponding PHR is triggered when the state in which the decrement of power backoff is greater than the threshold value is maintained for TTT. In FIG. 16, only the variation of the PMPR is illustrated.

[259] With reference to FIG. 16, power backoff (P-MPR) changes over time, and the condition 1 may include a case in which the decrement of power backoff is greater than the power backoff threshold value. Although not shown in FIG. 16, the case in which the variation of pathloss is greater than the pathloss threshold value or the case in which the periodic timer expires may be included in the condition 1. The condition 2 is a case in which the prohibit timer expires, and the condition 3 is a case in which the increment of power backoff is greater than the power backoff threshold value. Or, the

condition 1 to condition 3 may be defined based on new reference amounts. Meanwhile, a PHR transmission occurs at a timing when both the condition 1 and the condition 2 are met or when the condition 3 is met. The prohibit timer restarts by every PHR excluding PHR according to a case in which the increment of power backoff is greater than the threshold value.

[260] For example, at a point in time t_0, both the condition 1 and the condition 2 are met, so PHR is triggered and transmitted. At this time, the prohibit timer restarts.

[261] At a point in time t_1, the prohibit timer has not expired yet, so the condition 1 is met while the condition 2 is not met.

[262] At a point in time t_2, there is no change in the PMPR based on t_0, so the condition 1 is not met nor the condition 2 is met, and thus, PHR transmission does not occur. The reason for comparing the change in the PMPR at t_2 based on t_0 is because a PHR transmission has not occurred at the point in time t_1. In this manner, a variation of the PMPR or a variation of pathloss at a current point in time are measured based on the point in time at which the PHR is transmitted. For example, a variation of PMPR at t_2 is 0dB.

[263] At t_3, the condition 1 and the condition 2 are met, and if this state is maintained for TTT, the condition 4 would be met. However, before TTT expires, the power backoff value is increased at t_4, so the condition 1 is not maintained. Since the condition 4 is not met, HPR is not triggered. Here, the condition 4 is a new trigger condition, which corresponds only to triggering according to a reduction in the power backoff value. It is required to maintain the state in which the condition 1 (in FIG. 16, it is limited to a case in which the decrement of power backoff is greater than the threshold value) and the condition 2 are met for a certain period of time (during TTT). Namely, a point in time at which PHR is triggered is not when the condition 1 and the condition 2 are first met, but a point at which the state in which the condition 1 and the condition 2 are met has been maintained during TTT. This is because, with respect to the reduction in the power backoff value, a change in a state of a voice call can be recognized when the corresponding reduction state is maintained until when TTT has lapsed.

[264] Meanwhile, at t_5, the condition 1 and the condition 2 are met, and when this state is maintained during TTT, the condition 4 is met. Thus, at t_6, the MS triggers PHR.

[265] With respect to PHR according to the condition 3, the condition 4 is not considered.

[266] At t_7, the condition 3 is met, and a PHR transmission occurs. Although the PHR transmission occurs, since it is based on the condition 3, the prohibit timer does not restart.

[267] Here, in case in which the PHR based on FIG. 16 interworks with the PHR based on pathloss (PHR trigger by PL) as shown in FIGS. 11 to 15, the description with reference to FIGS. 11 to 15 can be applied as it is. For example, the prohibit timer in

FIG. 16 may be the second prohibit timer in FIGS. 14 and 15, and likewise as in FIGS. 14 and 15, PHR triggering may occur or may be prohibited. In this case, the TTT constituting the condition 4 does not have priority over the first prohibit timer. Namely, when the first prohibit timer expires, although the TTT has not lapsed, the PHR based on pathloss or the periodic PHT may be still triggered.

[268] FIG. 16 shows an example in which the prohibit timer does not restart after the PHR based on power backoff according to an increase in the PMPR is performed, and the present invention is not limited thereto. Namely, even when the prohibit timer restarts or only the prohibit timer which has expired restarts after the PHR based on power backoff according to an increase in the PMPR is performed, content that the PHR is triggered when the condition 4 according to TTT is met can be applied in the same manner.

[269] Also, in FIG. 16, the maintaining during TTT is described only for triggering of PHR with respect to a case in which the decrement of power backoff is greater than the power backoff threshold value, but the present invention is not limited thereto and may also be applicable to case in which the periodic timer expires or the variation of pathloss is greater than the pathloss threshold value or to a case in which the increment of power backoff is greater than the power backoff threshold value.

[270] FIG. 17 is a flow chart illustrating a method of performing PHR of a mobile station (MS) according to an embodiment of the present invention, in which when a single prohibit timer is provided and increment of power backoff is greater than the threshold value of power backoff (condition 3), the prohibit timer does not restart.

[271] With reference to FIG. 17, an MS receives an uplink grant from a BS (S1700). The uplink grant, which is downlink control information (DCI) having a format 0 or 4 for allocating uplink resource with respect to the MS, is transmitted on a PDCCH. The uplink grant may be configured as shown in Table 4 below.

[272] Table 4

[Table 4]

- Flag for format0/format1A differentiation – 1 bit, where value 0 indicates format 0 and value 1 indicates format 1A
- Frequency hopping flag – 1 bit
- Resource block assignment and hopping resource allocation – $\lceil \log_2(N_{RB}^{UL}(N_{RB}^{UL}+1)/2) \rceil$ bits
  - For PUSCH hopping:
    - N_{UL_hop} MSB bits are used to obtain the value of $\tilde{n}_{PRB}(i)$
    - $\left(\lceil \log_2(N_{RB}^{UL}(N_{RB}^{UL}+1)/2) \rceil - N_{UL\_hop}\right)$ bits provide the resource allocation of the first slot in the UL subframe
  - For non-hopping PUSCH:
    - $\left(\lceil \log_2(N_{RB}^{UL}(N_{RB}^{UL}+1)/2) \rceil\right)$ bits provide the resource allocation in the UL subframe
- Modulation and coding scheme and redundancy version – 5 bits
- New data indicator – 1 bit
- TPC command for scheduled PUSCH – 2 bits
- Cyclic shift for DM RS – 3 bits
- UL index – 2 bits (this field is present only for TDD operation with uplink-downlink configuration 0)
- Downlink Assignment Index (DAI) – 2 bits (this field is present only for TDD operation with uplink-downlink configurations 1-6)

[273]

[274] With reference to Table 4, the uplink grant includes information regarding RB, MCS, TPC, or the like.

[275] The MS measure a current prohibit timer (S1705). Points in time at which the prohibit timer starts or restarts are the same as described above. The current prohibit timer may be measured in units of subframes (or by subframe).

[276] The MS determines whether or not the prohibit timer has expired based on a value of the prohibit timer (S1710). When the prohibit timer does not expire, the trigger condition 2 is not met. Thus, PHR triggering by power backoff according to a reduction in the PMPR (or PHR triggering by PMPR down) or PHR triggering by expiration of the periodic timer or a variation of pathloss does not take place.

[277] When the prohibit timer expires, since the trigger condition 2 is met, the MS compares the pathloss variation ($\triangle$PL) and the pathloss threshold value (PL_{TH}), and determines whether or not the periodic timer has expired (S1715).

[278] When $\triangle PL > PL_{TH}$ or when the periodic timer has expired, the trigger condition 1 is met. Although both the trigger condition 1 and the condition 2 are met, if there is no uplink resource, PHR cannot be transmitted. Thus, the MS determines whether or not

uplink resource for transmitting PHR has been secured (S1720). If uplink resource has been secured, the MS transmits PHR to the BS (S1725). And, the MS makes the prohibit timer restart (S1730).

[279] In step S1720, if uplink resource has not been secured, the MS skips a transmission of PHR (S1735).

[280] In step S1715, if it is not $\triangle PL > PL_{TH}$ and the periodic timer has not expired, the MS determines whether or not power backoff decrement is greater than the power backoff threshold value (S1740). When the power backoff decrement is greater than the power backoff threshold value, trigger condition 1 is met. Thus, the MS performs the process sequentially starting from step S1720. If the power backoff decrement is not greater than the power backoff threshold value, the trigger condition 1 is not met, so the MS terminates the procedure.

[281] In step S1710, although the prohibit timer has not expired, triggering of PHR based on power backoff according to an increase in the PMPR can be performed irrespective of the condition 2, so it is determined whether or not the increment of power backoff is greater than the threshold value of power backoff (S1745). Namely, it is determined whether or not the condition 3 is met.

[282] When the condition 3 is met, the MS transmits PHR to the BS (S1750). And, the MS does not restart the prohibit timer but terminates the prohibit timer. When the condition 3 is not met, the MS terminates the procedure.

[283] FIG. 18 is a flow chart illustrating a method of performing PHR of a mobile station (MS) according to another embodiment of the present invention. Like the embodiment of FIG. 12, FIG. 18 shows a case in which a single prohibit timer is provided and the prohibit timer restarts when PHR is triggered by the condition 3.

[284] Thus, the embodiment of FIG. 18 is different from the embodiment of FIG. 17, in that whether or not the prohibit timer restarts when PHR is triggered by the condition 3.

[285] With reference to FIG. 18, the MS receives an uplink grant from the BS (S1800). The uplink grant is the same as described above.

[286] The MS measures a current prohibit timer (S1805). Starting or re-starting of the prohibit timer is the same as described above. The current prohibit timer may be measured in units of subframes.

[287] The MS determines whether or not the prohibit timer has expired based on the measured value of the prohibit timer (S1810).

[288] When the prohibit timer has expired, since the trigger condition 2 is met, the MS compares the pathloss variation $\triangle PL$ and the pathloss threshold value PL_{TH} and determines whether or not the periodic timer has expired (S1815).

[289] When $\triangle PL > PL_{TH}$ or when the periodic timer has expired, the trigger condition 1 is

met. Although both the trigger condition 1 and the condition 2 are met, if there is no uplink resource, PHR cannot be transmitted. Thus, the MS determines whether or not uplink resource for transmitting PHR has been secured (S1820). If uplink resource has been secured, the MS transmits PHR to the BS (S1825). And, the MS makes the prohibit timer restart (S1830).

[290] In step S1820, if uplink resource has not been secured, the MS skips transmission of PHR (S1835).

[291] In step S1815, if it is not $\triangle PL > PL_{TH}$ and the periodic timer has not expired, the MS determines whether or not power backoff decrement is greater than the power backoff threshold value (S1840). When the power backoff decrement is greater than the power backoff threshold value, trigger condition 1 is met. Thus, the MS performs the process sequentially starting from step S1820. If the power backoff decrement is not greater than the power backoff threshold value, the trigger condition 1 is not met, so the MS terminates the procedure.

[292] In step S1810, although the prohibit timer has not expired, triggering of PHR based on power backoff according to an increase in the PMPR can be performed irrespective of the condition 2, so it is determined whether or not the increment of power backoff is greater than the threshold value of power backoff (S1845). Namely, it is determined whether or not the condition 3 is met.

[293] When the condition 3 is met, the MS performs the process sequentially starting from step S1825. If uplink resource has been secured, the MS transmits PHR to the BS and makes the prohibit timer restart. When the condition 3 is not met, the MS terminates the procedure.

