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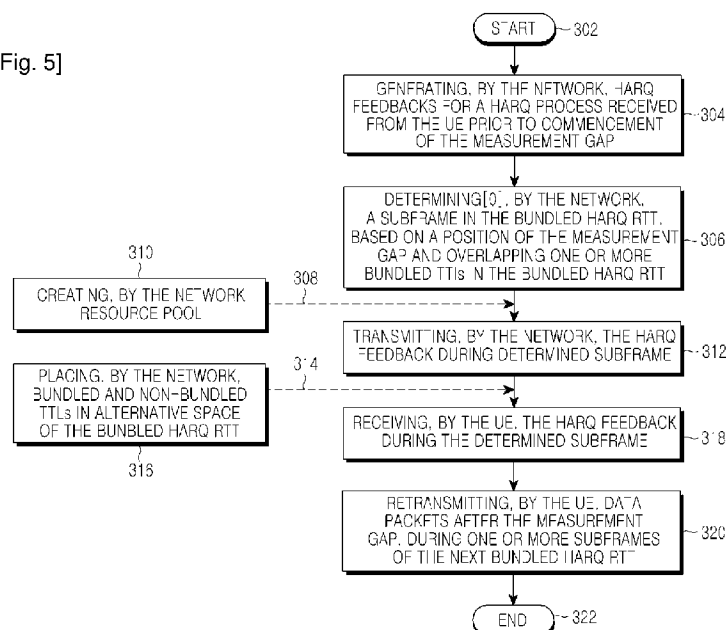
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(54) Title: A METHOD OF TIMING THE HARQ FEEDBACK WHEN THE CORRESPONDING TRANSMISSION OVERLAPS WITH THE MEASUREMENT GAPS IN A WIRELESS COMMUNICATION SYSTEM

[Fig. 5]



(57) Abstract: The HARQ feedbacks are generated by the network for the HARQ processes that were received from the UE prior to commencement of the measurement gap. The network then determines the subframes during which the HARQ feedbacks could be transmitted. The subframes are determined based on position of the overlapping measurement gap and the bundled TTIs in the bundled HARQ RTT. The HARQ feedbacks are transmitted by the network either after the measurement gap or prior to the commencement of the measurement gap depending on the overlap. The UE receives the HARQ feedbacks during the determined subframes and then retransmits corresponding redundancy versions of the data to the network after the measurement gap depending on the HARQ feedback. The UE retransmits after the measurement gap during one or more subframes of the next bundled HARQ RTT.

Description

A METHOD OF TIMING THE HARQ FEEDBACK WHEN THE CORRESPONDING TRANSMISSION OVERLAPS WITH THE MEASUREMENT GAPS IN A WIRELESS COMMUNICATION SYSTEM

Technical Field

- [1] The present invention, in general, relates to HARQ feedbacks in a wireless telecommunication system and, in particular, to transmission and reception of HARQ feedbacks during bundled TTIs that overlap measurement gap in a HARQ RTT in a wireless telecommunication system.

Background Art

- [2] The uplink LTE VoIP coverage can be improved by increasing the amount of energy that can be collected for a given air interface delay target. This is achievable by increasing the 'Transmission Time Interval' (or TTI) length beyond 1ms. One such known technique that is adopted in 3GPP to lengthen the TTI is to bundle several TTIs together. A few consecutive TTI subframes are bundled together, a single 'Transport Block' (or 'TB') is first coded, and then the TB is transmitted using the bundled TTIs. In each TTI, a redundancy version for a single 'Hybrid Automatic Repeat Request' (or 'HARQ') process is sent, without waiting for HARQ feedback. The same HARQ process number is used in each of the bundled subframes. Only when the last transmission of a TTI bundle is received, then only the HARQ feedback is sent and expected. The usage of bundling is switched on/off per 'User Equipment' (or 'UE') with higher layer signalling. When switched on, bundling would apply to all uplink transmissions using PUSCH.
- [3] The HARQ protocol is used in mobile communication system for facilitating fast error detection and correction. In HARQ, HARQ being a stop and wait protocol, subsequent transmission or retransmission by a transmitting entity (here, the UE) can take place only after the transmitting entity receives the HARQ feedback (that is, the acknowledgements or the ACK/NACKs) of the previously transmitted signal by the transmitting entity from the receiving entity. In case the ACK is received a new transmission is done and if a NACK is received then a retransmission is done. Conventionally, in uplink a UE of the mobile communication system receives the uplink grant on control channel for transmission. The grant indicates control information such as HARQ process ID, type of transmission (new/retransmission), redundancy version, etc.
- [4] However, the bundled TTIs at times overlap measurement gap that is scheduled by

