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(54) Title: OPTIMIZED ACTION AT REPEATING ARQ POLL

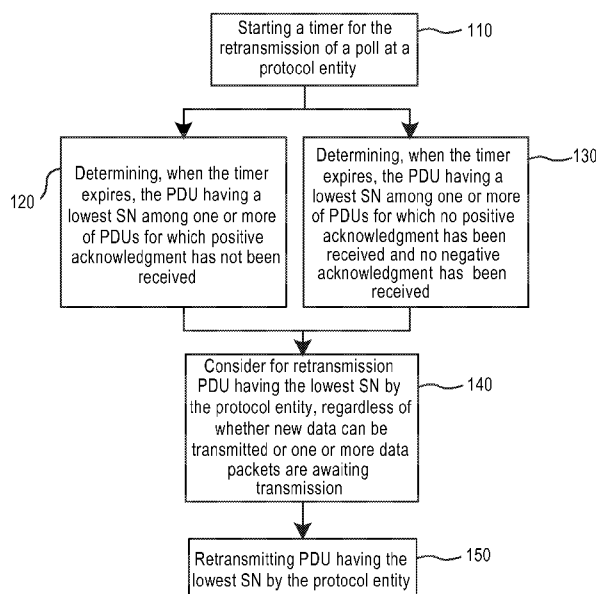


Figure 1

(57) Abstract: Various communication systems may benefit from improved acknowledgment methodology. For example, it may be helpful for a radio link control entity to receive acknowledgment information as soon as possible after the expiration of a poll-retransmission timer. A method may include starting a timer for retransmission of a poll at a protocol entity (110) in an acknowledged mode. The method may also include determining at the protocol entity, upon expiration of the timer, a data packet having a lowest sequence number among one or more data packets (120). In addition, the method may include considering retransmission of the data packet having the lowest sequence number by the protocol entity, regardless of whether new data can be transmitted and of whether any data packets are awaiting transmission (140). Further, the method may include transmitting the data packet having the lowest sequence number by the protocol entity (150).



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TITLE:

OPTIMIZED ACTION AT REPEATING ARQ POLL

CROSS REFERENCE TO RELATED APPLICATION:

- 5 This application claims priority to U.S. Provisional Application No. 62/315,940 filed on March 31, 2016. The entire content of the above-referenced provisional application is hereby incorporated by reference.

BACKGROUND:

10 **Field:**

Various communication systems may benefit from improved acknowledgment methodology. For example, it may be helpful for a radio link control entity to receive acknowledgment information as soon as possible after the expiration of a poll-retransmission timer.

15 **Description of the Related Art:**

Radio link control (RLC) sublayer is located between packet data convergence protocol (PDCP) and medium access control (MAC) sublayers. The RLC sublayer is responsible for transferring upper layer protocol or packet data units (PDUs), and can operate in a transparent mode (TM), unacknowledged mode (UM), or an acknowledged mode (AM). Depending on which operating
20 mode is used, the RLC entity may control the usage of error correction, concatenation, segmentation, resegmentation, duplicate detection, in-sequence delivery of service data units, and/or recovery.

Incorporated into the AM RLC entity is an automatic repeat request (ARQ) which provides error
25 correction mechanism to improve the reliability of packet transmission. Specifically, ARQ is an error-control mechanism for data transmission which uses acknowledgment and timeouts to achieve reliable data transmission. The ARQ scheme is used to detect if packets have gone missing. The transmitter is notified of successfully received packets by positive acknowledgments sent to the transmitter. If packets are detected to have gone missing, the
30 receiver requests retransmission by negative acknowledgments sent to the transmitter.

In RLC, the t-PollRetransmit timer is used by the transmitting side of an AM RLC entity in order to retransmit a poll for acknowledgement feedback. If acknowledgment feedback is not
35 received for too long a time, window stalling and overflow of the user equipment (UE) L2 buffer may occur.