[294] FIG. 19 is a flow chart illustrating a method of performing PHR of a mobile station (MS) according to another embodiment of the present invention. Like the embodiment of FIG. 13, FIG. 19 shows a case in which a single prohibit timer is provided, and when the condition 3 is met, only the prohibit timer which has expired restarts.

[295] Thus, the embodiment of FIG. 19 is different from the embodiment of FIG. 17, in that whether or not the prohibit timer restarts by the condition 3, and different from the embodiment of FIG. 18, in that the prohibit timer which has not expired restarts.

[296] With reference to FIG. 19, the MS receives an uplink grant from the BS (S1900). The uplink grant is the same as described above.

[297] The MS measures a current prohibit timer (S1905). Starting or re-starting of the prohibit timer is the same as described above. The current prohibit timer may be measured in units of subframes.

[298] The MS determines whether or not the prohibit timer has expired based on the measured value of the prohibit timer (S1910).

[299] When the prohibit timer has expired, since the trigger condition 2 is met, the MS

compares the pathloss variation $\triangle PL$ and the pathloss threshold value PL_{TH} and determines whether or not the periodic timer has expired (S1915).

[300] When $\triangle PL>PL_{TH}$ or when the periodic timer has expired, the trigger condition 1 is met. Although both of the trigger conditions 1 and 2 are met, if there is no uplink resource, PHR cannot be transmitted. Thus, the MS determines whether or not uplink resource for transmitting PHR has been secured (S1920). If uplink resource has been secured, the MS transmits PHR to the BS (S1925). And, the MS makes the prohibit timer restart (S1930). In step S1920, if uplink resource has not been secured, the MS skips transmission of PHR (S1935).

[301] In step S1915, if it is not $\triangle PL>PL_{TH}$ and the periodic timer has not expired, the MS determines whether or not power backoff decrement is greater than the power backoff threshold value (S1940). When the power backoff decrement is greater than the power backoff threshold value, trigger condition 1 is met. Thus, the MS performs the process sequentially starting from step S1920. If the power backoff decrement is smaller than the power backoff threshold value, the trigger condition 1 is not met, so the MS terminates the procedure.

[302] In step S1910, although the prohibit timer has not expired, triggering of PHR based on power backoff according to an increase in the PMPR can be performed irrespective of the condition 2, so it is determined whether or not the increment of power backoff is greater than the threshold value of power backoff (S1945). Namely, it is determined whether or not the condition 3 is met.

[303] When the condition 3 is met, the MS transmits PHR to the BS (S1950). And, the MS determines whether or not the prohibit timer has expired (S1955). When the prohibit timer has expired and has not started yet, the prohibit timer restarts (S1960). If the prohibit timer has not expired, the prohibit timer is not reset or does not restart.

[304] In step S1945, when the condition 3 is not met, the MS terminates the procedure.

[305] FIG. 20 is a flow chart illustrating a method of performing PHR of a mobile station (MS) according to another embodiment of the present invention. FIG. 20 shows a case in which two prohibit timers are provided, both the first and second prohibit timers are reset or restart according to PHR triggering based on a pathloss variation and only the second prohibit timer is reset or restarts according to PHR triggering based on power backoff, like the case of FIG. 14.

[306] With reference to FIG. 20, the MS receives an uplink grant from the BS (S2000). The MS measures current first and second prohibit timers (S2005).

[307] The MS first determines whether or not the first prohibit timer has expired based on a value of the first prohibit timer and that of the second prohibit timer (S2010). When the first prohibit timer has expired, since the trigger condition 2 is met, the MS compares the pathloss variation $\triangle PL$ and the pathloss threshold value PL_{TH} (S2015). Also, the

MS determines whether or not the periodic timer has expired. Or, PHR triggering may occur even when the periodic timer has expired in step S2015.

[308] When $\triangle PL>PL_{TH}$ or when the periodic timer has expired in step S2015, the trigger condition 1 is met. Although both of the trigger conditions 1 and 2 are met, if there is no uplink resource, PHR cannot be transmitted. Thus, the MS determines whether or not uplink resource for transmitting PHR has been secured (S2020). If uplink resource has been secured, the MS transmits PHR to the BS (S2025). And, the MS makes both the first and second prohibit timers restart (S2030). Namely, when transmission of PHR based on pathloss occurs, both the first and second prohibit timers restart.

[309] In step S2020, if uplink resource has not been secured, the MS skips transmission of PHR (S2035).

[310] In step S2015, if it is not $\triangle PL>PL_{TH}$ and the periodic timer has not expired, the trigger condition 1 is not met. The MS determines whether or not the second prohibit timer has expired (S2040). If the second prohibit timer has not expired, the trigger condition 2 is not met, so the MS terminates the procedure. If the second prohibit timer has expired, the trigger condition 2 is met, so the MS determines whether or not power backoff decrement is greater than the power backoff threshold value (S2045). When the power backoff decrement is greater than the power backoff threshold value, trigger condition 1 is met. Thus, the MS determines whether or not uplink resource for transmitting PHR has been secured (S2050). When uplink resource has been secured, the MS transmits PHR to the BS (S2055) and makes only the second prohibit timer restart (S2060). Namely, when transmission of PHR based on power backoff according to a reduction in the PMPR occurs, only the second prohibit timer restarts.

[311] In step S2050, if uplink resource has not been secured, the MS skips transmission of PHR (S2035).

[312] In step S2010, when the first prohibit timer has not expired, the MS determines whether or not the increment of power backoff is greater than the threshold value (S2065). Namely, the MS determines whether or not the condition 3 is met.

[313] When the condition 3 is met, the MS determines whether or not the condition 2 is met as to whether or not the second prohibit timer has expired. Namely, the MS performs steps sequentially starting from step S2040. When the condition 3 is not met, the MS terminates the procedure.

[314] FIG. 21 is a flow chart illustrating a method of performing PHR of a mobile station (MS) according to another embodiment of the present invention. FIG. 21 shows a case in which two prohibit timers are provided, only the first prohibit timer is reset or restart according to PHR triggering based on a pathloss variation and only the second prohibit timer is reset or restart according to PHR triggering based on power backoff like the case of FIG. 15.

[315] Thus, the embodiment of FIG. 21 is different from the embodiment of FIG. 20, in that whether or not only the prohibit timer is reset restarts or whether or not both the first and second prohibit timers are reset or restart by the PHR triggering based on a pathloss variation.

[316] With reference to FIG. 21, the MS receives an uplink grant from the BS (S2100). The MS measures current first and second prohibit timers (S2105). The MS first determines whether or not the first prohibit timer has expired based on a value of the first prohibit timer and that of the second prohibit timer (S2110). When the first prohibit timer has expired, since the trigger condition 2 is met, the MS compares the pathloss variation $\triangle PL$ and the pathloss threshold value PL_{TH} (S2115). Also, the MS determines whether or not the periodic timer has expired. Or, PHR triggering may occur even when the periodic timer has expired in step S2115.

[317] When $\triangle PL > PL_{TH}$ or when the periodic timer has expired in step S2115, the trigger condition 1 is met. Although both of the trigger conditions 1 and 2 are met, if there is no uplink resource, PHR cannot be transmitted. Thus, the MS determines whether or not uplink resource for transmitting PHR has been secured (S2120). If uplink resource has been secured, the MS transmits PHR to the BS (S2125). And, the MS makes only the first prohibit timer restart (S2130). Namely, when transmission of PHR based on pathloss occurs, only the first prohibit timer restarts, and the second prohibit timer is not affected.

[318] In step S2120, if uplink resource has not been secured, the MS skips transmission of PHR (S2135).

[319] In step S2115, if it is not $\triangle PL > PL_{TH}$ and the periodic timer has not expired, the trigger condition 1 is not met. The MS determines whether or not the second prohibit timer has expired (S2140). If the second prohibit timer has not expired, the trigger condition 2 is not met, so the MS terminates the procedure.

[320] If the second prohibit timer has expired, the trigger condition 2 is met, so the MS determines whether or not power backoff decrement is greater than the power backoff threshold value (S2145). When the power backoff decrement is greater than the power backoff threshold value, trigger condition 1 is met. Thus, the MS determines whether or not uplink resource for transmitting PHR has been secured (S2150). When uplink resource has been secured, the MS transmits PHR to the BS (S2155) and makes only the second prohibit timer restart (S2160). Namely, when transmission of PHR based on power backoff according to a reduction in the PMPR occurs, only the second prohibit timer restarts and the first prohibit timer is not affected.

[321] In step S2150, if uplink resource has not been secured, the MS skips transmission of PHR (S2135).

[322] In step S2110, when the first prohibit timer has not expired, the MS determines

whether or not the increment of power backoff is greater than the threshold value (S2165). Namely, the MS determines whether or not the condition 3 is met.

[323] When the condition 3 is met, the MS determines whether or not the condition 2 is met and performs the process sequentially starting from step S2140. When the condition 3 is not met, the MS terminates the procedure.

[324] FIG. 22 is a flow chart illustrating a method of performing PHR of a mobile station (MS) according to another embodiment of the present invention.

[325] With reference to FIG. 22, the BS transmits prohibit timer configuration information to the MS (S2200). The prohibit timer configuration information includes information regarding a length of the first prohibit timer and that of the second prohibit timer. The length of the first prohibit timer and that of the second prohibit timer may be in units of subframes. The prohibit timer configuration information, as an RRC message, may have a format as shown in Table 2 or Table 3.

[326] The BS transmits an uplink grant to the MS (S2210). The uplink grant is, for example, as shown in Table 4.

[327] The BS receives PHR transmitted through uplink resource allocated by the uplink grant from the MS (S2220).

[328] FIG. 23 is a block diagram showing a terminal (or an MS) and a BS performing PHR according to an embodiment of the present invention.

[329] With reference to FIG. 23, a MS 2300 includes a downlink reception unit 2305, a trigger prohibition unit 2310, a PHR generation unit 2315, and an uplink transmission unit 2320.

[330] The downlink reception unit 2305 receives an uplink grant or an RRC message from a BS 2350. The RRC message includes prohibit timer configuration information or a MAC-MainConfig information element. For example, the RRC message may be as shown in Table 2 or Table 3.

[331] The trigger prohibition unit 2310 measures a variation of pathloss with respect to a sub-serving cell set in the MS 2300 and increment or decrement of power backoff, measures a first prohibit timer 2311 and a second prohibit timer 2312 used to prohibit PHR triggering, and generates or prohibits triggering of first PHR based on the variation of pathloss and triggering of a second PHR based on the increment or decrement of power backoff, based on the state of the first prohibit timer 2311 and the second prohibit timer 2312.

[332] For example, when the first does not expire, the trigger prohibition unit 2310 prohibits triggering of the first PHR and triggering of the second PHR. Or, the trigger prohibition unit 2310 generates or prohibits triggering of the second PHR based on the state of the second prohibit timer 2312. Or, when any one of triggering of the first PHR and triggering of the second PHR is triggered and transmitted, the trigger prohibition

unit 2310 make at least one of the first prohibit timer 2311 and the second prohibit timer restart 2312.