the network for the UE. In a mobile communication system, as the UE also receives data from its network, the timing for transmission and reception of the data is controlled by some element of the network or the network. An example of such a network element in LTE could be the eNode B. To enable effective exchange of data between the UE and the network and also allow the UE to perform the measurements during the measurement gap the timing is precisely scheduled by the network. This schedule is usually carried using schedule periods, which include the idle time during which transmission and/or reception of data by the UE temporarily ceases. UE, during the measurement gap period, is not allowed to either receive or transmit any data. Hence the UE is not able to receive the HARQ feedback during such a period for any data that was transmitted by the UE prior to the commencement of the period.

Disclosure of Invention

Technical Problem

- [5] As per existing standard when the HARQ feedback is not received by the UE the ACK is assumed to have been received by the UE and the UE HARQ process prepares for a new transmission. This approach suits well for a non bundled HARQ process but is suboptimal for a bundled HARQ process. The new data indicator bit in downlink control channel could indicate to the UE that the UE actually received a NACK from the eNode B further indicating that the network has not received the data transmitted by the UE prior to the commencement of the measurement gap. Hence the UE is required to generate retransmission packet for the NACK-ed data and retransmit the data in the next retransmission space. For a bundled HARQ process this retransmission is inaptly delayed. This delay could further affect the QoS of the network when the UE is a cell edge user and may lead to drop in connection between the UE and the network.

Technical Solution

- [6] Thus a scope is identified to efficiently position the transmission and reception of HARQ feedbacks during bundled TTIs that overlap the measurement gap of the UE in a HARQ RTT in a wireless telecommunication system.
- [7] Methods are provided that eliminate, or at least significantly alleviate, the limitations and drawbacks of the prior art, including those described herein above. Accordingly, a method for transmitting HARQ feedback to a UE by a network during bundled TTIs of a bundled HARQ RTT, when the bundled TTIs are overlapping a measurement gap of the UE in a wireless telecommunication system is provided. The method comprises of generating, by the network, the HARQ feedback for the HARQ process received from the UE prior to the commencement of the measurement gap and then determining a subframe in the bundled HARQ RTT for transmitting the HARQ feedback to the UE.

The subframe is determined based on a position of the measurement gap and the overlapping bundled TTIs in the bundled HARQ RTT. The HARQ feedback is transmitted after the measurement gap during a first subframe of the bundled HARQ RTT when the determined first subframe is located after the measurement gap and the first subframe is not the last subframe amongst the subframes in the bundled TTIs. The UE receives the HARQ feedback from the network during the first subframe and then retransmits a data packet after the measurement gap during another subframe depending on the status of the received HARQ feedback. The another subframe is located after at least three subframes from the first subframe in the bundled HARQ RTT. Also the HARQ feedbacks are transmitted prior to the commencement of the measurement gap during a second subframe of the bundled HARQ RTT when the determined second subframe is located before the measurement gap, the subframe belongs to the one or more bundled TTIs and the second subframe is not the last subframe amongst a plurality of subframes in the one or more bundled TTIs.

- [8] Accordingly, another method is provided for transmitting the HARQ feedback by the network to the UE. The network creates a resource pool using one or more channels for the HARQ feedbacks and transmits the HARQ feedbacks using the channels from the resource pool. The network further places the bundled TTIs and the non-bundled TTIs in alternative spaces or subframes of the bundled HARQ RTT.
- [9] These methods, features and other advantages of the present invention would become more apparent in the ensuing detailed description of the drawings and embodiments of the present invention, which is further limited by the scope of the claims.

Advantageous Effects

- [10] The network of the present invention does not assume the HARQ feedback for a data (or a redundancy version of a HARQ process) when the HARQ feedback for the data is not received by the network due to some error. One example of such an error, as described here, is overlapping of the measurement gap with the bundled TTIs. The embodiments of the present invention as described here, thus in addition to describing various other advantages and features of the present invention, also describes how the unnecessary assumptions of the existing art are overcome and consequently provide measures to improve the retransmission delay in the UE.

