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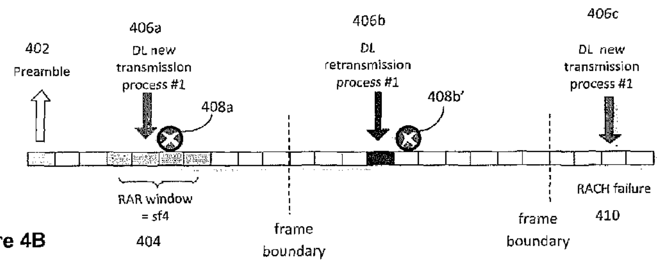


Figure 4B

**(57) Abstract**: In response to transmitting a preamble in a random access procedure, a receiver is tuned to receive from a network a dedicated random access response. It is decided to re- transmit the preamble only if: a) a command from the network is received that indicates an identifier of the preamble, a resource allocation, and power; or b) no dedicated transmission from the network access node is received during a time window defined for the random access response; or c) a hybrid automatic repeat request HARQ process associated with the random access response has expired without a successful decoding of the random access response. In one example the preamble is transmitted on a second component carrier CC in response to receiving on a first CC a physical downlink control channel identifying the preamble.

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# HANDLING RANDOM ACCESS FAILURE

## TECHNICAL FIELD:

[0001] The exemplary and non-limiting embodiments of this invention relate generally to wireless communication systems, methods, devices and computer programs and, more specifically, relate to random access procedures when using an identifier that is specific to a particular user equipment seeking network access, such as for example a C-RNTI.

## BACKGROUND:

[0002] Abbreviations used in this description and/or in the referenced drawings are defined below following the Detailed Description section.

[0003] The teachings herein dovetail with those detailed at co-owned PCT/CN2011/072453 filed on April 4, 2011. The background section of that co-owned application details carrier aggregation CA and cross carrier scheduling in a wireless communication system which is relevant to the teachings herein.

[0004] In LTE Release 10 it has been agreed that random access (by which a UE in an unconnected state with the network obtains a connection to the network) will only be done on the UE's primary component carrier PCC, sometimes referred to as the PCell. There is to be only intra-band CA for the uplink and only one timing advance TA for all UL CCs. But in LTE Release 11 and beyond, when considering taking inter-band CA as well as Radio Remote Radio Heads (RRHs) and repeaters, multiple TAs will be necessary. It has also been agreed in the 3GPP development of Release 11 that a RACH procedure will be enabled on the secondary CC or SCell to allow the UE acquire the TA value that is valid for the SCell. As was noted in co-owned PCT/CN2011/072453, this differs from prior RACH scenarios in that the UE using RACH only to obtain a TA for the SCell will already have an established RRC connection with the network on the PCell.

[0005] There are two main procedures for RACH: contention based and contention free. In the former the UE randomly selects a RACH preamble and sends the selected preamble on a PRACH using a common identifier (random access RNTI or RA-RNTI). In the contention-based RACH procedure the UE's preamble has the potential to interfere with another UE's preamble sent at the same time-frequency resource. A higher probability of success can be achieved if instead the UE ran a contention-free RACH procedure. In this case, the network would send to the UE a PDCCH which has the preamble for the UE to use for its RACH procedure, and the UE uses a UE-specific identifier such as the cell-RNTI (C-RNTI).

[0006] Figure 1 repeats Figure 1B of PCT/CN2011/072453 and gives an overview of a contention-free RACH procedure in the LTE system using the conventional designators 0, 1 and 2 for the illustrated messages. The network/eNB assigns the random access preamble to the UE in message 0 which is sent via dedicated DL signaling (e.g., directed specifically to the UE using its C-RNTI). For the case of cross-scheduling message 0 would be a PDCCH on the PCell. The UE sends message 1 UL on the RACH. Message 1 includes the preamble which was assigned by message 0 and is sent on a PRACH identified by a PRACH mask index. Message 2 (msg2) is the network's random access response to message 1, which is sent on the DL-SCH. There is a predetermined mapping from message 1 to the DL-SCH so the UE knows where to look for message 2. Message 2 indicates to the UE the absolute UL timing advance and also includes a UL grant as well.

[0007] In the 3GPP WG2 75bis and 76 meetings, it was discussed how to transmit the Message 2 for the RACH procedure on the SCell when cross carrier scheduling is configured. As recounted in document R2-115449 (by NTT Docomo as rapporteur) entitled Summary of email discussion [75#33]-LTE: Carrier Aggregation scenarios and resulting requirements [3GPP TSG RAN WG2 Meeting #75-bis; Zhuhai, China; 10-14 October 2011], there were totally three options on the table:

i. Address Msg2 with PDCCH in the common search space (RA-RNTI) and transmit Msg2 on the scheduling SCell/PCell with modified RAR or modified RA-RNTI

ii. Address Msg2 with PDCCH in the common search space (RA-RNTI) and transmit Msg2 on PCell with modified RAR or modified RA-RNTI

iii. Address Msg2 with PDCCH in the UE specific search space (C-RNTI) and transmit Msg2 on any serving cells

[0008] The third solution (C-RNTI based solution) is disclosed in detail at PCT/CN2011/072453 such that for the SCell, if only non-contention based RACH is *allowed, the eNB could always know which preamble is from which UE. And to avoid* possible random access response (Message 2) ambiguity in the cross carrier scheduling case, the eNB can send Msg2 on a dedicated PDSCH and use the PDCCH addressed to the UE's C-RNTI as the DL assignment. This approach reduces the size of Message 2 by omitting some unnecessary information for those instances where a RACH procedure is performed on the SCell (for example, where a timing advance C-RNTI sometimes referred to as a T_C-RNTI is used, or for an UL grant). As summarized in *document R2-115449, most of the participants in the RAN2 meeting, support the* C-RNTI based solution noted above.

[0009] These teachings consider how to handle random access failure for the case in which RACH message 2 is addressed to the UE's C-RNTI as detailed in PCT/CN2011/072453 and summarized above. First consider how this situation was handled in E-UTRAN Release 8/9/10 in which RACH was only performed on one cell and so Message 2 was addressed to the RA-RNTI in the common search space and multiplexed with the Message 2's directed to the RA-RNTIs other UE's might have used. Each different Message 2 is represented in Figure 2 as a RAR (random access response), and each is addressed to a different RA-RNTI which a different UE used with its randomly selected preamble they sent on the RACH (there is no preamble assignment for Figure 2 as depicted in Figure 1 since Figure 1 uses C-RNTI/UE-specific search spaces and Figure 2 uses RA-RNTIs and common search spaces).

[0010] For a contention-based RACH procedure, once a given UE transmits its preamble with its RA-RNTI at subframe $n$, it will start to monitor for a PDCCH addressed to that RA-RNTI on the common search space at subframe $n$+3 until subframe $n$+3+RAR_window. RAR_window is a parameter provided by the network via RRC signaling. If the UE does not detect a PDCCH addressed to the RA-RNTI it used in its preamble, or if the UE detected a RAR but did not find one addressed to itself, the UE will assume the RA procedure failed and return to the preamble selection step and begin again with transmitting Message 1. In legacy LTE systems, Message 2/RAR is transmitted by a common PDSCH and addressed by a common PDCCH, so it is impossible for the UE to report any feedback to inform the eNB whether the Message 2/RAR is successfully detected or not. This means the eNB has no means by which to know whether or not a retransmission of Message 2/RAR is needed, and the UE could not know if a retransmission of its preamble is necessary.