[333] In detail, the trigger prohibition unit 2310 may prohibit or perform triggering of PHR according to any one of procedures illustrated in FIGS. 17 to 21. Namely, when the variation of pathloss if greater than a pathloss threshold value or when the decrement of power backoff is greater than power backoff threshold value, the trigger prohibition unit 2310 determines that the condition 1 is met and determines that the trigger condition 2 is met according to expiration of the first prohibit timer 2311 or the second prohibit timer 2312. Also, when the increment of power backoff is greater than the power backoff threshold value, the trigger prohibition unit 2310 determines that the condition 3 is met.

[334] When the trigger condition are not met, the trigger prohibition unit 2310 prohibits PHR triggering, and when the trigger condition is met, the trigger prohibition unit 2310 triggers PHR and informs the PHR generation unit 2315 accordingly.

[335] For another example, the trigger prohibition unit 2310 generates or prohibits triggering of report of the power headroom by considering a variation of pathloss (PL) with respect to the at least one serving cell and a varation of power backoff (PB) caused by other communication system which the MS supports, and by considering a time value received from a base station (BS) through a radio resource control (RRC) message.

[336] For another example, the trigger prohibition unit 2310 prohibits the report of the power headroom by considering increment or decrement of the PB, or by considering increment or decrement of the PB and a variation of the PL.

[337] For another example, the trigger prohibition unit 2310 generates the report of the PH when increment of PB is greater than a predetermined threshold

[338] For another example, the trigger prohibition unit 2310 includes a first prohibit timer 2311 prohibiting the report of the PH by considering decrement of the PB and variation of the PL and a second prohibit timer 2312 prohibiting the report of the PH by considering increment or decrement of the PB. Also, the trigger prohibition unit 2310 may measure whether the first prohibit timer 2311 and the second prohibit timer 2312 operate or not.

[339] For another example, when the first prohibit timer 2311 does not expire, the trigger prohibition unit 2310 prohibits both a report of power headroom triggered if decrement of PB is greater than a predetermined threshold and a report of power headroom triggered if variation of PL is greater than a predetermined threshold .

[340] For another example, when the first prohibit timer 2311 expires, the trigger prohibition unit 2310 may restart the first prohibit timer 2311 after a report of power headroom in case that decrement of PB is greater than a predetermined threshold or

variation of PL is greater than a predetermined threshold is triggered.

[341] For another example, trigger prohibition unit 2310 generates or prohibits triggering under the condition that a PHR available state continues for a certain trigger time.

[342] The PHR generation unit 2315 generates a MAC control element (CE) for PHR, and transfers the same to the uplink transmission unit 2320. The PHR generation unit 2315 calculates power headroom of at least one serving cell which the MS 2300 supports, and generating a medium access control (MAC) message including the calculated PH;

[343] The uplink transmission unit 2320 transmits the generated MAC CE for PHR to the BS 2350. The uplink transmission unit 2320 transmits the MAC message which includes the PH selectively based on trigger prohibition of the trigger prohibition unit, to the BS.

[344] The downlink reception unit 2305 receives an uplink grant considering the PH for allocating resource from the BS 2350.

[345] The BS 2350 includes an RRC configuration unit 2355, a scheduling unit 2360, a downlink transmission unit 2365, and an uplink reception unit 2370.

[346] The RRC configuration unit 2355 configures a prohibit timer, generates an RRC message including information regarding the prohibit timer, and transmits the generated RRC message to the downlink transmission unit 2365.

[347] The scheduling unit 2365 performs uplink scheduling for the MS 2300, and generates an uplink grant to be transmitted via a PDCCH.

[348] The downlink transmission unit 2365 transmits the RRC message or the uplink grant to the MS 2300.

[349] For example, a downlink transmission unit 2365 transmits a time value about length of a first prohibit timer prohibiting a PHR by considering decrement of power backoff (PB) and variation of the pathloss (PL), or a time value about length of a second prohibit timer prohibiting a PHR by considering increment or decrement of the PB, to the MS 2300.

[350] For another example, the downlink transmission unit 2365 transmits updated uplink grant by considering the PHR, through a radio resource control message, to the MS 2300.

[351] The uplink reception unit 2370 receives PHR transmitted by PHR triggering from the MS 2300.

[352] The embodiments of the present invention have been described with reference to the accompanying drawings, and it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope of the invention. Thus, it is intended that any future modifications of the embodiments of the present invention will come within the scope of the appended claims and their equivalents.

Claims

[Claim 1] A mobile station (MS) performing power headroom report (PHR) in wireless communication system, the MS comprising:
a PHR generation unit for calculating power headroom (PH) of at least one serving cell which the MS supports, and generating a medium access control (MAC) message including the calculated PH;
a trigger prohibition unit for generating or prohibiting triggering of report of the PH by considering a variation of pathloss (PL) with respect to the at least one serving cell and a varation of power backoff (PB) caused by other communication system which the MS supports, and by considering a time value received from a base station (BS) through a radio resource control (RRC) message; and
an uplink transmission unit for transmitting the MAC message which includes the PH selectively based on trigger prohibition of the trigger prohibition unit, to the BS.

[Claim 2] The MS of claim 1, further includes a downlink reception unit for receiving an uplink grant considering the PH for allocating resource from the BS;

[Claim 3] The MS of claim 1, wherein the trigger prohibition unit is configured to prohibit the report of the PH by considering increment or decrement of the PB, or by considering increment or decrement of the PB and a variation of the PL.

[Claim 4] The MS of claim 3, wherein the trigger prohibition unit is configured to generate the report of the PH when increment of PB is greater than a predetermined threshold

[Claim 5] The MS of claim 3, wherein the trigger prohibition unit further includes a first prohibit timer prohibiting the report of the PH by considering decrement of the PB and variation of the PL; and
a second prohibit timer prohibiting the report of the PH by considering increment or decrement of the PB.

[Claim 6] The MS of claim 5, wherein the time value received from the BS is the length of the first prohibit timer and the second prohibit timer; and
the trigger prohibition unit further measures whether the first prohibit timer and the second prohibit timer operate or not

[Claim 7] The MS of claim 5, wherein when the first prohibit timer does not expire, the trigger prohibition unit prohibits both a report of PH triggered if decrement of PB is greater than a predetermined threshold and a report of PH triggered if variation of PL is greater than a predetermined threshold .

[Claim 8] The MS of claim 1, wherein when the first prohibit timer expires, the trigger prohibition unit further comprising of restarting the first prohibit timer after a report of PH in case that decrement of PB is greater than a predetermined threshold or variation of PL is greater than a predetermined threshold is triggered.

[Claim 9] The MS of claim 1, where the trigger prohibition unit generates or prohibits triggering under the condition that a PHR available state continues for a certain trigger time.

[Claim 10] A method of performing power headroom report (PHR) by a mobile station (MS) in wireless communication system, the method comprising:
calculating power headroom (PH) of at least one serving cell which the MS supports, and generating a medium access control (MAC) message including the calculated PH;
generating or prohibiting triggering of report of the PH by considering a variation of pathloss (PL) with respect to the at least one serving cell and a varation of power backoff (PB) caused by other communication system which the MS supports, and by considering a time value received from a base station (BS) through a radio resource control (RRC) message; and
transmitting the MAC message which includes the PH selectively based on trigger prohibition of the trigger prohibition unit, to the BS.

[Claim 11] The method of claim 10, further comprises receiving an uplink grant considering the PH for allocating resource from the BS;

[Claim 12] The method of claim 10, wherein triggering of the report of the PH is prohibited by considering increment or decrement of the PB, or by considering increment or decrement of the PB and a variation of the PL.

[Claim 13] The method of claim 12, wherein triggering of the report of the PH is generated when a increment of PB is greater than a predetermined threshold

[Claim 14] The method of claim 12, wherein triggering of report of the PH is generated of prohibited by using a first prohibit timer prohibiting the report of the PH by considering decrement of the PB and variation of the PL and a second prohibit timer prohibiting the report of the PH by considering increment or decrement of the PB.

[Claim 15] The method of claim 14, wherein the time value received from the BS

is the length of the first prohibit timer and the second prohibit timer; and
further measuring whether the first prohibit timer and the second prohibit timer operate or not

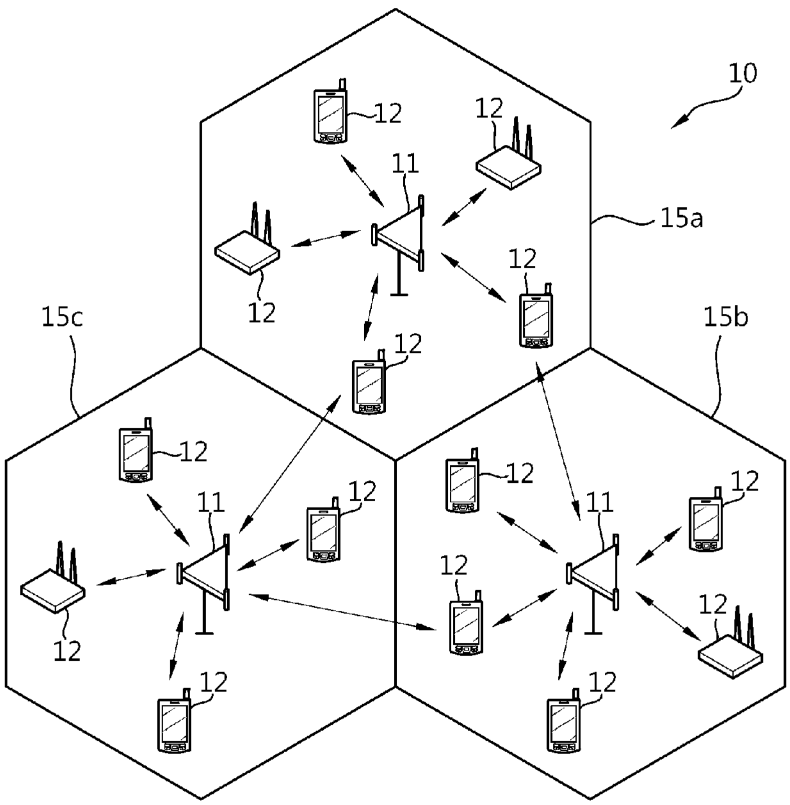
[Claim 16] The method of claim 14, wherein when the first prohibit timer does not expire, further prohibiting both a report of PH triggered if decrement of PB is greater than a predetermined threshold and a report of PH triggered if variation of PL is greater than a predetermined threshold .

[Claim 17] The method of claim 10, wherein when the first prohibit timer expires, restarting the first prohibit timer after a report of PH in case that decrement of PB is greater than a predetermined threshold or variation of PL is greater than a predetermined threshold is triggered.

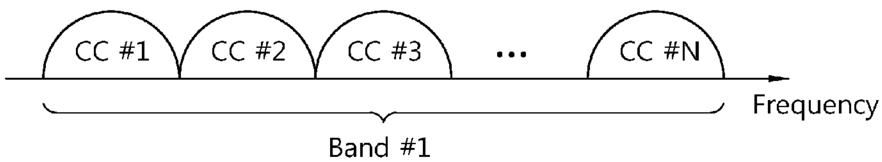
[Claim 18] The method of claim 10, wherein the triggering is generated or prohibited under the condition that a PHR available state continues for a certain trigger time.