Brief Description of Drawings

- [11] The following description of the invention would become more apparent when taken in conjunction with the accompanying drawings, wherein:
- [12] Figure 1 depicts the bundled HARQ RTT frame comprising the bundled TTIs.
- [13] Figure 2 illustrates the bundled HARQ RTT frame when bundled TTIs are overlapping a measurement gap in the HARQ RTT frame.

- [14] Figure 3 depicts the bundled HARQ RTT frame comprising bundled TTIs and non-bundled TTIs.
- [15] Figure 4 illustrates an environment, in accordance with the present invention, comprising a UE and a network in a wireless telecommunication system.
- [16] Figure 5 illustrates a method for transmitting and receiving HARQ feedbacks in accordance with the present invention.

Best Mode for Carrying out the Invention

- [17] In the following descriptions of the various embodiments of the present invention, the embodiments are just few of the illustrations the way the methods of the invention can be practiced and thus do not impose any limitation to the scope of the present invention. Further, any relational terms and sequence numbers, like first and second and alike, as may have been used in the description for referring to the accompanying drawings are used to distinguish between two entities without necessarily implying any actual relation between the two entities, unless otherwise specified in the description. The reference numbers, as used in this description, are made unique so that whenever and wherever they are quoted in any part of the description they indicate to only one entity of the drawings. Details, as deemed necessary for a proper understanding of the present invention, are produced here so as not to obscure the description. However, it is to be understood that various other modifications and enhancements to the present invention as may be possible without departing from the scope and spirit of the present invention are all included in the scope of the present invention.
- [18] Figure 1 depicts the bundled HARQ RTT frame, as per existing standard, comprising bundled TTIs. Existing 3GPP standard defines the downlink control channel using one subframe 102 wherein one subframe is equivalent to one TTI. One TTI is of 1ms duration. Four such consecutive TTIs or subframes (subframes from 1 to 4) are bundled together to give one bundled TTI 104. Thus, subsequent bundled TTIs 106, 108, 110 are formed where each bundled TTIs comprises of four subframes (subframes from 5 to 8, from 9 to 12, and from 13 to 16). As in each subframe 102, a redundancy version for a single HARQ process is sent, without waiting for a HARQ feedback of the last redundancy version. A single Transport Block (or 'TB') is first coded, and then the TB is transmitted using such bundled TTIs. The HARQ processes are further bundled to form the HARQ RTT 112 that comprises of eight subframes (subframes from 1 to 8) or two bundled TTIs 104, 106. Subsequent HARQ RTT 114 is formed, in the similar manner, using two bundled TTIs 108, 110 (that is using subframes from 9 to 16). Two such HARQ RTTs 112, 114 finally constitutes one bundled HARQ RTT 116. Thus the bundled HARQ RTT 116 comprises of four bundled TTIs 104, 106, 108, 110 or sixteen subframes. Similarly successive bundled HARQ RTTs, each having a

duration of 16ms, are formed.