[0011] For the contention-free RACH procedure where the Message 2/RAR is addressed to the UE's unique C-RNTI there will be different mechanisms than those for the RA-RNTI legacy scenario immediately above. Since in this case the Message 2/RAR is transmitted via a dedicated PDSCH there is the possibility of it being re-transmitted in a normal HARQ process rather than the contention-based RACH where the UE must re-initiate the RACH sequence by transmitting a new RACH Message 1. So for contention-free RACH if the UE does not receive the eNB's Message 2 directed to the UE's C-RNTI, the UE can simply send a NACK (not send an ACK) in the UL resource that maps from the PDCCH which scheduled the PDSCH and the eNB will re-transmit the Message 2/RAR in the DL resource that HARQ process reserves for re-transmissions.

[0012] Document R2-115407 by InterDigital Communications entitled NETWORK-CONTROLLED PREAMBLE (RE)TRANSMISSION FOR SCELLS [3GPP TSG RAN WG2 Meeting #75-bis; Zhuhai, China; 10-14 October 2011] proposes that the UE not do an autonomous preamble retransmission but instead ramp up the power for the preamble if it receives another PDCCH format 1A to trigger the RACH on the given SCell. This document further proposes that this next preamble transmission be considered as an initial transmission after the UE receives a TA command, meaning the eNB controls the transmission power for it.

[0013] These teachings detail what the inventors deem more effective and faster ways to get Message 2 to the UE in the case of an initial Message 2/RAR failure.

SUMMARY:

[0014] In a first exemplary aspect of the invention there is a method for operating a wireless device comprising: in response to transmitting a preamble in a random access procedure, tuning a wireless receiver to receive from a network access node a dedicated random access response; and deciding to re-transmit the preamble only if:

- a command from the network access node is received that indicates an identifier of the preamble, a resource allocation, and re-transmit power; or
- no dedicated transmission from the network access node is received during a time window defined for the random access response; or
- a hybrid automatic repeat request HARQ process associated with the random access response has expired without a successful decoding of the random access response.

[0015] In a second exemplary aspect of the invention there is an apparatus for communicating comprising a processing system, in which the processing system includes or otherwise comprises at least one processor and a memory storing a set of computer instructions. In this embodiment the at least one processor is arranged with the memory storing the instructions to cause the apparatus to perform: in response to transmitting a preamble in a random access procedure, tuning a wireless receiver to receive from a network access node a dedicated random access response; and deciding to re-transmit the preamble only if:

- a command from the network access node is received that indicates an identifier of the preamble, a resource allocation, and power; or
- no dedicated transmission from the network access node is received during a time window defined for the random access response; or
- a hybrid automatic repeat request HARQ process associated with the random access response has expired without a successful decoding of the random access response.

[0016] In a third exemplary aspect of the invention there is a computer readable

memory tangibly storing a set of instructions which, when executed on a user equipment causes the user equipment to perform at least: in response to transmitting a preamble in a random access procedure, tuning a wireless receiver to receive from a network access node a dedicated random access response; and deciding to re-transmit the preamble only if:

- *a command from the network access node is received that indicates an identifier* of the preamble, a resource allocation, and power; or
- no dedicated transmission from the network access node is received during a time window defined for the random access response; or
- a hybrid automatic repeat request HARQ process associated with the random access response has expired without a successful decoding of the random access response.

[0017] In a fourth exemplary aspect of the invention there is an apparatus for communicating, and this apparatus comprises control means and decision means. The control means is for tuning a wireless receiver to receive from a network access node a dedicated random access response, in response to transmitting a preamble in a random access procedure. The decision means is for deciding to re-transmit the preamble only if:

- *a command from the network access node is received that indicates an identifier* of the preamble, a resource allocation, and power; or
- no dedicated transmission from the network access node is received during a time window defined for the random access response; or
- a hybrid automatic repeat request HARQ process associated with the random access response has expired without a successful decoding of the random access response.

[0018] In specific examples of the above fourth aspect, the control means may be one or more processors executing a program of instructions tangibly stored in or on a computer readable memory in combination with a bus or other interface to control a radio receiver, and the decision means may be the one or more processors with implementing software stored in or on the computer readable memory. By example such processors/software/memory may be a chipset or a modem.

[0019] These and other embodiments and aspects are detailed below with particularity.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0020] Figure 1 repeats Figure 1B of co-owned PCT/CN2011/072453 and shows a signaling diagram illustrating a contention-free RACH procedure according to conventional LTE systems.

[0021] Figure 2 is an example of a downlink signaling in a conventional contention-based RACH procedure in which the random access responses/message 2's for a number of UE's are multiplexed together.

[0022] Figure 3 is a DCI format 1A message adapted according to these teachings for a RACH procedure initiated by a PDCCH order, and indicating power ramping for the case autonomous preamble re-transmissions by the UE are not allowed or used.

[0023] Figure 4A illustrates signaling for the case in which the UE correctly decodes the first re-transmission by the eNB of a DL random access response, according to an exemplary embodiment of these teachings.

[0024] Figure 4B is similar to Figure 4A but for the case in which the UE fails to correctly decode any of the eNB's DL random access responses, according to an exemplary embodiment of these teachings.

[0025] Figure 5 is a logic flow diagram from the perspective of the UE that illustrates the operation of a method, and a result of execution by an apparatus of a set of computer program instructions embodied on a computer readable memory, in accordance with the exemplary embodiments of this invention.

[0026] Figure 6 is a simplified block diagram of a UE and an eNB which are exemplary electronic devices suitable for use in practicing the exemplary embodiments of the invention.

DETAILED DESCRIPTION:

[0027] Consider again the contention-free RACH procedure of Figure 1 in the context of cross-scheduling across CCs with different TAs. If the intent of the RACH procedure is for the UE to obtain the TA for an SCell, the UE will need to transmit the PRACH preamble/message 1 on the intended SCell so the e-NB can estimate the propagation delay. If the UE is configured with cross-carrier scheduling for the intended SCell, co-owned PCT/CN2011/072453 details that the PDCCH should be on the PCell and the Message 2/RAR can be sent on either the PCell or the SCell (where the Message 1 is on the SCell for which the UE does not yet have the TA).

[0028] In this contention-free RACH scenario the Message 2/RAR is addressed to the UE's C-RNTI, and so as noted in the background section above the eNB could get the feedback (ACK/NACK) from UE using normal PDCCH mapping rules to know if the Message 2/RAR has been successfully decoded by the UE. Since this C-RNTI based solution is for contention-free RACH only, the eNB could also know whether the UE transmits the preamble by discontinuous transmission DTX detection. Therefore, it is always possible for the eNB to send a PDCCH to trigger the PRACH/Message 1 transmission again from the UE, which is a premise behind the solution of the above-referenced document R2-115449 by InterDigital Communications. One result of this is that for each triggering, an additional PDCCH has to be sent by the eNB. But considering the fact that in practice the PRACH event is not frequent, the overall increment of PDCCH overhead is seen to be limited.

[0029] Embodiments of these teachings fall into two main categories. The first concerns the UE re-transmitting in a non-autonomous manner a new preamble/Message 1 for the case of a Message 2/RAR failure. Such a failure can occur if the UE does not receive a Message 2/RAR, or if the UE receives Message 2/RAR on time but cannot properly decode it. It is not autonomous because the UE does not do this automatically in response to the failed Message 2/RAR.