[Claim 19] A base station (BS) performing power headroom report (PHR) in wireless communication system, the BS comprising:
a downlink transmission unit for transmitting a time value about length of a first prohibit timer prohibiting a PHR by considering decrement of power backoff (PB) and variation of the pathloss (PL), or a time value about length of a second prohibit timer prohibiting a PHR by considering increment or decrement of the PB, to a mobile station (MS); and
a uplink reception unit for receiving the PHR through uplink resource allocated by uplink grant, from the MS
wherein the downlink transmission unit transmits updated uplink grant by considering the PHR, through a radio resource control message, to the MS.

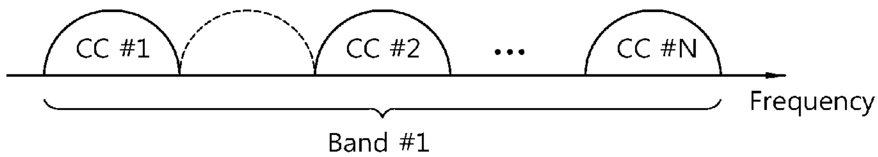
[Fig. 1]



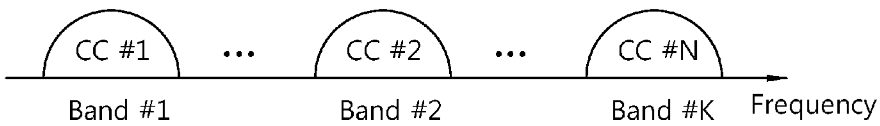
[Fig. 2]



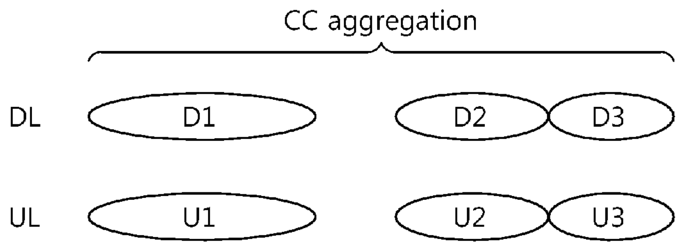
[Fig. 3]



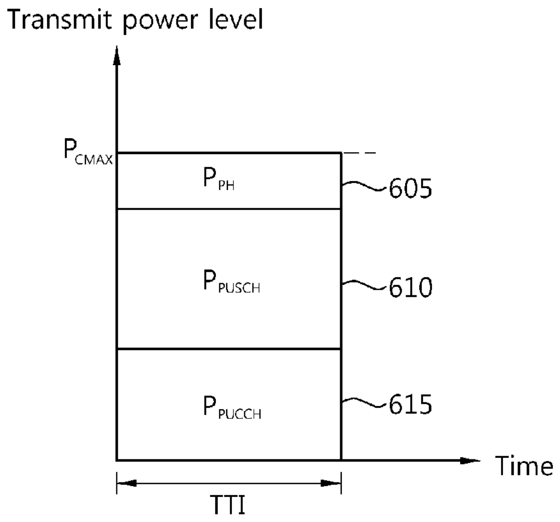
[Fig. 4]



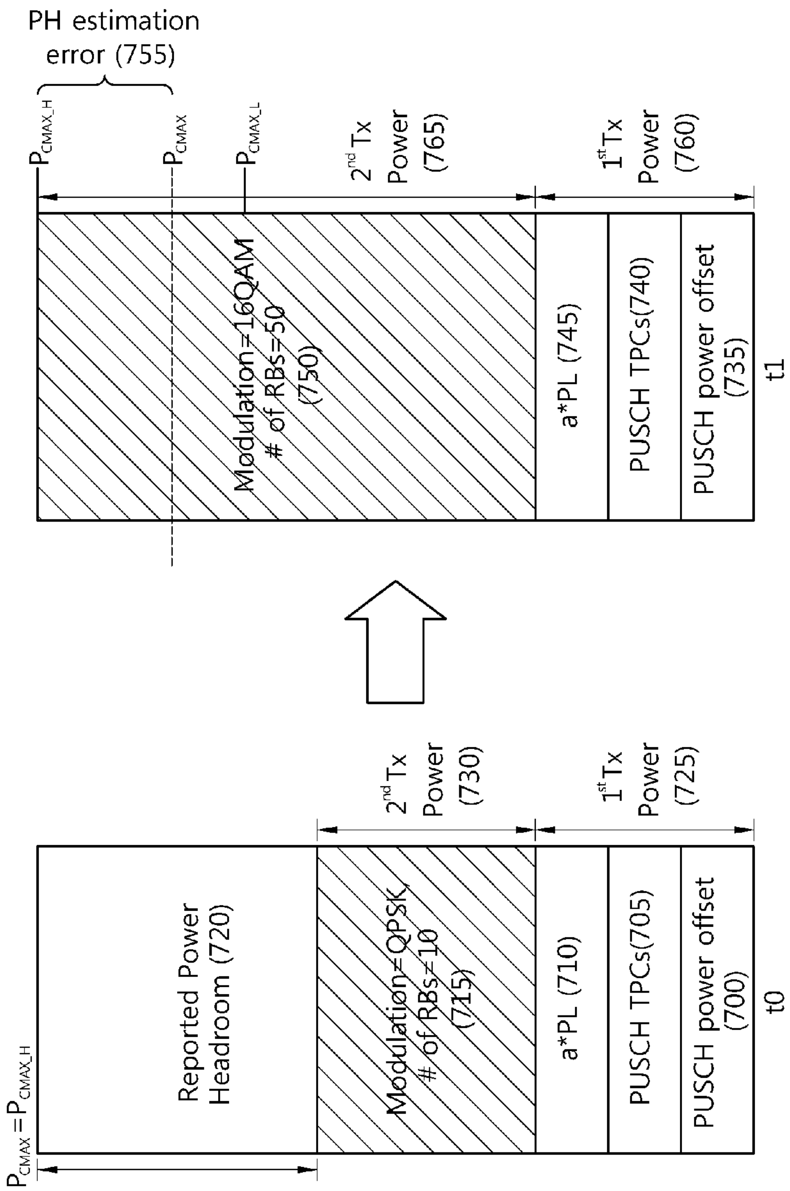
[Fig. 5]


CC aggregation
DL
D1
D2
D3
UL
U1
U2
U3

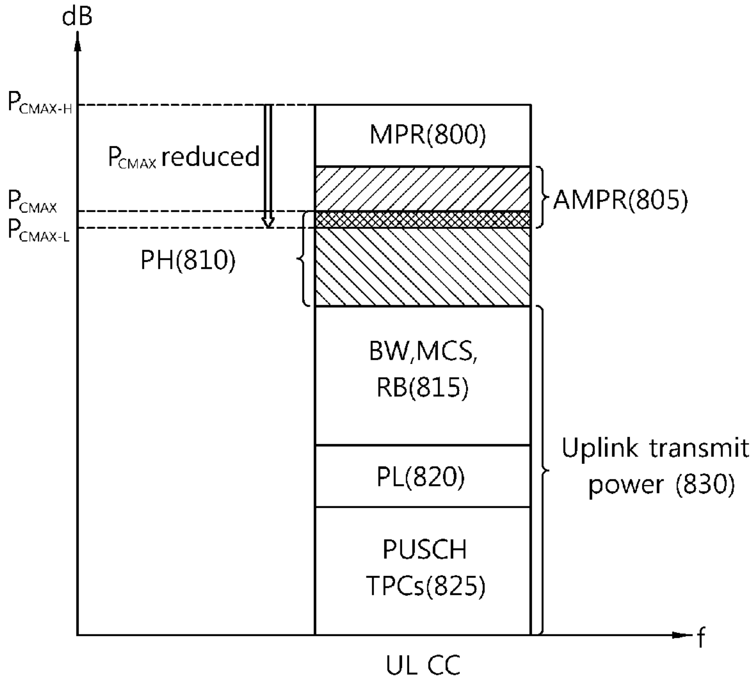
[Fig. 6]


Transmit power level
P_{CMAX}
P_{PH}
605
P_{PUSCH}
610
P_{PUCCH}
615
Time
TTI

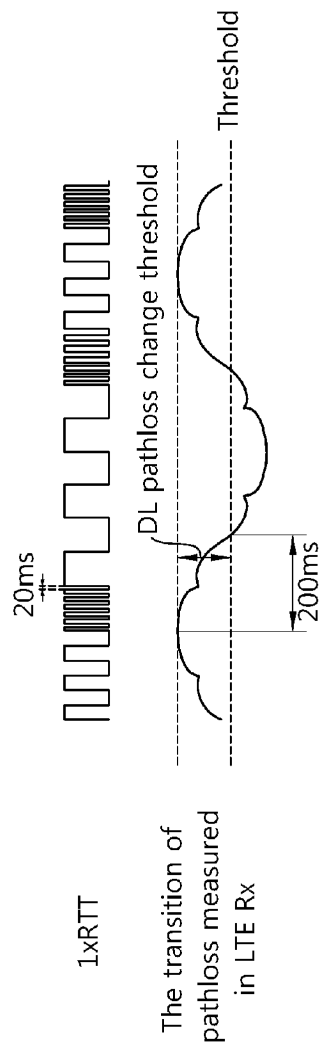
[Fig. 7]


PH estimation error (755)
P_{CMAX_H}
P_{CMAX}
P_{CMAX_L}
2nd Tx Power (765)
1st Tx Power (760)
Modulation=16QAM
# of RBs=50
(750)
a*PL (745)
PUSCH TPCs(740)
PUSCH power offset (735)
t1
2nd Tx Power (730)
1st Tx Power (725)
$P_{CMAX}=P_{CMAX\_H}$
Reported Power Headroom (720)
Modulation=QPSK
# of RBs=10
(715)
a*PL (710)
PUSCH TPCs(705)
PUSCH power offset (700)
t0