- [19] Figure 2 illustrates the bundled HARQ RTT frame when bundled TTIs are overlapping a measurement gap in the HARQ RTT frame. A measurement gap in 3GPP is usually for a duration of 6ms. Thus the duration of a measurement gap is equivalent to the duration of six subframes. As a measurement gap can get triggered at any point of time during a bundled HARQ RTT frame, the measurement gap can begin to overlap the bundled TTIs at any of the subframes of a bundled TTI and continue to overlap till six consecutive subframes. Given that the measurement gap, if triggered, overlaps six consecutive subframes, it is obvious that it would overlap two bundled TTIs and may spread over one or two HARQ RTTs.
- [20] Figure 4, in accordance with one embodiment of the present invention, illustrates an exemplary environment comprising of, but not limited to, a UE 202 and a network 204 in a wireless telecommunication system 208, wherein the UE 202 is connected 206 to the network 204 of the wireless telecommunication system 208. The wireless telecommunication system 206 could be any of the legacy telecommunication systems that allow bundling of TTIs for the UE. Example of such a telecommunication system could be, but not limited to, the LTE, the HSPA+, the UMTS, etc. Thus the UE 202 could be a wireless communication device (such as a mobile station) that is capable of functioning in any of the aforesaid telecommunication systems. As the UE 202 is connected to the network 204 both the entities 202, 204 are assumed to function in a manner as is prescribed in the relevant standard.
- [21] Figure 5 illustrates a method for transmitting and receiving a HARQ feedback in accordance with one embodiment of the present invention. The method of Figure 5 is described by referring to the environment, as illustrated by Figure 4. A UE communicates with its network during bundled TTIs. Referring to Figure 4, the UE 202 transmits or receives data to or from the network 204 during the bundled TTIs 104, 106, 108, 110. Assuming a scenario where the UE 202 transmits a data (usually a redundancy version of a HARQ process) to the network 204 during the bundled TTIs of first four subframes 104 (subframes from 1 to 4) and the measurement gap 120 overlaps the bundled HARQ RTT 116 from 5th subframe to the 10th subframe. The network 204 generates 304 a HARQ feedback for the redundancy versions of the HARQ process that were received from the UE 202 prior to commencement of the measurement gap 120. The network 204 actually generates 304 one HARQ feedback for all the redundancy versions (four redundancy versions), treating the final redundancy version (in this case the fourth redundancy version (r4)) as the final received data, that were transmitted during the 1st to 4th subframes 104. The network 204 then determines 306 the subframe of the bundled HARQ RTT 116 during which the generated HARQ feedback could be transmitted to the UE 202. However, as the next set of

bundled TTIs 106 in the HARQ RTT 112 comprising of the immediate subframes (5th to 10th subframes) are overlapping with the measurement gap 120 the suitable subframe for transmitting the generated HARQ feedback is determined by the network 204 based on a position of the measurement gap 120 and the overlapping bundled TTIs 104, 106, 108, 110 in the bundled HARQ RTT 116. The network 204 then transmits 312 the HARQ feedback to the UE 202 during the determined subframes.

[22] The network 204 determines 306 a subframe, which is after the measurement gap 120 and which is not the last subframe in the bundled TTIs. The network 204 thus determines the 11th subframe 108 for transmitting the HARQ feedback for the redundancy versions received during the first four subframes 104. The network 204 then transmits 312 the HARQ feedback after the measurement gap 120 during the 11th subframe 108 for the HARQ feedback that was blocked due to the overlapping measurement gap of 120. The subframes are used for transmitting depending on their availability after the measurement gap and thus any subsequent subframe as may be found suitable in the same bundled HARQ RTT 116 can be used by the network 204 for transmitting the HARQ feedback. However, the last subframe in the 3rd bundled TTIs 108 which is the 12th subframe is not used for transmitting the HARQ feedback.

[23] The transmitted HARQ feedback is received 318 by the UE 202, as illustrated by Figure 5. For the aforesaid scenario wherein the network 204 transmits 312 the HARQ feedback after the measurement gap 120 when the determined subframe (11th subframe) 108 is after the measurement gap 120, the UE 202 receives 318 the HARQ feedback during the same subframe, that is, the 11th subframe 108.

[24] Thus, in the above example, referring to the Figure 2, the HARQ feedback could also be transmitted by the network 204 during the 13th subframe or the 14th subframe 108, 110 for the corresponding redundancy versions of the HARQ processes that were transmitted by the UE 202 during the 6th subframe and/or the 7th subframe, and eventually the HARQ feedbacks could be received 318 by the UE 202 during the 13th or the 14th subframe 108 or any other subsequent subframe that is available in the same bundled HARQ RTT 116.

[25] The UE 202 then retransmits 320 the data to the network 204 based on the HARQ feedback received from the network 204 for the corresponding redundancy version of the data. If the UE 202 receives 318 a NACK indicating a non receipt of the data that was transmitted by the UE 202 prior to the commencement of the measurement gap then the UE 202 prepares the same data packet using the HARQ process for retransmission. Referring to Figure 2, the UE 202 retransmits 320 the data, using the 4th redundancy version (r4) of the data, after the measurement gap 118 during the subframes of the next bundled HARQ RTT 124 (the 17th subframe and/or the and/or the 18th subframe, and/or the 19th subframe, and/or the 20th subframe), which are

located after at least three subframes from the subframe, (the 11th subframe here) during which the HARQ feedback was received 318 by the UE 202. The HARQ feedback is for the 4th redundancy version as the last data received by the network 204 from the UE 202 was during the 4th subframe 104 of the bundled TTIs.