[0030] The second main category assumes that autonomous preamble re-transmission is allowed for the UE. This second category re-defines how the UE determines there has been a Message 2/RAR failure for a RACH procedure on the SCell.

[0031] Consider now the first main category where the UE is unable to perform any kind of autonomous preamble re-transmission (for example, if future iterations of LTE do away with this feature). In current versions of LTE the RAR window is configured by RRC signaling and has the value range below, where sf is the number of subframes:

ra-ResponseWindowSize ENUMERATED {sf2, sf3, sf4, sf5, sf6, sf7, sf8, sf10},

[0032] If re-transmission of Message 2/RAR is allowed, the minimum round trip time RTT of the DL HARQ is 8ms. So for example if the eNB configures 10ms as the RAR window, the Message 2/RAR could only be transmitted two times at most. If the UE still assumes a RA failure at that point, it is still possible for the UE to successfully decode the Message 2/RAR later by DL HARQ soft combining.

[0033] According to these teachings, for the first main category the eNB controls the entire RACH re-transmission procedure to avoid having a random access failure on the SCell. Specifically, the eNB does not configure the RAR window when configuring RACH on the SCell, and the eNB does not configure the *preambleTransMax* parameter when configuring RACH on the SCell. The *preambleTransMax* parameter sets the maximum number of preamble re-transmissions in conventional LTE RACH procedures.

[0034] From the UE's perspective, this means the UE will always follow the eNB's command on whether to transmit (or re-transmit) the preamble on the SCell. If the UE receives a RACH order, it should transmit the preamble accordingly. For a UE having an active PCell and an inactive SCell, examples of a RACH order include a PDCCH scheduling resources on that SCell, or a specific command indicating the SCell index to activate that SCell. These and other examples are detailed further in co-owned PCT/CN2011/072453. After the UE transmits is preamble/Message 1, even if the UE does not receive the Message 2/RAR it should just wait for a further command from the eNB, regardless of whether it receives no RAR or whether it receives one but cannot properly decode it.

[0035] If the UE has already transmitted one preamble and is to re-transmit another per the eNB's command, in this embodiment the UE does not automatically ramp up power for the preamble re-transmission as it does for contention-based RACH in conventional LTE. In this embodiment the UE will increase transmit power for the preamble only if the eNB indicates it should do so. This is because there are different reasons why the UE may not have successfully received the Message 2/RAR: it may be due to failure of its earlier preamble transmission meaning the eNB never sent a RAR for the UE to receive, or it may be due to the UE's failure to receive or to properly decode a RAR that the eNB did in fact send. It is inefficient for the UE to ramp up its transmit power for preamble re-transmissions in every instance, because for some causes of RAR failure that power ramping would be unnecessary. Additionally, there may be instances where the UE is simultaneously sending data on the PCell and a PRACH on the SCell, in which case unnecessary power ramping of the PRACH is harmful since it limits transmit power that could otherwise be available for the data.

[0036] Figure 3 is an example of a DCI format 1A adapted according to these teachings for the first category by which the eNB indicates to the UE whether to ramp up the power of its preamble re-transmission. The carrier indicator field is three bits in conventional LTE and is used to indicate to the UE the component carrier which the PDCCH carrying this field is scheduling (defined in 3GPP TS 36.213). Following that is a flag to indicate if this DCI is format 0 or format 1A. Format 1A is used for a RACH procedure initiated by a PDCCH order only if the format 1A cyclic redundancy check CRC is scrambled with the UE's C-RNTI and all the remaining fields following the format flag are set as shown at Figure 3. As indicated under the power ramping up field, those relevant signaling bits can be used to specify only whether power ramping is to be used or not, or can more particularly be used to directly specify how much power the UE should ramp up (the power step increment). DCI format 1A is used for the compact scheduling of one PDSCH codeword in one cell and random access procedure initiated by a PDCCH order.

[0037] Within the second main category of the invention are two embodiments. In this main category autonomous preamble re-transmission by the UE is still used (for example, this feature is retained in future versions of LTE). In the first embodiment the *RA failure condition is redefined for the RACH procedure on the UE's SCell.* Specifically, if no new DL transmission happens during the RAR window, the UE will consider that the RA has failed. If there is a new DL transmission in the RAR window but UE does not successfully decode it, then the RAR window is considered by the UE to be expired. If at the close of the related HAR! Process the UE still has not decoded the DL transmission (that is, if the eNB re-sent the DL transmission and even from soft combining the UE is still not able to correctly decode any of them), the UE will *consider that the RA attempt has failed. Once the UE concludes that the RA on the* SCell has failed, it should re-transmit the preamble using the same mechanism as LTE Release 8/9/10 (for example, using automatic power ramping and back-off timing).

[0038] Figure 4A provides an example of this first embodiment and utilizes the convention of 10 subframes with a frame boundary shown by the dashed line and Figure 1 beginning at subframe #0. The UE sends its Message 1/preamble at 402 in subframe #0. The RAR window 404 then begins at subframe #3 and in this case extends 4 subframes to subframe #6. Listening in this window 404 the UE receives a new DL transmission 406a in subframe #4, but by subframe #5 is unable to decode it 408a. The UE considers the RAR window 404 to have expired after subframe #5 rather than after subframe #6 due to that decoding failure 408a. The HARQ process corresponding to the first DL transmission 406a puts the first re-transmission opportunity at subframe #4 of the next frame (frame break shown by dashed line), where the UE again receives a DL transmission 406b. the UE correctly decodes 408b this DL (re-) transmission 406b whether individually or by soft combining with partially decoded data that the UE buffered from its failed decoding 406a.

[0039] Figure 4B illustrates the case in which there is no successful decoding and the UE autonomously re-transmits a preamble with incremented power. Reference numbers 402, 404, 406a, 408a and 406b are as detailed for Figure 4A. But in the Figure 4B example the UE's attempt to decode DL transmission 406b fails as shown at 408b'. The eNB then sends its second and final re-transmission at 408c which the UE never receives, and so the UE concludes RACH failure 410 and in consequence will autonomously re-transmit a preamble to begin the process again (but at a higher transmit power than preamble 402). Figure 4B illustrates one exemplary HARQ process associated with the RAR, in this example the HARQ process has one transmission 406a and two re-transmissions 406b, 406c. Once the UE re-transmits its preamble the Message 2/RAR that maps from that preamble re-transmission will begin a new HARQ process. Other examples may have only one or more than two re-transmissions per HARQ process, as is well understood in the wireless arts.

[0040] For the second embodiment there is a value "infinity" added to the possible values for the RAR window. This addition provides the possibility for the eNB to disable the UE's autonomous preamble re-transmission at the discretion of the network vendor. If some other value apart from "infinity" is configured for a given UE, the UE then follows the procedure for the first embodiment immediately above. In this second embodiment the RAR window is configured by RRC signaling and has the value range below, where sf is the number of subframes:

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ra-ResponseWindowSize          ENUMERATED {sf2, sf3, sf4, sf5,
                                   sf6, sf7, sf8, sf10, infinity,
                                   spare, spare, spare...},
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[0041] Various of the above embodiments provide the following technical effects. For the first category the eNB maintains control over the preamble transmission and re-transmissions on the SCell. For the second category there is a reasonable UE behavior assuming RA failure is retained in future versions of LTE, and also ensures the gain of the re-transmission of Message 2/RAR.