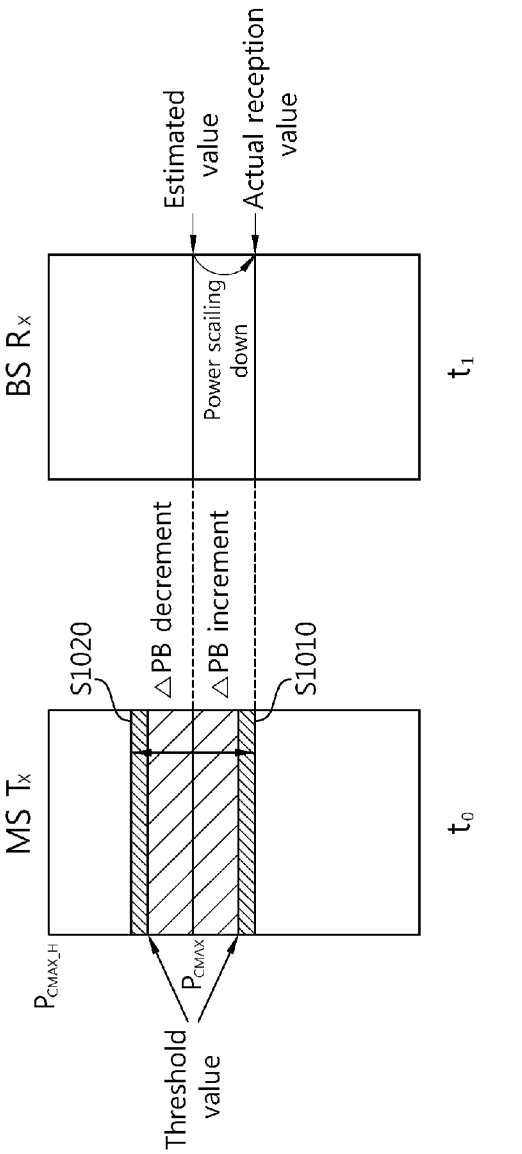
[Fig. 8]


dB
P_{CMAX-H}
P_{CMAX} reduced
P_{CMAX}
P_{CMAX-L}
PH(810)
MPR(800)
AMPR(805)
BW,MCS,
RB(815)
PL(820)
PUSCH
TPCs(825)
Uplink transmit
power (830)
f
UL CC

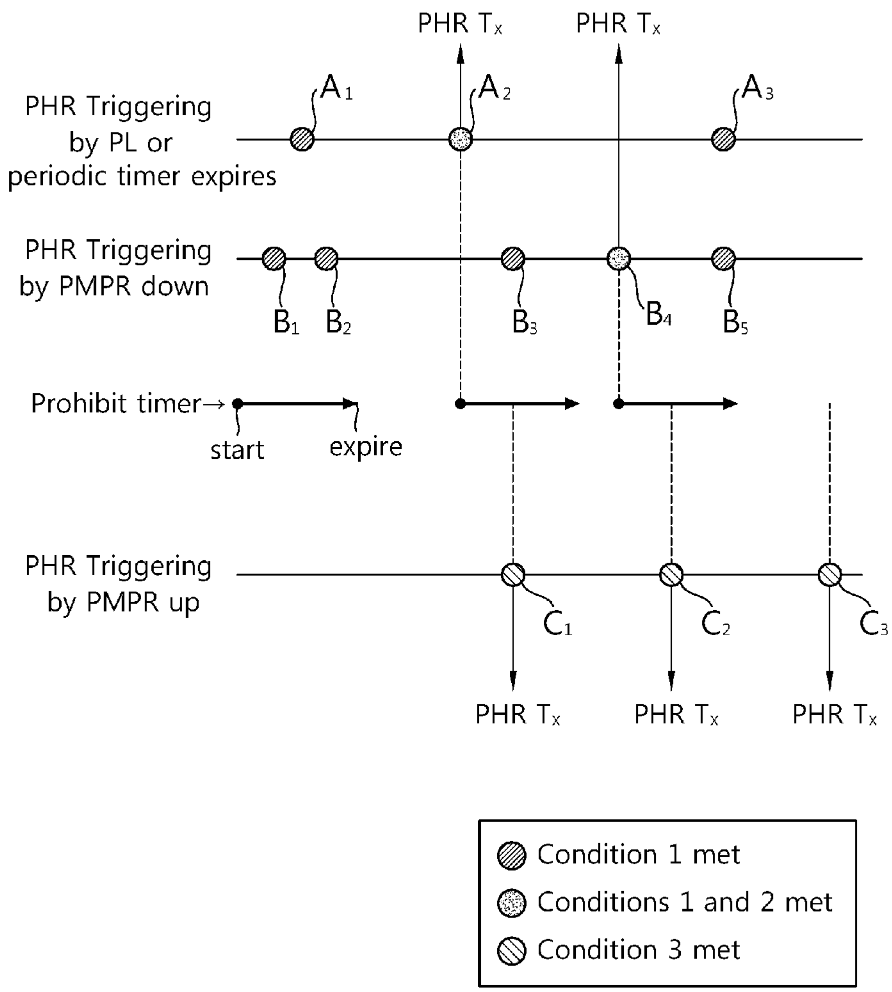
[Fig. 9]


Threshold
DL pathloss change threshold
20ms
200ms
1xRTT
The transition of
pathloss measured
in LTE Rx

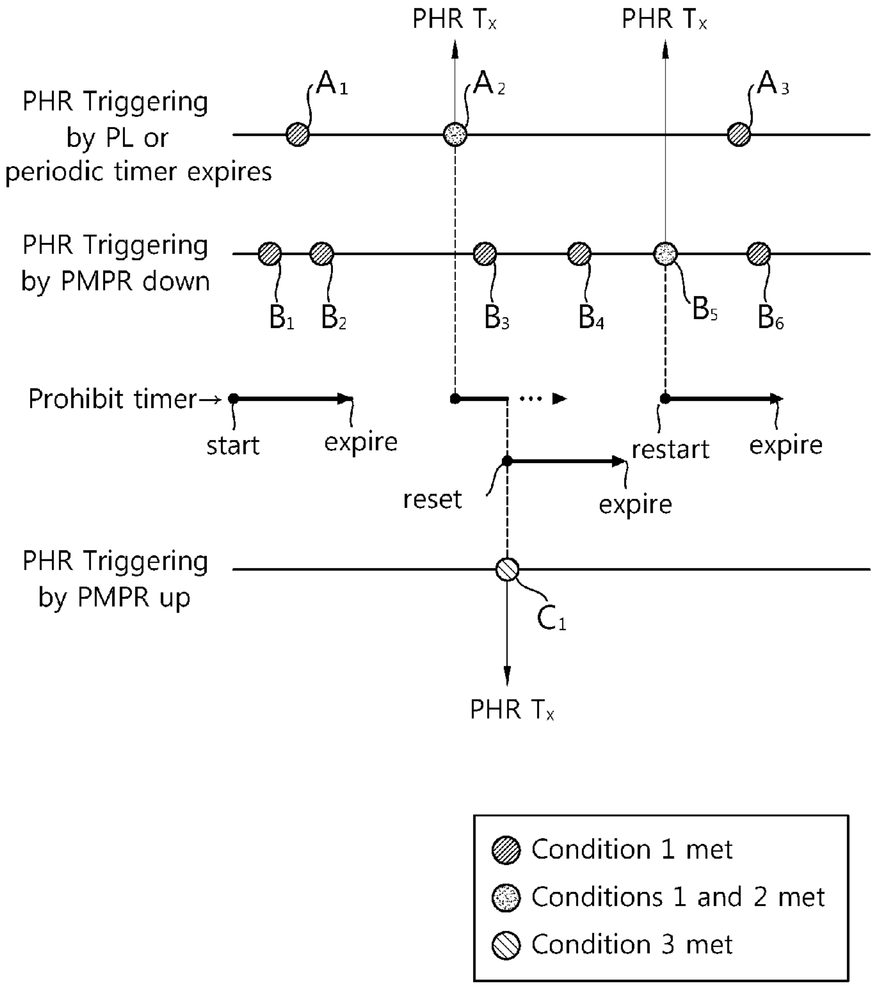
[Fig. 10]


BS Rx
MS Tx
Estimated value
Actual reception value
Power scailing down
t1
t0
S1020
S1010
△PB decrement
△PB increment
PCMAX_H
PCMAX
Threshold value

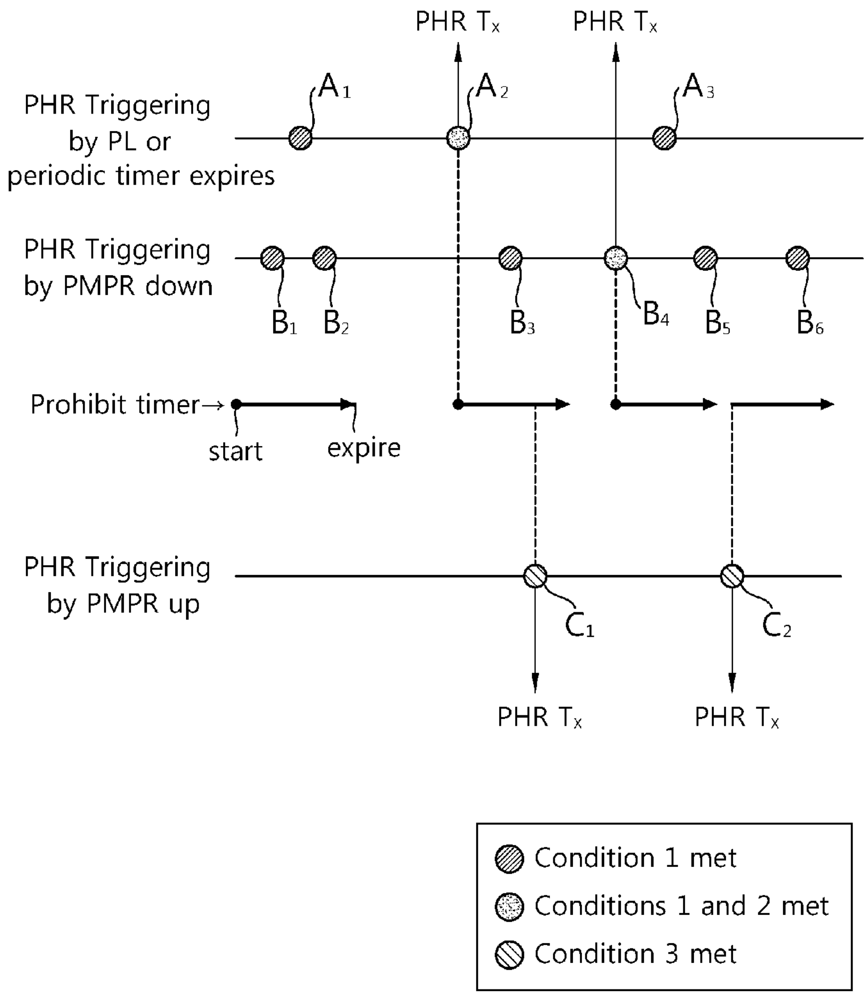
[Fig. 11]


PHR T_x
PHR T_x
PHR Triggering by PL or periodic timer expires
A_1
A_2
A_3
PHR Triggering by PMPR down
B_1
B_2
B_3
B_4
B_5
Prohibit timer→
start
expire
PHR Triggering by PMPR up
C_1
C_2
C_3
PHR T_x
PHR T_x
PHR T_x
Condition 1 met
Conditions 1 and 2 met
Condition 3 met