- [26] There could be scenarios where the measurement gap may get triggered in middle of a HARQ process reception or transmission leading to overlapping of the bundled HARQ RTT during any consecutive six subframes. Couple of such scenarios could be when the exemplary measurement gaps of 120, 122, 124, as illustrated in the Figure 2, may begin to overlap the bundled HARQ RTT 116 at the 6th subframe, or at the 7th subframe, or at the 8th subframe and then eventually overlap six consecutive subframes from the aforesaid subframes.
- [27] For such scenarios, the network 204, as it is aware of the measurement gap schedule for the UE 202, generates 304 the HARQ feedbacks for the last corresponding redundancy versions of the HARQ processes that were received by the network 204 from the UE 202 during the subframes of the bundled TTIs 106, which are overlapping the measurement gaps 120, 122, 124, wherein the 5th subframe, or the 6th subframe, or the 7th subframe are the ones that are before the overlapping of the measurement gaps of 120, 122, 124. Thus, referring to the Figure 2, the network 204 generates 304 the HARQ feedback for the 1st redundancy version (r1) of the data if the measurement gap 120 is overlapping from the 6th subframe 106 as in HARQ process there should at least be a gap of 4ms between a transmission and reception of a data. Similarly, the network 204 generates HARQ feedbacks for the redundancy versions (r2 to r3) of the data that were received by the network 204 during the 2nd and/or the 3rd subframes 104. The network 204 then determines 306 the suitable subframe in the bundled HARQ RTT 116 based on the position of the overlapping measurement gaps 120, 122, 124 and the bundled TTIs 106, 108 in the bundled HARQ RTT 116 during which the generated HARQ feedback could be sent to the UE 202. In this example, for the exemplary measurement gap of 120 the network 204 determines 306 the subframe, which is immediate before the measurement gap of 120, as the suitable subframe. Thus the network 204 determines 306 the 5th subframe 106 as the suitable subframe for transmitting the HARQ feedback for the 1st redundancy version. The network 204 then transmits 312 the generated HARQ feedback for the 1st redundancy version to the UE 202 during the determined 5th subframe 106. Similarly, HARQ feedbacks are generated 304 for the data that was received by the network 204 prior to the commencement of the measurement gaps of 122, 124 during the 2nd and/or the 3rd subframes 104. This method thus enables generation of HARQ feedbacks for a portion (or partial) of the redundancy versions of the data that were transmitted by the UE 202 even if a single subframe is available in the bundled HARQ RTT 116, instead of the normal bundling

of four TTIs, and thus can be called as partial bundling of TTIs. As the measurement gaps of 122, 124 are blocking the HARQ feedbacks for the redundancy versions received during the 2nd or the 3rd subframes 104, the 6th subframe 106 or the 7th subframe 106 is determined as the suitable subframes. The network 204 then transmits 312 the generated 304 HARQ feedbacks to the UE 202, prior to the commencement of the measurement gaps of 122, 124, during the 7th or the 8th subframes 106. Such HARQ feedbacks could be called as Early HARQ feedbacks or Early ACK/NACKs.

[28] The transmitted HARQ feedbacks are received 318 by the UE 202, as illustrated by Figure 5. For the aforesaid scenarios wherein the network 204 transmits 312 the HARQ feedbacks during subframes, which are immediate before the measurement gaps 120, 122, 124 the UE 202 receives 318 the HARQ feedbacks during the same subframes. Thus the UE 202 receives the HARQ feedbacks for the corresponding redundancy versions of the data during the 6th, or the 7th, or the 8th subframe 106 prior to the commencement of the measurement gaps 120, 122, 124.