[0042] Figures 5 is a logic flow diagram which summarizes the above various exemplary embodiments of the invention. Figure 5 describes from the perspective of a user equipment and may be considered to illustrate the operation of a method, and a result of execution of a computer program stored in a computer readable memory, and a specific manner in which components of an electronic device are configured to cause that electronic device to operate, whether such an electronic device is the UE or one or more components thereof such as a modem, chipset, or the like. For example, re-transmitting the preamble at block 504 may be implemented by one or more UE components (modem, chipset) which make the decision to re-transmit, and then control a transmitter of the UE to actually send that re-transmission. In this case the transmitter itself takes no part in the decision to transmit but carries out that decision, and the receiver of block 502 need not be one of those other components which decide whether to re-transmit since the receiver may take its tuning command from those other UE component(s). Similarly, the RAR of block 502 and the command of block 504 need not be received directly from the eNB but may originate from an eNB and be input to the relevant chipset/modem component(s). The various blocks shown in Figure 5 may also be considered as a plurality of coupled logic circuit elements constructed to carry out the associated function(s), or specific result of strings of computer program code or instructions stored in a memory.

[0043] Such blocks and the functions they represent are non-limiting examples, and may be practiced in various components such as integrated circuit chips and modules, and that the exemplary embodiments of this invention may be realized in an apparatus that is embodied as an integrated circuit. The integrated circuit, or circuits, may comprise circuitry (as well as possibly firmware) for embodying at least one or more of a data processor or data processors, a digital signal processor or processors, baseband circuitry and radio frequency circuitry that are configurable so as to operate in accordance with the exemplary embodiments of this invention.

[0044] Such circuit/circuitry embodiments include any of the following: (a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and (b) combinations of circuits and software (and/or firmware), such as: (i) a combination of processor(s) or (ii) portions of processor(s)/software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone/UE, to perform the various functions summarized at Figure 5) and (c) circuits, such as a microprocessor(s) or a portion of a microprocessor(s), that require software or firmware for operation, even if the software or firmware is not physically present. This definition of 'circuitry' applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term "circuitry" would also cover an implementation of merely a processor (or multiple processors) or portion of a processor and its (or their) accompanying software and/or firmware. The term "circuitry" also covers, for example, a baseband integrated circuit or applications processor integrated circuit for a mobile phone/UE or a similar integrated circuit in a server, a cellular network device, or other network device which receives the preamble and which sends the RAR according to these teachings.

[0045] In the Figure 5 embodiment at block 502, in response to transmitting a preamble in a random access procedure, the UE tunes a wireless receiver to receive from a network access node a dedicated random access response RAR. By example such a dedicated RAR is addressed to a dedicated (unique) user equipment identifier such as a C-RNTI that is specifically assigned to only one UE, and in one non-limiting embodiment the RAR is scrambled with the C-RNTI. The RA-RNTI is not a dedicated user equipment identifier because it is possible for two UEs to select the same RA-RNTI at the same time, which can lead to ambiguity if there is overlap of the RAR windows of their respective RACH procedures. Thus a RAR addressed to a RA-RNTI is not a dedicated RAR, and the C-RNTI is a non-limiting example of how to identify the RAR as a dedicated one; other types of dedicated UE identifiers can be used in place of it.

[0046] Block 504 gives the conditions by which the UE can re-transmit the preamble as outlined in the three embodiments above. In the first main category of the invention the UE re-transmits the preamble only if there is received from the network access node a command that indicates an identifier of the preamble, a resource allocation (e.g., the command indicates the resource on which to re-transmit the preamble), and transmission power. In the first embodiment of the second main category the UE re-transmits the preamble only if it receives no dedicated transmission from the network access node during a time window defined for the random access response.

This window is shown at Figures 4A-B as the RAR window 404. A dedicated transmission is addressed to the UE specifically and uniquely, such as via the C-RNTI noted above. A message addressed to a RA-RNTI is generally not considered dedicated signaling in the cellular radio arts. And also in the first embodiment of the second main category the UE re-transmits the preamble only if a HARQ process *associated with the random access response has expired without a successful decoding* of the random access response.

[0047] Note that the different conditions of block 504 are not mutually exclusive; the UE can condition its re-transmissions of the preamble on either of the two latter restrictions, and in an embodiment the eNB reserves the option to command a preamble retransmission even when autonomous re-transmissions of the preamble are possible.

[0048] Further portions of Figure 5 provide the various exemplary embodiments as detailed above. Block 506 stipulates the cross carrier scheduling environment noted above; the preamble is transmitted in the RA procedure on a second component carrier in response to the UE receiving from the network access node on a first component carrier a physical downlink control channel PDCCH that identifies the preamble. The PDCCH identifying the preamble to re-transmit categorizes the RA procedure as being contention-free. The terms first CC and second CC are used to distinguish them from one another; the first CC may be a PCell or an activated SCell for example and the second CC may be some other SCell for which the UE does not have the UL TA. Block 508 sets forth the RRC connected state and TA environment noted above; when transmitting the preamble the UE is in a radio resource control connected state on the first component carrier but lacks a valid timing advance for the second component carrier. Note that while block 508 may be the typical scenario used in the above examples, it is not limiting to the broader teachings herein.

[0049] For the case of block 504 in which the preamble is re-transmitted only if the command is received from the network access node; block 510 tells that the PDCCH of block 506 that identifies the preamble (which in this case is the 'command' of block 502) indicates the transmit power for re-transmitting the preamble by an indication whether to ramp power. As shown at Figure 3, in an exemplary but non-limiting embodiment the indication whether to ramp power when re-transmitting the preamble quantifies an amount to ramp. The other example of the transmit power indication is simply a qualitative (binary) indication whether or not to ramp power. For block 506 that same PDCCH also allocates the resource on which the UE is to re-transmit the preamble.

[0050] For the case of block 504 in which the preamble is re-transmitted only if no dedicated transmission from the network access node is received during the time window defined for the random access response, block 512 provides that re-transmission of the preamble is autonomous by the UE. Block 514 summarizes the second embodiment of the second main category of these teachings; the UE is prohibited from re-transmitting the preamble as a result of a message received from the network access node which sets the time window defined for the random access response to infinity.

[0051] And for the case of block 504 in which the preamble is re-transmitted only if the HARQ process associated with the random access response has expired without successful decoding of the random access response, then block 516 provides that re-transmission of the preamble is autonomous by the UE.

[0052] In the various Figure 5 embodiments the network access node may be an eNB, a frequency selective repeater, a remote radio head, or similar such network entities.

[0053] Reference is now made to Figure 6 for illustrating a simplified block diagram of various electronic devices and apparatus that are suitable for use in practicing the exemplary embodiments of this invention. In Figure 6 an eNB 22 is adapted for communication over a wireless link 21 with an apparatus, such as a mobile terminal or UE 20. The eNB 22 may be any access node (including frequency selective repeaters) of any wireless network using licensed (and in some embodiments also unlicensed) bands, such as LTE, LTE-A, GSM, GERAN, WCDMA, and the like. The operator network of which the eNB 22 is a part may also include a network control element such as a mobility management entity MME and/or serving gateway SGW 24 or radio network controller RNC which provides connectivity with further networks (e.g., a publicly switched telephone network PSTN and/or a data communications network/Internet).

[0054] The UE 20 includes processing means such as at least one data processor (DP) 20A, storing means such as at least one computer-readable memory (MEM) 20B storing at least one computer program (PROG) 20C, communicating means such as a transmitter TX 20D and a receiver RX 20E for bidirectional wireless communications with the eNB 22 via one or more antennas 20F. Also stored in the MEM 20B at reference number 20G are the conditions by which the UE is allowed to re-transmit a RACH preamble as variously described in the embodiments above.