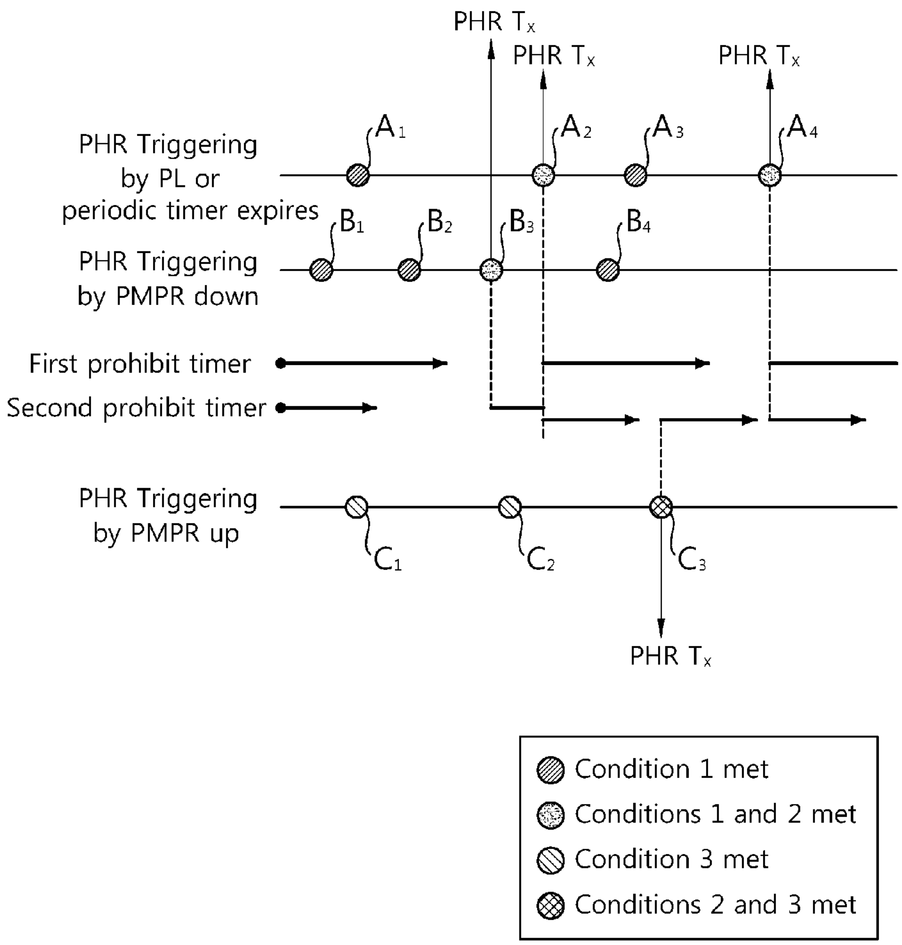
[Fig. 12]


PHR Tx
PHR Tx
PHR Triggering by PL or periodic timer expires
A1
A2
A3
PHR Triggering by PMPR down
B1
B2
B3
B4
B5
B6
Prohibit timer→
start
expire
reset
expire
restart
expire
PHR Triggering by PMPR up
C1
PHR Tx
Condition 1 met
Conditions 1 and 2 met
Condition 3 met

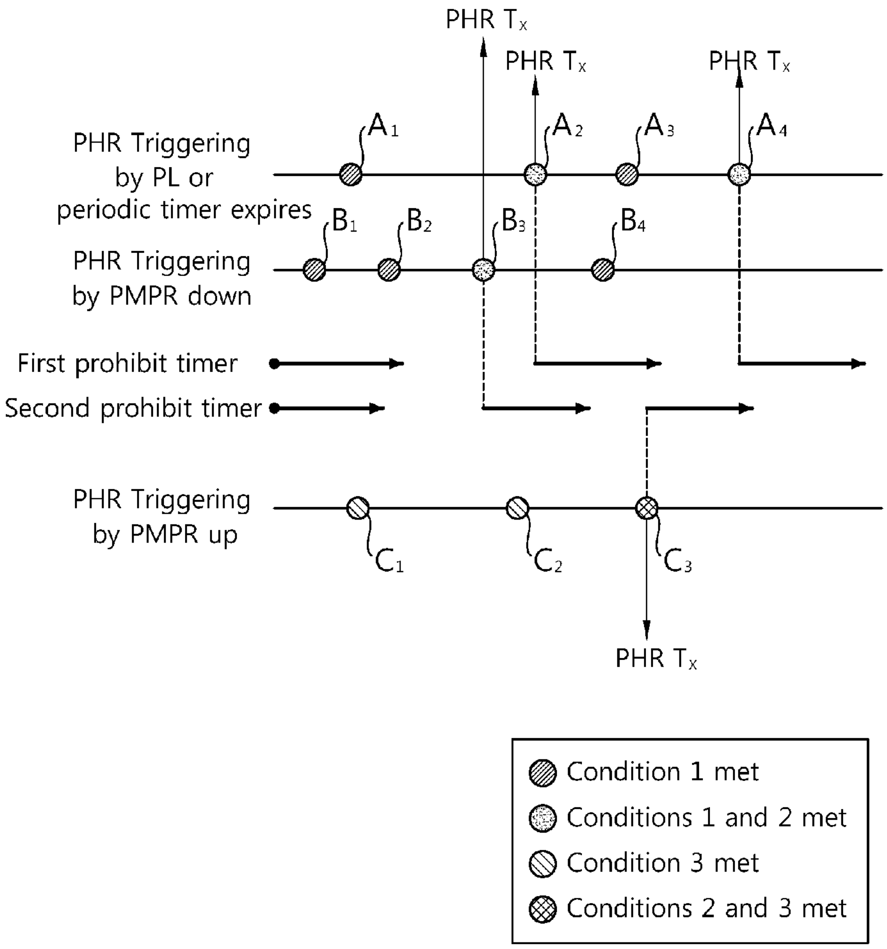
[Fig. 13]


PHR Tx
PHR Tx
A1
A2
A3
PHR Triggering by PL or periodic timer expires
PHR Triggering by PMPR down
B1
B2
B3
B4
B5
B6
Prohibit timer→
start
expire
PHR Triggering by PMPR up
C1
C2
PHR Tx
PHR Tx
Condition 1 met
Conditions 1 and 2 met
Condition 3 met

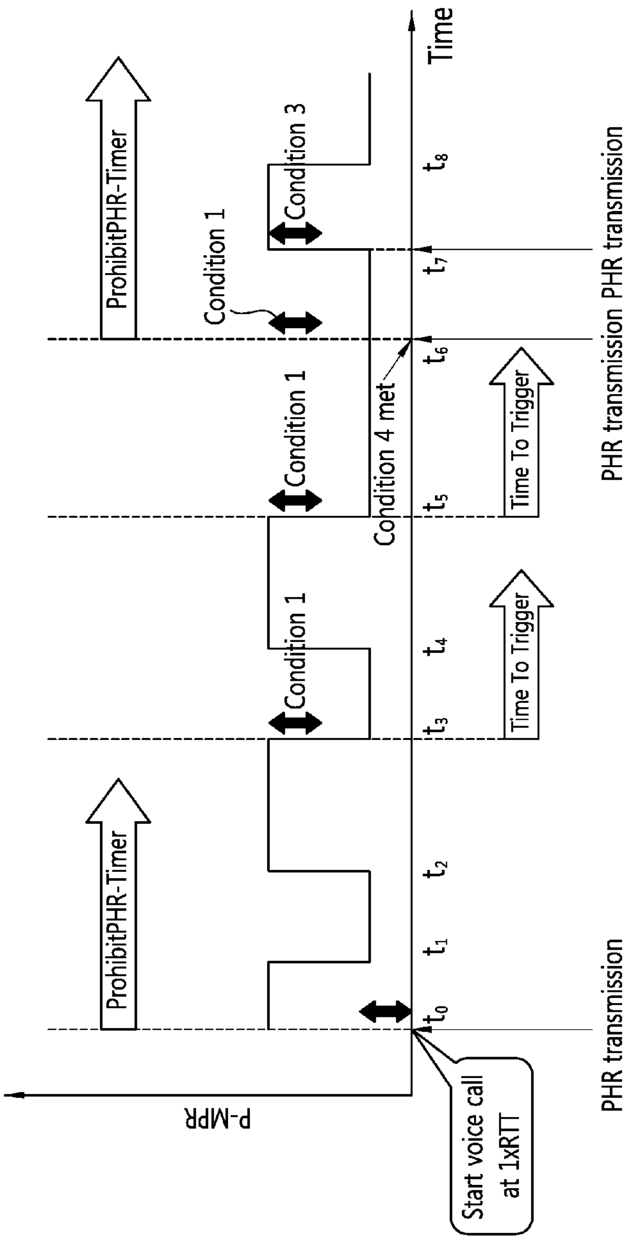
[Fig. 14]


PHR Tx
PHR Tx
PHR Tx
A1
A2
A3
A4
PHR Triggering by PL or periodic timer expires
B1
B2
B3
B4
PHR Triggering by PMPR down
First prohibit timer
Second prohibit timer
PHR Triggering by PMPR up
C1
C2
C3
PHR Tx
Condition 1 met
Conditions 1 and 2 met
Condition 3 met
Conditions 2 and 3 met

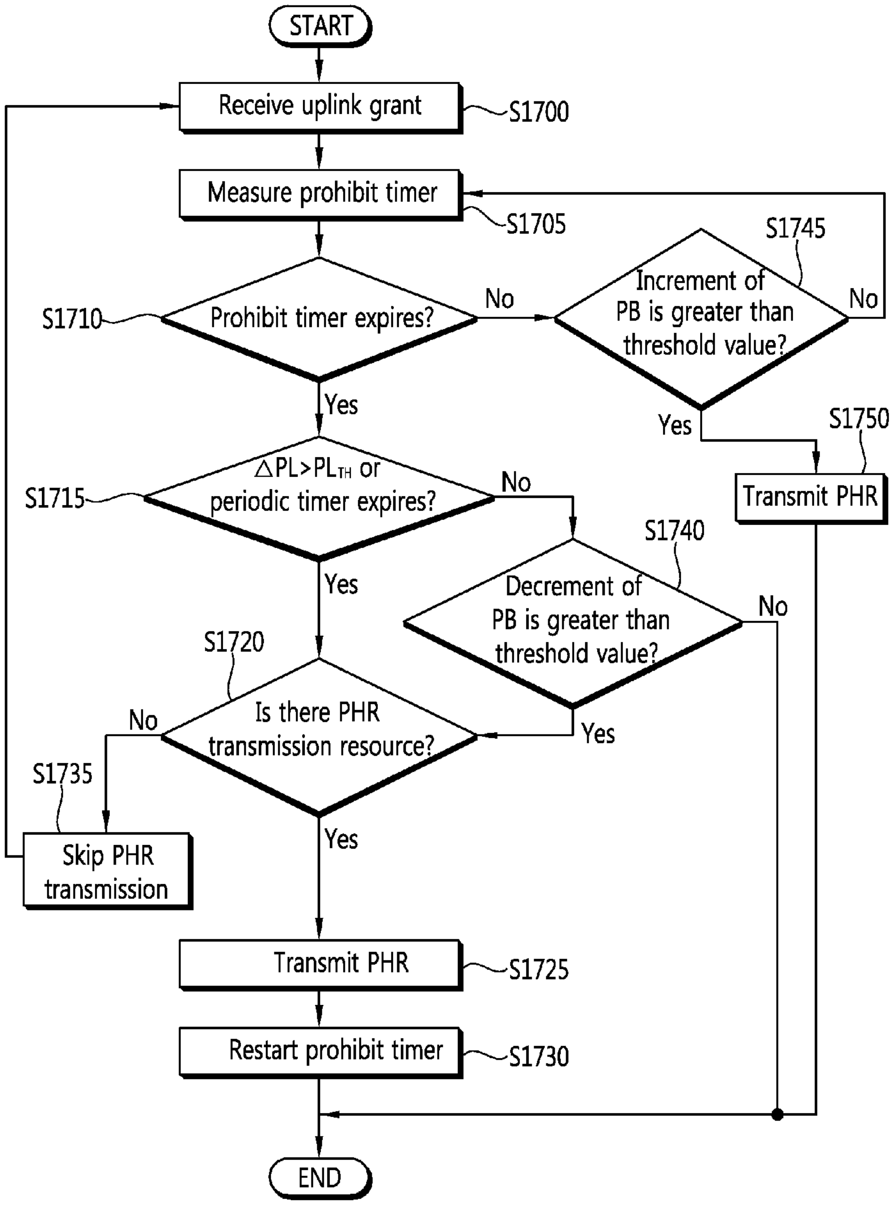
[Fig. 15]