[29] The UE 202 then retransmits 320 the data to the network 204 based on the HARQ feedback received from the network 204 for the corresponding redundancy version of the data. If the UE 202 receives 318 a NACK indicating a non receipt of the data that was transmitted by the UE 202 prior to the commencement of the measurement gap then the UE 202 prepares the same data packet using the HARQ process for retransmission. Referring to Figure 2, the UE 202 retransmits 320 the data, using the 1st (r1) and/or the 2nd (r2) and/or the 3rd (r3) redundancy versions of the, depending on for which the data the NACK was received, after the measurement gaps 120, 122, 124 during the subframes of the next bundled HARQ RTT 124 (the 17th subframe, and/or the 18th subframe, and/or the 19th subframe, and/or the 20th subframe). The subframes for retransmission are located after atleast three subframes from the subframe, (the 5th or the 6th or the 7th subframes) during which the HARQ feedback was received 318 by the UE 202. Incase the UE 202 receives the HARQ feedback during the 14th or the 15th or the 16th subframe 110 then the UE 202 retransmits 320 the corresponding redundancy versions of the data using partial bundling of TTIs, that is, the UE 202 retransmits 320 the data during the 18th or the 19th or the 20th subframes of the next bundled HARQ RTT 124. The 18th, the 19th and the 20th subframes 124 are located after the measurement gap and are after three subframes from the subframes during which the HARQ feedbacks were received by the UE 202.

[30] Every bundled TTIs are used by, other than the UE 202, all such UEs which are connected to the same network 204, depending on the allotment to the UEs by the network 204. The lowest index of assigned UL RBs to the different UEs in the bundled HARQ RTT 116 are not the same, as the HARQ feedback is generated based on the lowest index of the assigned UL RBs. The network 204 thus further creates 310 a

resource pool using one or more channels for the generated 304 HARQ feedback and then transmits 312 the HARQ feedback using the channels from the resource pool. Thus the possibility of two HARQ feedbacks colliding while being transmitted during a subframe, after the network 204 determines the subframe using the steps of 304 and 306 of Figure 5, is averted.

[31] If bundled and non bundled TTIs are kept together, as illustrated by Figure 1 and Figure 2, then there is a possibility of collision between two or more HARQ feedbacks that are being transmitted to two or more UEs during a single subframe of the HARQ RTT under the same network 204 in case of persistence retransmission. The network 204 thus places 316 the bundled TTIs and non-bundled TTIs in alternative spaces (or subframes) of the bundled HARQ RTT. The network 204 thus places 316 the bundled HARQ processes 104, 108 in the odd numbered spaces or subframes 132, that is, in the 1st and 3rd slots in the bundled HARQ RTT 116. Whereas the network 204 places 316 the non-bundled HARQ processes 106, 110 in the even numbered spaces or subframes 134, that is, in the 2nd and 4th slots in the bundled HQ RTT 116. Such an approach mitigates the possibility of a collision between two or more HARQ feedbacks being transmitted during a single subframe in case of persistence retransmission. The network 202 can also place 316 the bundled TTIs in the even numbered spaces 106, 110 and the non-bundled TTIs in the odd numbered spaces 104, 108 in the bundled HARQ RTT 116.

[32] The steps of 310 and 316, as are illustrated by Figure 5, do not necessarily follow any particular sequence with respect to the method (steps 304, 306 and 312) and the same is indicated by the dashed lines 308 and 314. Thus the steps of 310 and 316 can be performed at any suitable point of time.

[33] Thus, the network of the present invention does not assume the HARQ feedback for a data (or a redundancy version of a HARQ process) when the HARQ feedback for the data is not received by the network due to some error. One example of such an error, as described here, is overlapping of the measurement gap with the bundled TTIs. The embodiments of the present invention as described here, thus in addition to describing various other advantages and features of the present invention, also describes how the unnecessary assumptions of the existing art are overcome and consequently provide measures to improve the retransmission delay in the UE.