[0055] The eNB 22 also includes processing means such as at least one data processor (DP) 22A, storing means such as at least one computer-readable memory (MEM) 22B storing at least one computer program (PROG) 22C, and communicating means such as a transmitter TX 22D and a receiver RX 22E for bidirectional wireless communications with the UE 20 via one or more antennas 22F. The eNB 22 stores at block 22G similar conditions by which the UE is allowed to re-transmit a RACH preamble as variously described in the embodiments above so that the eNB knows what behavior to expect from the UE 20.

[0056] While not particularly illustrated for the UE 20 or eNB 22, those devices are also assumed to include as part of their wireless communicating means a modem and/or a chipset which may or may not be inbuilt onto an RF front end chip within those devices 20, 22 and which also operates utilizing the RACH preamble re-transmission rules as set forth in detail above.

[0057] At least one of the PROGs 20C in the UE 20 is assumed to include a set of program instructions that, when executed by the associated DP 20A, enable the device to operate in accordance with the exemplary embodiments of this invention, as detailed above. The eNB 22 also has software stored in its MEM 22B to implement certain aspects of these teachings. In these regards the exemplary embodiments of this invention may be implemented at least in part by computer software stored on the MEM 20B, 22B which is executable by the DP 20A of the UE 20 and/or by the DP 22A of the eNB 22, or by hardware, or by a combination of tangibly stored software and hardware (and tangibly stored firmware). Electronic devices implementing these aspects of the invention need not be the entire devices as depicted at Figure 10 or may be one or more components of same such as the above described tangibly stored software, hardware, firmware and DP, or a system on a chip SOC or an application specific integrated circuit ASIC.

[0058] In general, the various embodiments of the UE 20 can include, but are not limited to personal portable digital devices having wireless communication capabilities, including but not limited to cellular telephones, navigation devices, laptop/palmtop/tablet computers, digital cameras and music devices, and Internet appliances.

[0059] Various embodiments of the computer readable MEMs 20B, 22B include any data storage technology type which is suitable to the local technical environment, including but not limited to semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory, removable memory, disc memory, flash memory, DRAM, SRAM, EEPROM and the like. Various embodiments of the DPs 20A, 22A include but are not limited to general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and multi-core processors.

[0060] Various modifications and adaptations to the foregoing exemplary embodiments of this invention may become apparent to those skilled in the relevant arts in view of the foregoing description. While the exemplary embodiments have been described above in the context of the LTE-A system, as noted above the exemplary embodiments of this invention are not limited for use with only this one particular type of wireless communication system.

[0061] Further, some of the various features of the above non-limiting embodiments may be used to advantage without the corresponding use of other described features. The foregoing description should therefore be considered as merely illustrative of the principles, teachings and exemplary embodiments of this invention, and not in limitation thereof.

[0062] The following abbreviations used in the above description and/or in the drawing figures are defined as follows:

| | |
|---|---|
| 3GPP | third generation partnership project |
| CA | carrier aggregation |
| CC | component carrier |
| C-RNTI | cell-RNTI |
| DCI | downlink control information |
| DL | downlink |
| eNB | node B/base station in an E-UTRAN system |
| E-UTRAN | evolved UTRAN (LTE) |
| LTE | long term evolution |
| LTE-A | long term evolution-advanced |
| MAC | medium access control |
| PCell | primary component carrier/primary cell in a CA system |
| PDCCH | physical downlink control channel |
| PDSCH | physical downlink shared channel |
| PRACH | physical random access channel |
| RACH | random access channel |
| RAR | random access response |
| RNTI | radio network temporary identifier |
| RRC | radio resource control |
| SCell | secondary component carrier/secondary cell in a CA system |
| TA | timing advance |
| UE | user equipment |
| UL | uplink |
| UTRAN | universal terrestrial radio access network |

WHAT IS CLAIMED IS:

1. A method for operating a wireless device, comprising:

in response to transmitting a preamble in a random access procedure, tuning a wireless receiver to receive from a network access node a dedicated random access response; and

deciding to re-transmit the preamble only if:

a command from the network access node is received that indicates an identifier of the preamble, a resource allocation, and power; or

no dedicated transmission from the network access node is received during a time window defined for the random access response; or

a hybrid automatic repeat request HARQ process associated with the random access response has expired without a successful decoding of the random access response.

2. The method according to claim 1, in which the preamble is transmitted in the random access procedure and on a second component carrier in response to receiving from the network access node on a first component carrier a physical downlink control channel identifying the preamble.

3. The method according to claim 2, in which the method is executed by a user equipment which, when transmitting the preamble, is in a radio resource control connected state on the first component carrier but lacks a valid timing advance for the second component carrier.

4. The method according to any one of claims 2 or 3, in which it is decided to re-transmit the preamble if the command is received from the network access node; and the command comprises the physical downlink control channel identifying the preamble and which indicates the power by an indication whether to ramp power when re-transmitting the preamble.

5. The method according to claim 4, in which the indication whether to ramp power when re-transmitting the preamble quantifies an amount to ramp.

6. The method according to claim 1, in which it is decided to re-transmit the preamble if no dedicated transmission from the network access node is received during the time window defined for the random access response, in which the decision to re-transmit the preamble is autonomous by a user equipment executing the method.

7. The method according to claim 6, in which the user equipment is prohibited from re-transmitting the preamble as a result of a message received from the network access node which sets the time window defined for the random access response to infinity.

8. The method according to claim 1, in which it is decided to re-transmit the preamble if the hybrid automatic repeat request HARQ process associated with the random access response has expired without successful decoding of the random access response, in which the decision to re-transmit the preamble is autonomous by a user equipment executing the method.

9. The method according to any one of claims 1 through 8, in which the method is executed by circuitry configured for use in a mobile device.

10. An apparatus for communicating, comprising:

at least one processor; and

a memory storing a set of computer instructions,

in which the at least one processor is arranged with the memory storing the instructions to cause the apparatus to perform:

in response to transmitting a preamble in a random access procedure, tuning a wireless receiver to receive from a network access node a dedicated random access response; and

deciding to re-transmit the preamble only if:

a command from the network access node is received that indicates an identifier of the preamble, a resource allocation, and power; or

no dedicated transmission from the network access node is received during a time window defined for the random access response; or

a hybrid automatic repeat request HARQ process associated with the random access response has expired without a successful decoding of the random access response.

11. The apparatus according to claim 10, in which the preamble is transmitted in the random access procedure and on a second component carrier in response to receiving from the network access node on a first component carrier a physical downlink control channel identifying the preamble.

12. The apparatus according to claim 11, in which the apparatus comprises a user equipment which, when transmitting the preamble, is in a radio resource control connected state on the first component carrier but lacks a valid timing advance for the second component carrier.

13. The apparatus according to any one of claims 11 or 12, in which the at least one processor is arranged with the memory storing the instructions to cause the apparatus to decide to re-transmit the preamble if the command is received from the network access node; and the command comprises the physical downlink control channel identifying the preamble and which indicates the power by an indication whether to ramp power when re-transmitting the preamble.

14. The apparatus according to claim 13, in which the indication whether to ramp power when re-transmitting the preamble quantifies an amount to ramp.

15. The apparatus according to claim 10, in which the at least one processor is arranged with the memory storing the instructions to cause the apparatus to decide to re-transmit the preamble if no dedicated transmission from the network access node is received during the time window defined for the random access response, in which the decision to re-transmit the preamble is autonomous by the apparatus.