PHR Tx
PHR Tx
PHR Tx
A1
A2
A3
A4
PHR Triggering by PL or periodic timer expires
B1
B2
B3
B4
PHR Triggering by PMPR down
First prohibit timer
Second prohibit timer
PHR Triggering by PMPR up
C1
C2
C3
PHR Tx
Condition 1 met
Conditions 1 and 2 met
Condition 3 met
Conditions 2 and 3 met

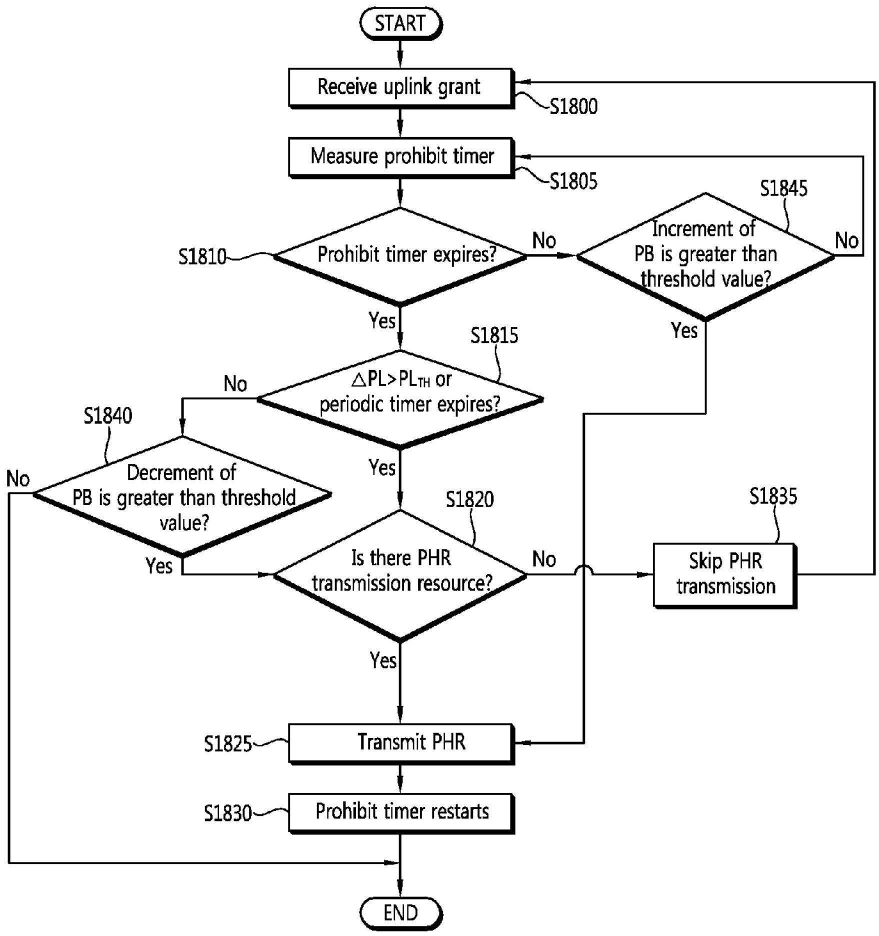
[Fig. 16]


Time
P-MPR
ProhibitPHR-Timer
ProhibitPHR-Timer
Condition 1
Condition 1
Condition 1
Condition 3
Condition 4 met
Time To Trigger
Time To Trigger
Start voice call at 1xRTT
PHR transmission
PHR transmission
PHR transmission
t_0
t_1
t_2
t_3
t_4
t_5
t_6
t_7
t_8

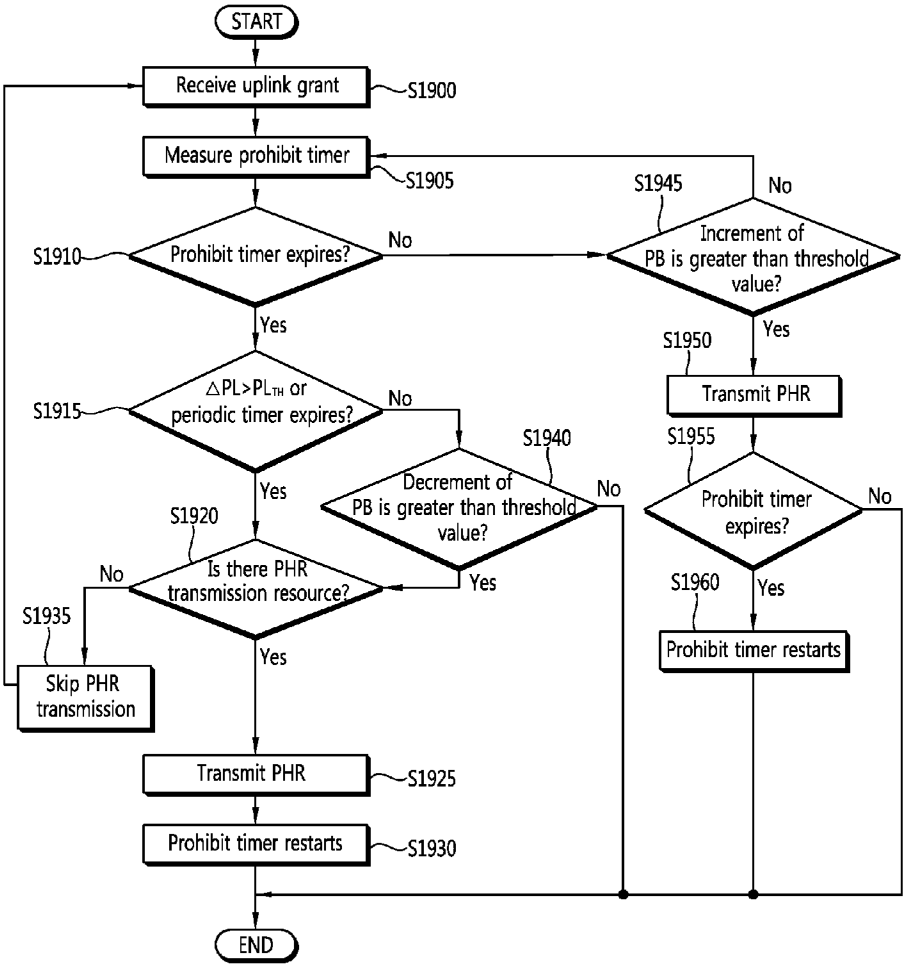
[Fig. 17]


START
Receive uplink grant
S1700
Measure prohibit timer
S1705
S1745
Prohibit timer expires?
S1710
No
Increment of PB is greater than threshold value?
No
Yes
Yes
S1750
$\triangle PL > PL_{TH}$ or periodic timer expires?
S1715
No
Transmit PHR
S1740
Yes
Decrement of PB is greater than threshold value?
No
S1720
Is there PHR transmission resource?
No
Yes
S1735
Yes
Skip PHR transmission
Transmit PHR
S1725
Restart prohibit timer
S1730
END

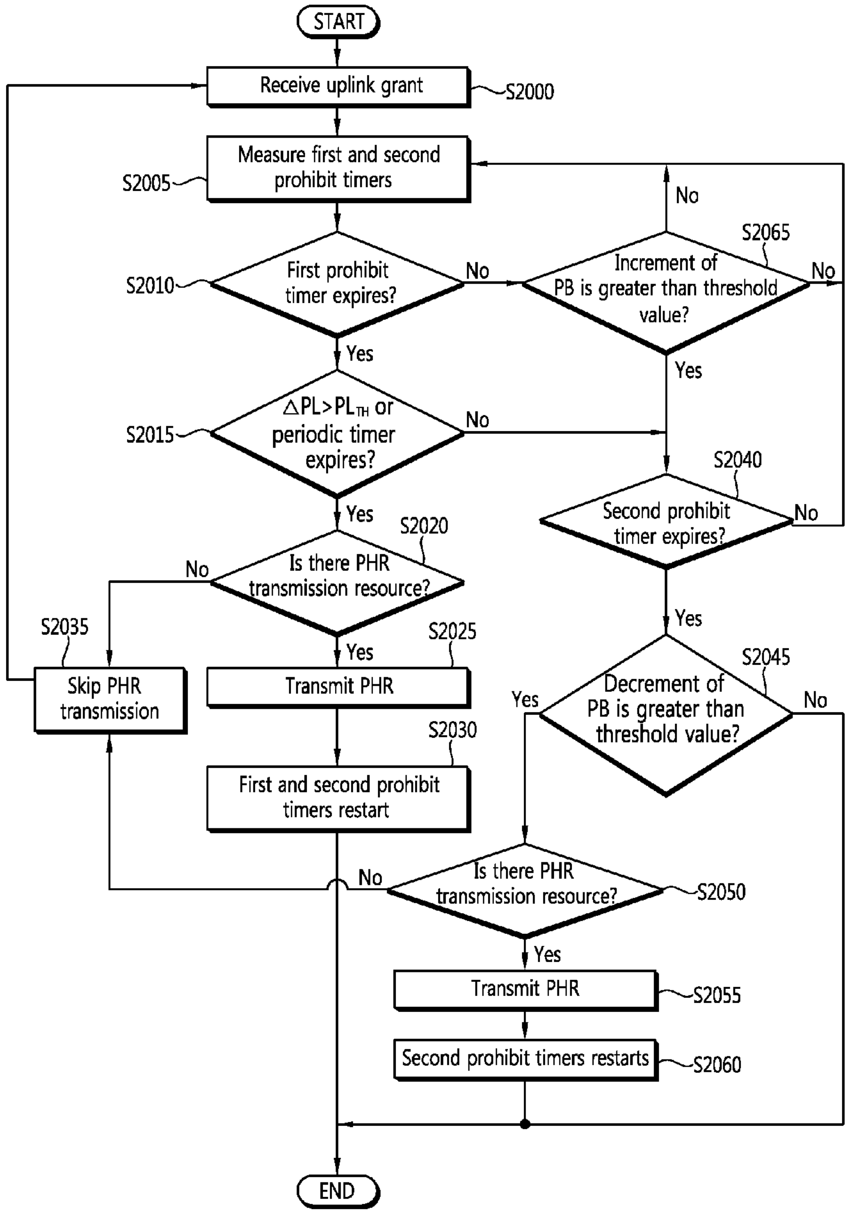
[Fig. 18]