[34] GLOSSARY OF TERMS AND DEFINITIONS THEREOF

[35] HARQ : Hybrid Automatic Repeat Request

[36] TB : Transport Block

[37] RTT : Round Trip Time

[38] TTI : Transmission Time Interval

[39] 3GPP : Third Generation Partnership Projects

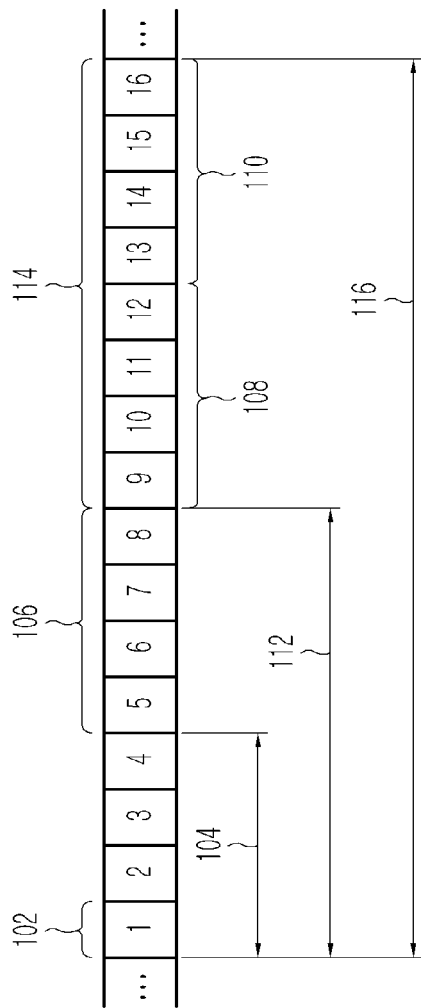
- [40] UE : User Equipment
- [41] RB : Radio Bearer
- [42] LTE : Long Term Evolution
- [43] HSPA+ : Evolved High Speed Packet Access
- [44] UMTS : Universal Mobile Telecommunication Systems

Claims

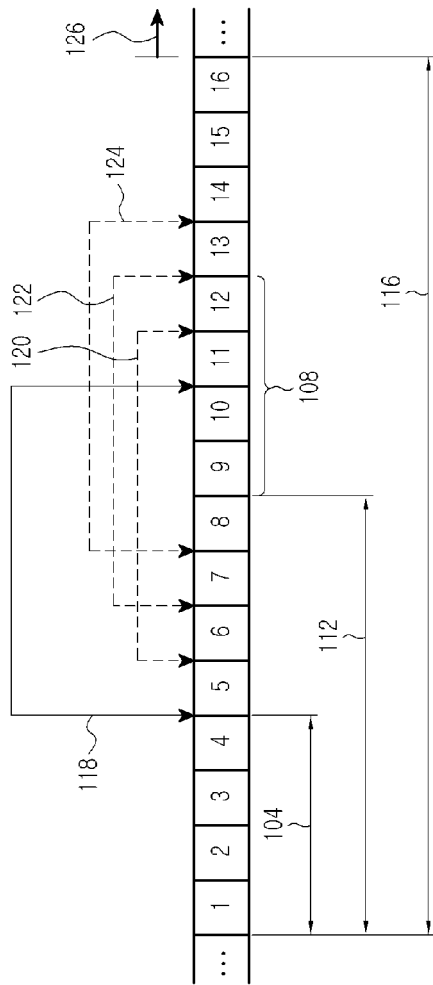
- [1] A method for transmitting a HARQ feedback to a UE by a network when one or more bundled TTIs of a bundled HARQ RTT are overlapping a measurement gap of the UE in a wireless telecommunication system, wherein the UE is connected to the network in the wireless telecommunication system; the method comprising: generating, by the network, the HARQ feedback for one or more redundancy versions of a HARQ process, wherein the one or more redundancy versions of the HARQ processes were received from the UE prior to commencement of the measurement gap in a first bundled HARQ RTT; determining, by the network, a subframe for transmitting the HARQ feedback, wherein the subframe is determined based on a position of the measurement gap and the overlapping one or more bundled TTIs in the first bundled HARQ RTT; and transmitting, by the network, the HARQ feedback to the UE during the subframe.
- [2] The method according to claim 1, wherein transmitting the HARQ feedback comprises of:
determining, by the network, a first subframe having a position after the measurement gap, wherein the first subframe is not the last subframe amongst a plurality of subframes in the one or more bundled TTIs; and
transmitting, by the network, the HARQ feedback during the first subframe after the measurement gap.
- [3] The method according to claim 2, further comprising of:
receiving, by the UE, the HARQ feedback from the network after the measurement gap, during the first subframe; and
retransmitting, by the UE, the one or more redundancy versions of the HARQ process to the network based on the received HARQ feedback, during one or more subframes of a second bundled HARQ RTT after the measurement gap, wherein the one or more subframes are located after at least three subframes from the first subframe.
- [4] The method according to claim 1, wherein transmitting the HARQ feedback comprises of:
determining, by the network, a second subframe having a position immediate before the measurement gap in the first bundled HARQ RTT, wherein the second subframe is not the last subframe amongst a plurality of subframes in the one or more bundled TTIs; and
transmitting, by the network, the HARQ feedback during the second subframe prior to the commencement of the measurement gap.