16. The apparatus according to claim 15, in which the apparatus is prohibited from re-transmitting the preamble as a result of a message received from the network access node which sets the time window defined for the random access response to infinity.

17. The apparatus according to claim 10, in which the at least one processor is arranged with the memory storing the instructions to cause the apparatus to decide to re-transmit the preamble if the hybrid automatic repeat request HARQ process associated with the random access response has expired without successful decoding of the random access response, in which the decision to re-transmit the preamble is autonomous by the apparatus.

18. A computer readable memory tangibly storing a set of instructions which, when executed on a user equipment causes the user equipment to perform at least:

in response to transmitting a preamble in a random access procedure, tuning a wireless receiver to receive from a network access node a dedicated random access response; and

deciding to re-transmit the preamble only if:

a command is received from the network access node that indicates an identifier of the preamble, a resource allocation, and power; or

no dedicated transmission from the network access node is received during a time window defined for the random access response; or

a hybrid automatic repeat request HARQ process associated with the random access response has expired without a successful decoding of the random access response.

19. The computer readable memory according to claim 18, in which the preamble is transmitted in the random access procedure and on a second component carrier in response to receiving from the network access node on a first component carrier a physical downlink control channel identifying the preamble.

20. The computer readable memory according to claim 19, in which it is decided to

re-transmit the preamble if the command is received from the network access node; and the command comprises the physical downlink control channel identifying the preamble and which indicates the power by an indication whether to ramp power when re-transmitting the preamble.

21. The computer readable memory according to claim 18, in which it is decided to re-transmit the preamble if no dedicated transmission from the network access node is received during the time window defined for the random access response, in which the decision to re-transmission of the preamble is autonomous by the user equipment.

22. The computer readable memory according to claim 21, in which the user equipment is prohibited from re-transmitting the preamble as a result of a message received from the network access node which sets the time window defined for the random access response to infinity.

23. The computer readable memory according to claim 18, in which it is decided to re-transmit the preamble if the hybrid automatic repeat request HARQ process associated with the random access response has expired without successful decoding of the random access response, in which the decision to re-transmit the preamble is autonomous by the user equipment.

24. An apparatus for communicating, comprising:

control means for tuning a wireless receiver to receive from a network access node a dedicated random access response, in response to transmitting a preamble in a random access procedure; and

decision means for deciding to re-transmit the preamble only if:

a command from the network access node is received that indicates an identifier of the preamble, a resource allocation, and power; or

no dedicated transmission from the network access node is received during a time window defined for the random access response; or

a hybrid automatic repeat request HARQ process associated with the random access response has expired without a successful decoding of the random access response.

25. The apparatus according to claim 24, in which the preamble is transmitted in the random access procedure and on a second component carrier in response to the apparatus receiving from the network access node on a first component carrier a physical downlink control channel identifying the preamble.

26. The apparatus according to claim 25, in which the apparatus comprises a user equipment which, when transmitting the preamble, is in a radio resource control connected state on the first component carrier but lacks a valid timing advance for the second component carrier.

27. The apparatus according to any one of claims 24 or 25, in which the decision means is for deciding to re-transmit the preamble if the command is received from the network access node; and the command comprises the physical downlink control channel identifying the preamble and which indicates the power by an indication whether to ramp power when re-transmitting the preamble.

28. The apparatus according to claim 27, in which the indication whether to ramp power when re-transmitting the preamble quantifies an amount to ramp.

29. The apparatus according to claim 24, in which the deciding means is for deciding to re-transmit the preamble if no dedicated transmission from the network access node is received during the time window defined for the random access response, in which the decision to re-transmit the preamble is autonomous by the apparatus.

30. The apparatus according to claim 29, in which the deciding means prohibits the apparatus from re-transmitting the preamble as a result of a message received from the network access node which sets the time window defined for the random access response to infinity.

31. The apparatus according to claim 24, in which the deciding means is for

deciding to re-transmit the preamble if the hybrid automatic repeat request HARQ process associated with the random access response has expired without successful decoding of the random access response, in which the decision to re-transmit the preamble is autonomous by the apparatus.

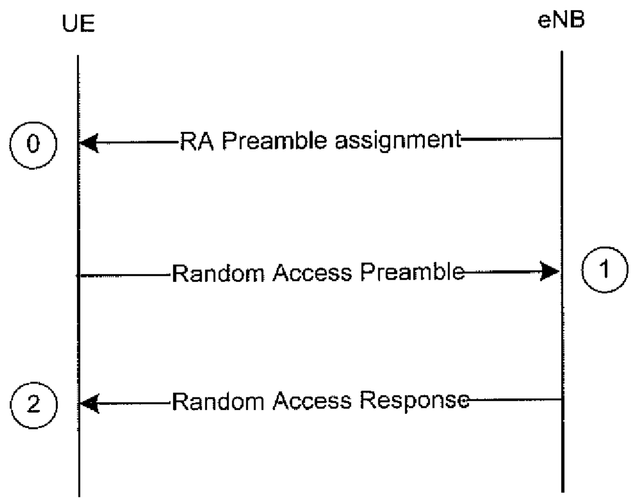


**Figure 1**

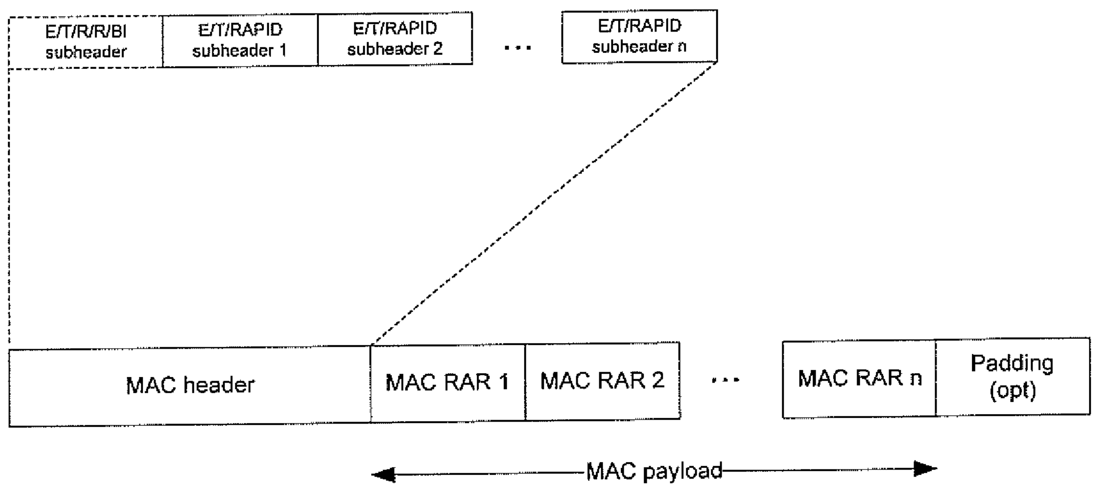


**Figure 2**

- Carrier indicator – 0 or 3 bits. This field is present according to the definitions in 3GPP TS 36.13
- Flag for format0/format1A differentiation – 1 bit, where value 0 indicates format 0 and value 1 indicates format 1A
  - Localized/Distributed VRB assignment flag – 1 bit is set to '0'
  - Resource block assignment – $\lceil \log_2(N_{RB}^{DL}(N_{RB}^{DL}+1)/2) \rceil$ bits, where all bits shall be set to 1
  - Preamble Index – 6 bits
  - PRACH Mask Index – 4 bits,
  - Power Ramping Up – 1 or 2 bits (could indicate whether to do power ramp up, or directly indicate the ramp up step)
  - All the remaining bits in format 1A for compact scheduling assignment of one PDSCH codeword are set to zero