START
Receive uplink grant
S1800
Measure prohibit timer
S1805
S1810
Prohibit timer expires?
No
S1845
Increment of PB is greater than threshold value?
No
Yes
Yes
S1815
△PL>PL_TH or periodic timer expires?
No
S1840
Decrement of PB is greater than threshold value?
No
Yes
Yes
S1820
Is there PHR transmission resource?
No
S1835
Skip PHR transmission
Yes
S1825
Transmit PHR
S1830
Prohibit timer restarts
END

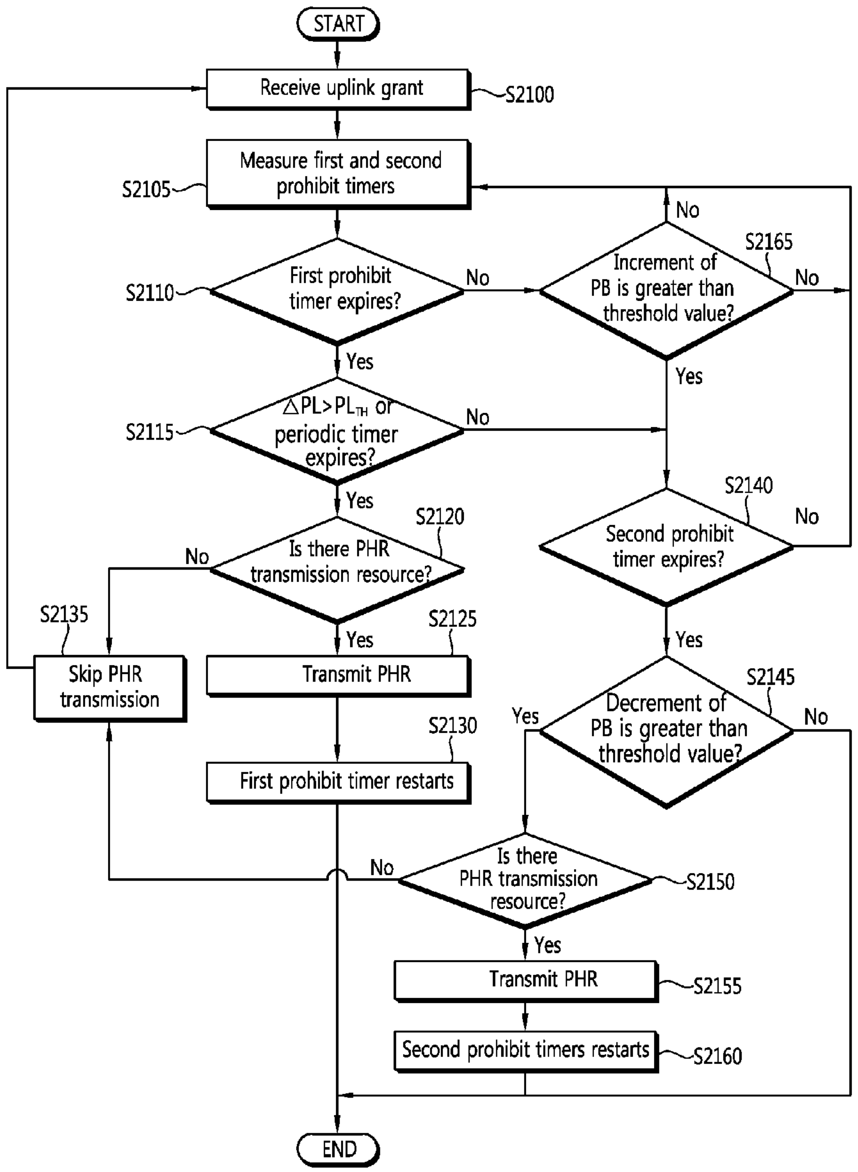
[Fig. 19]


START
Receive uplink grant
S1900
Measure prohibit timer
S1905
S1910
Prohibit timer expires?
No
Yes
S1945
No
Increment of
PB is greater than threshold
value?
Yes
S1950
Transmit PHR
S1955
Prohibit timer
expires?
No
S1960
Yes
Prohibit timer restarts
S1915
△PL>PL_TH or
periodic timer expires?
No
S1940
Decrement of
PB is greater than threshold
value?
No
Yes
S1920
Is there PHR
transmission resource?
No
Yes
S1935
Skip PHR
transmission
Transmit PHR
S1925
Prohibit timer restarts
S1930
END

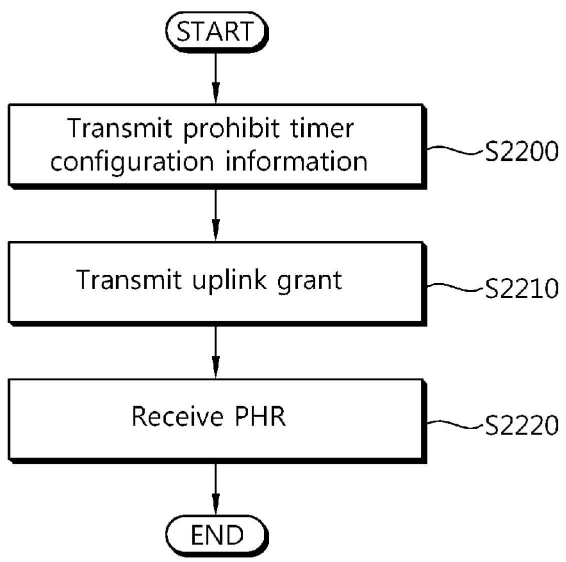
[Fig. 20]


START
Receive uplink grant
S2000
Measure first and second prohibit timers
S2005
First prohibit timer expires?
S2010
No
Increment of PB is greater than threshold value?
S2065
No
No
Yes
Yes
△PL>PL_TH or periodic timer expires?
S2015
No
S2040
Second prohibit timer expires?
No
Yes
S2020
Is there PHR transmission resource?
No
S2035
Yes
S2025
Skip PHR transmission
Transmit PHR
Yes
S2045
Yes
Decrement of PB is greater than threshold value?
No
S2030
First and second prohibit timers restart
No
Is there PHR transmission resource?
S2050
Yes
Transmit PHR
S2055
Second prohibit timers restarts
S2060
END

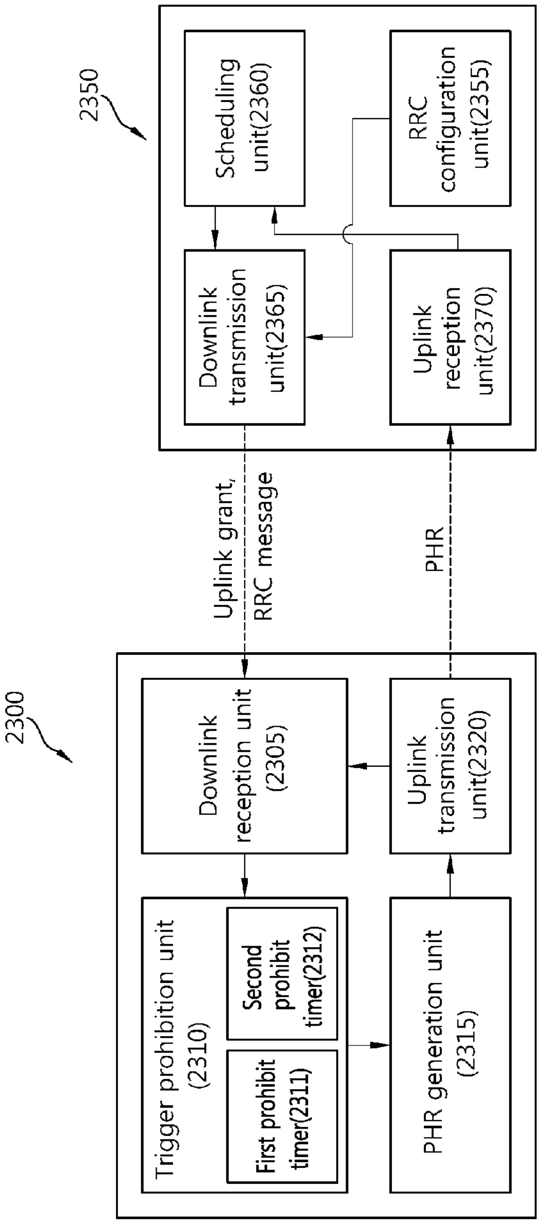
[Fig. 21]


START
Receive uplink grant
S2100
Measure first and second prohibit timers
S2105
First prohibit timer expires?
S2110
No
Yes
Increment of PB is greater than threshold value?
S2165
No
No
Yes
△PL>PL$_{TH}$ or periodic timer expires?
S2115
No
Yes
Is there PHR transmission resource?
S2120
No
Yes
S2140
Second prohibit timer expires?
No
Yes
S2135
Skip PHR transmission
S2125
Transmit PHR
S2130
First prohibit timer restarts
Decrement of PB is greater than threshold value?
S2145
Yes
No
Is there PHR transmission resource?
S2150
No
Yes
Transmit PHR
S2155
Second prohibit timers restarts
S2160
END

[Fig. 22]


START
Transmit prohibit timer configuration information
S2200
Transmit uplink grant
S2210
Receive PHR
S2220
END

[Fig. 23]


2350
Scheduling unit(2360)
RRC configuration unit(2355)
Downlink transmission unit(2365)
Uplink reception unit(2370)
Uplink grant, RRC message
PHR
2300
Downlink reception unit (2305)
Uplink transmission unit(2320)
Trigger prohibition unit (2310)
First prohibit timer(2311)
Second prohibit timer(2312)
PHR generation unit (2315)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2012/002460

A. CLASSIFICATION OF SUBJECT MATTER

H04W 24/10(2009.01)i, H04W 88/02(2009.01)i, H04W 72/14(2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W 24/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords:PHR, pathloss, power backoff, trigger, power headroom

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Ericsson et al., "Adding a Power Management indication in PHR" 3GPP TSG-RAN2 Meeting #73, R2-111601, Taipei, Taiwan, 21th-25th February 2011. see the whole document.	1-19
A	NEW POSTCOM, "Unification of Extended PHR MAC CE formats", 3GPP TSG-RAN WG2 Meeting #73, R2-111723, Taipei, Taiwan, 21th-25th February 2011. see the whole document.	1-19
A	SAMSUNG, "PHR timer handling after handover", 3GPP TSG-RAN2#66 meeting, R2-093431, San Francisco, USA, 4th-8th May 2009. see the whole document.	1-19

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 AUGUST 2012 (31.08.2012)	**19 SEPTEMBER 2012 (19.09.2012)**

Name and mailing address of the ISA/KR
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea
Facsimile No. 82-42-472-7140

Authorized officer
Ko, Yeon Hwa
Telephone No. 82-42-481-8569

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2012/002460

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
None			