- [5] The method according to claim 4 further comprising of:
receiving, by the UE, the HARQ feedback from the network prior to the commencement of the measurement gap, during the second subframe; and re-transmitting, by the UE, one or more redundancy versions of the HARQ process to the network based on the received HARQ feedback, during one or more subframes of a second bundled HARQ RTT after the measurement gap, wherein the one or more subframes are located after atleast three subframes from the first subframe.
- [6] The method according to claim 1, wherein generating the HARQ feedback for the one or more redundancy versions of the HARQ process comprises of:
generating only one HARQ feedback for the one or more redundancy versions, wherein the one or more redundancy versions belong to a set of four redundancy versions of the HARQ process.
- [7] The method according to claim 1, wherein transmitting the HARQ feedback further comprises of:
creating, by the network, a resource pool using one or more channels for the HARQ feedback; and
transmitting, by the network, the HARQ feedback using the channels from the resource pool.
- [8] The method according to claim 1 further comprising of:
placing, by the network, the one or more bundled TTIs and one or more non-bundled TTIs in alternative space of the bundled HARQ RTT.

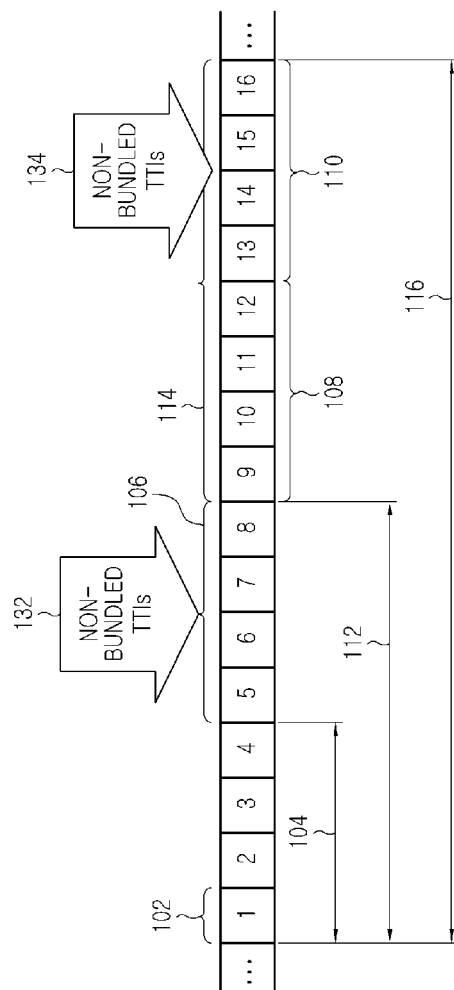
[Fig. 1]



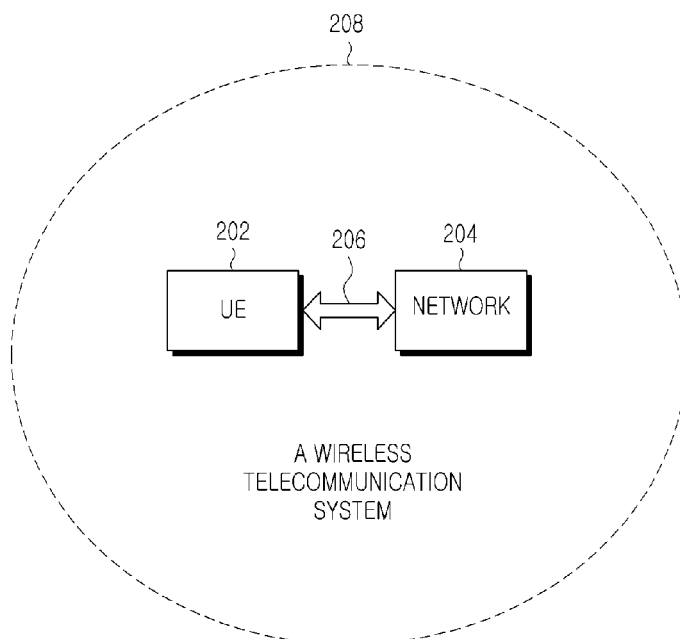
[Fig. 2]



[Fig. 3]



[Fig. 4]



[Fig. 5]