**Figure 3**

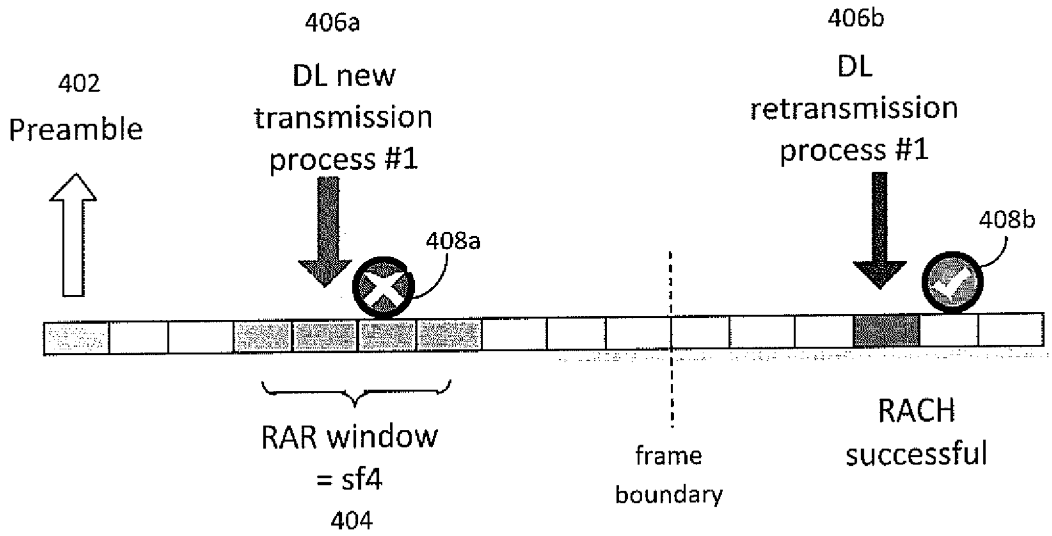


**Figure 4A**

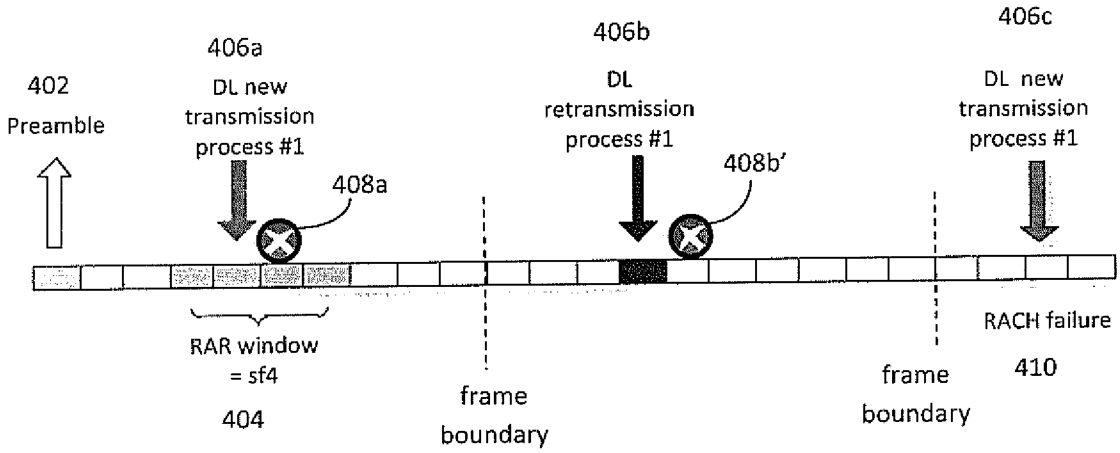


**Figure 4B**

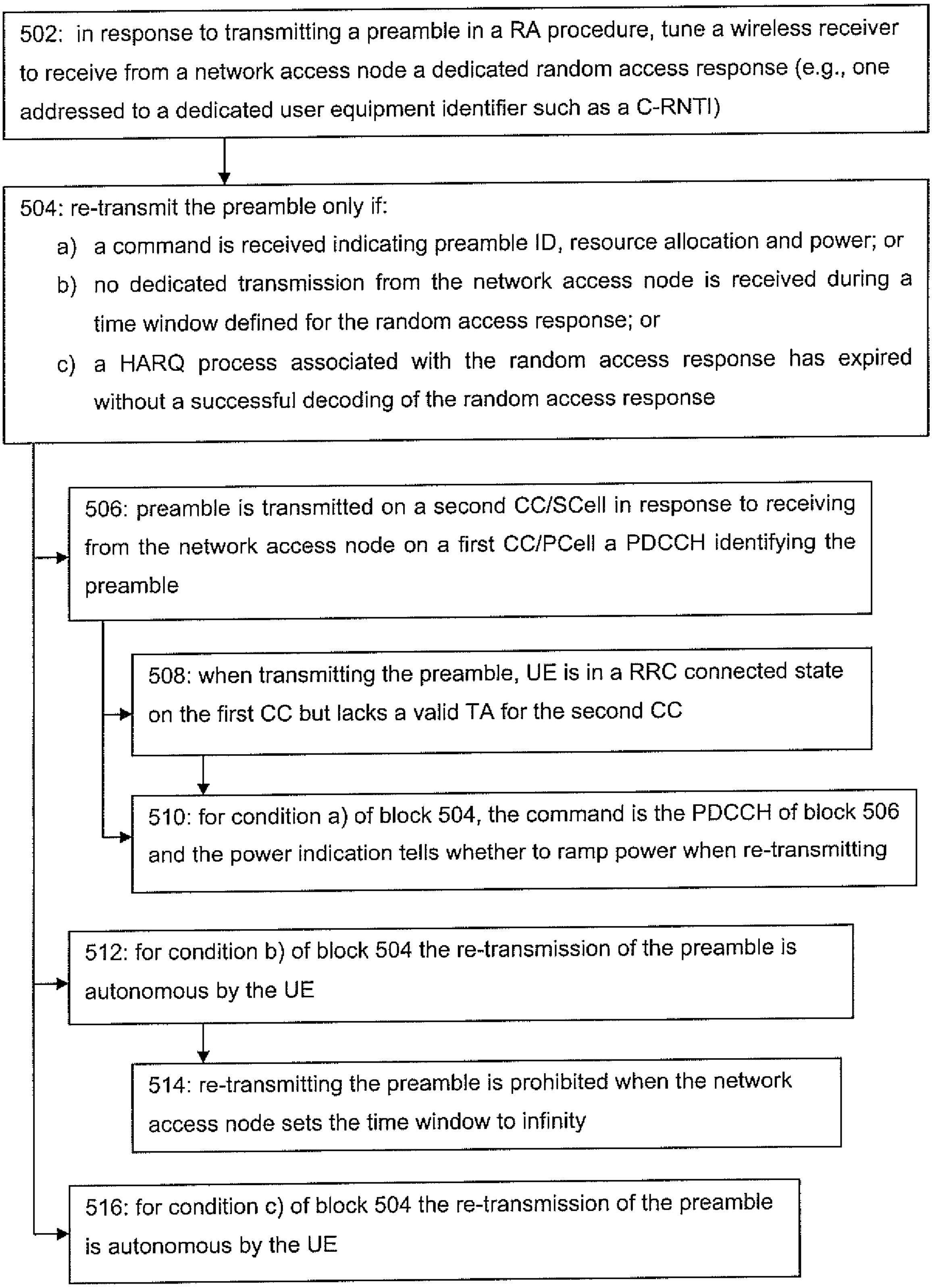
502: in response to transmitting a preamble in a RA procedure, tune a wireless receiver to receive from a network access node a dedicated random access response (e.g., one addressed to a dedicated user equipment identifier such as a C-RNTI)
504: re-transmit the preamble only if:
a) a command is received indicating preamble ID, resource allocation and power; or
b) no dedicated transmission from the network access node is received during a time window defined for the random access response; or
c) a HARQ process associated with the random access response has expired without a successful decoding of the random access response
506: preamble is transmitted on a second CC/SCell in response to receiving from the network access node on a first CC/PCell a PDCCH identifying the preamble
508: when transmitting the preamble, UE is in a RRC connected state on the first CC but lacks a valid TA for the second CC
510: for condition a) of block 504, the command is the PDCCH of block 506 and the power indication tells whether to ramp power when re-transmitting
512: for condition b) of block 504 the re-transmission of the preamble is autonomous by the UE
514: re-transmitting the preamble is prohibited when the network access node sets the time window to infinity
516: for condition c) of block 504 the re-transmission of the preamble is autonomous by the UE