SUMMARY:

A method may include starting a timer for retransmission of a poll at a protocol entity in an acknowledged mode. The method may also include determining at the protocol entity, upon
40 expiration of the timer, a data packet having a lowest sequence number among one or more data

packets. In addition, the method can include considering for retransmission the data packet having the lowest sequence number by the protocol entity, regardless of whether new data can be transmitted and regardless of whether any data packets are awaiting transmission. Further, the method may include transmitting the data packet having the lowest sequence number by the protocol entity.

According to certain embodiments, an apparatus may include at least one memory including computer program code, and at least one processor. The at least one memory and the computer program code may be configured, with the at least one processor, at least to start a timer for retransmission of a poll at a protocol entity in an acknowledged mode. The at least one memory and the computer program code may also be configured, with the at least one processor, at least to determine at the protocol entity, upon expiration of the timer, a data packet having a lowest sequence number among one or more data packets. In addition, the at least one memory and the computer program code may also be configured, with the at least one processor, at least to consider for retransmission the data packet having the lowest sequence number by the protocol entity, regardless of whether new data can be transmitted and regardless of whether any data packets are awaiting transmission. Further, the at least one memory and the computer program code may be configured, with the at least one processor, at least to transmit the data packet having the lowest sequence number by the protocol entity.

An apparatus, in certain embodiments, may include means for starting a timer for retransmission of a poll at a protocol entity in an acknowledged mode. The apparatus may also include means for determining at the protocol entity, upon expiration of the timer, a data packet having a lowest sequence number among one or more data packets. In addition, the apparatus may include means for considering for retransmission the data packet having the lowest sequence number by the protocol entity, regardless of whether new data can be transmitted and regardless of whether any data packets are awaiting transmission. Further, the method may include transmitting the data packet having the lowest sequence number by the protocol entity.

According to certain embodiments, a non-transitory computer-readable medium encoding instructions that, when executed in hardware, perform a process. The process may include starting a timer for retransmission of a poll at a protocol entity in an acknowledged mode. The process may also include determining at the protocol entity, upon expiration of the timer, a data packet having a lowest sequence number among one or more data packets. In addition, the process may include considering for retransmission the data packet having the lowest sequence number by the protocol entity, regardless of whether new data can be transmitted and regardless of whether any data packets are awaiting transmission. Further, the process may include transmitting the data packet having the lowest sequence number by the protocol entity.

According to certain embodiments, a computer program product encoding instructions for

performing a process according to a method including starting a timer for retransmission of a poll at a protocol entity in an acknowledged mode. The method may also include determining at the protocol entity, upon expiration of the timer, a data packet having a lowest sequence number among one or more data packets. In addition, the method includes considering for retransmission the data packet having the lowest sequence number by the protocol entity, regardless of whether new data can be transmitted and regardless of whether any data packets are awaiting transmission. Further, the method may include transmitting the data packet having the lowest sequence number by the protocol entity.

BRIEF DESCRIPTION OF THE DRAWINGS:

For proper understanding of the invention, reference should be made to the accompanying drawings, wherein:

Figure 1 illustrates a flow diagram according to certain embodiments.

Figure 2 illustrates a table according to certain embodiments.

Figure 3 illustrates a table according to certain embodiments.

Figure 4 illustrates a system according to certain embodiments.

DETAILED DESCRIPTION:

Certain embodiments provide a method by which acknowledgment, whether positive or negative, is received by the sending entity as soon as possible. Doing so may help limit or prevent window stalling and overflow of the UE's L2 buffer. Such a procedure can be implemented in the Long Term Evolution (LTE) RLC protocol or in some other access-technology counterpart. The entire content of 3GPP TS 36.322: LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); RLC protocol specification, is hereby incorporated by reference.

An AM RLC may poll its peer AM RLC entity in order to trigger STATUS reporting at the peer AM RLC entity. Expiry of t-PollRetransmit can mean that although previously requested or polled from the peer RLC entity, an acknowledgment or negative acknowledgement information has not been received for the highest-numbered PDU outstanding at the time of sending the request or poll. In some embodiments, expiry of t-PollRetransmit may indicate that acknowledgment has not been received for the highest-numbered PDU outstanding within the expiry time of a timer which represents the expected reasonable delay from time of sending the poll. The acknowledgment may be positive or negative.