**Figure 5**

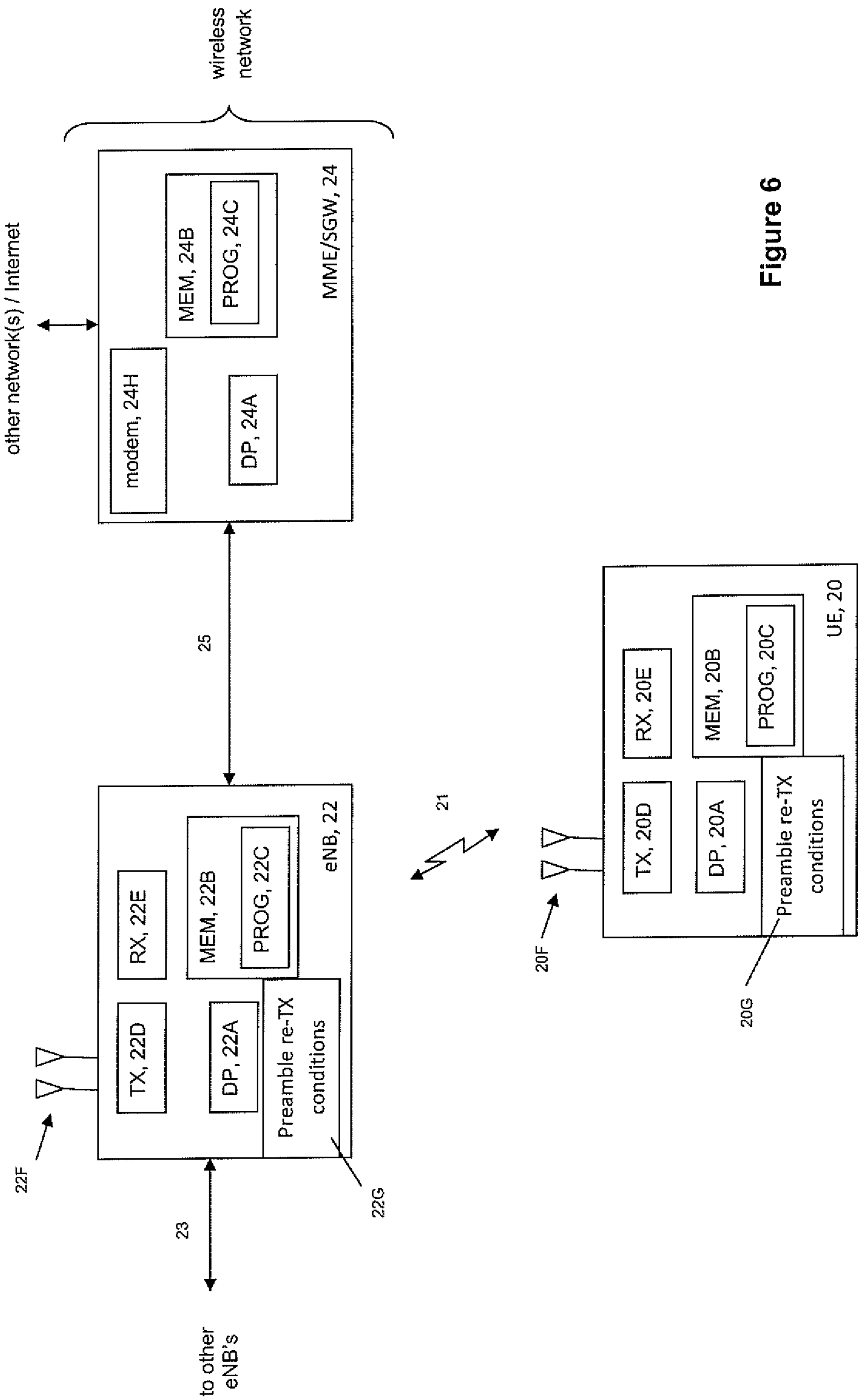
wireless network
other network(s) / Internet
modem, 24H
MEM, 24B
PROG, 24C
DP, 24A
MME/SGW, 24
25
RX, 22E
TX, 22D
MEM, 22B
PROG, 22C
DP, 22A
Preamble re-TX conditions
eNB, 22
22F
22G
23
to other eNB's
21
RX, 20E
TX, 20D
MEM, 20B
PROG, 20C
DP, 20A
Preamble re-TX conditions
UE, 20
20F
20G

Figure 6

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2012/070651

**A. CLASSIFICATION OF SUBJECT MATTER**

H04W74/08 (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)

IPC: H04W, H04Q, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CPRSABS,CNABS,CNKI,DWPI,SIPOABS,3GPP: random, access, re?transmit+, preamble, HARQ, RAR,

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | CN101370270A (ZTE CORP.) 18 Feb. 2009(18.02.2009) description page 2 line 5 – page 3 line 2 | 1,6,8,9,10,15,17,18,21,23,24,29,31 |
| A | CN102111895A (HUAWEI TECHNOLOGIES CO., LTD.) 29 Jun. 2011(29.06.2011) the whole document | 1-31 |
| A | US2007115872A1 (SAMSUNG ELECTRONICS CO., LTD.) 24 May 2007(24.05.2007) the whole document | 1-31 |

☐ 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

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"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 |
|---|---|
| 12 Oct. 2012(12.10.2012) | **01 Nov. 2012 (01.11.2012)** |


Name and mailing address of the ISA/CN
The State Intellectual Property Office, the P.R.China
6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China
100088
Facsimile No. 86-10-62019451

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YI, Jiling
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## INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2012/070651

| Patent Documents referred in the Report | Publication Date | Patent Family | Publication Date |
|---|---|---|---|
| CN101370270A | 18.02.2009 | NONE | |
| CN102111895A | 29.06.2011 | NONE | |
| US2007115872A1 | 24.05.2007 | KR20070041235A | 18.04.2007 |
| | | KR100735401B1 | 04.07.2007 |
| | | US7865209B2 | 04.01.2011 |