Missing acknowledgement feedback may increase the risk of several undesirable events. For example, window stalling may occur. Window stalling describes a throughput-limiting situation where new acknowledgment mode data (AMD) PDU can no longer be transmitted. The reason for the inability to transmit may be that the sequence numbers of the AMD PDUs would progress too far ahead of the oldest PDU still waiting to be acknowledged. As explained in

section 5.1.3.1.1 of 3GPP TS 36.322, the transmitting side of an AM RLC entity shall maintain a transmitting window according to state variables VT(A) and VT(MS).

VT(A) can be a state variable that holds the value of the sequence number of the next AMD PDU for which a positive acknowledgment is going to be received in-sequence. VT(A) serves as the lower edge of the transmitting window, having an initial value of zero. The VT(A) may be updated whenever the AM RLC entity receives a positive acknowledgement for an AMD PDU having a sequence number equal to VT(A). VT(MS), on the other hand, may be the maximum send state variable that serves as the higher edge of the transmitting window. State variables related to the AMD PDU may take values from 0 to 1023 when a 10 bit sequence number is used.

In certain embodiments, a sequence number (SN) falls within the transmitting window if $VT(A) \leq SN < VT(MS)$. If the SN of any RLC data PDU falls outside the transmitting window, however, the transmitting side of an AM RLC may not deliver to lower layers, such as a MAC layer or a physical layer (PHY). This inability to deliver to lower layers leads to window stalling. In certain other embodiments, rather than window stalling, failing to receive acknowledgment information may lead to an overflow of a user equipment Layer 2 (L2) buffer.

In order to avoid undesirable situations, such as window stalling or as overflow of the UE's L2 buffer, acknowledgment should be received by the sending RLC entity as soon as possible after t-PollRetransmit expires. In certain embodiments, as soon as possible can mean an immediate acknowledgment, or an acknowledgment being received within an acceptable time period in order to avoid window stalling or an overflow of the UE's L2 buffer. The AM RLC entity may be located in both the UE and in a network entity, such as an evolved NodeB. In some embodiments the transmitting side of the AM RLC entity may be located in the UE while the receiving side of the AM RLC entity may be located in the network entity, and/or vice versa.

In certain embodiments, upon expiration of a timer, such as a t-PollRetransmit, the repeated poll may be carried in the highest-numbered N outstanding PDU. In such embodiments, the PDU numbered N may be received at the peer RLC entity before the preceding PDU numbered N-1 is received. This may lead to the initiation of the re-ordering timer at the receiving side of the peer AM RLC entity. The reordering timer can be used to detect a loss of RLC PDUs at the lower layers. In this case, the reordering timer may be used to detect that PDU numbered N-1 is missing.

The polled status PDU may in some embodiments only be transmitted when the reordering timer expires. For example, section 5.2.3 of 3GPP TS 36.322 describes delaying the triggering of the STATUS report until $SN < VR(MS)$ or $SN \geq VR(MR)$. VR(MS) may represent the state variable holding the highest possible value of the SN that can be indicated as ACK_SN, the SN

of the next not received RLC Data PDU which is not reported as missing, when a status PDU needs to be constructed. VR(MR), on the other hand, holds the value of the SN of the first AM data (AMD) PDU that is beyond the receiving window, and serves as the higher edge of the receiving window. Repeated polling in the highest-numbered outstanding PDU may therefore not be adequate for getting a new acknowledgment feedback as soon as possible.

Figure 1 illustrates a flow diagram according to certain embodiments. In step 110, a timer, for example, a t-PollRetransmit timer, is started for the retransmission of a poll at a protocol entity, for example an AM RLC entity. As discussed above, the t-PollRetransmit timer may be used by the transmitting side of a protocol entity, such as AM RLC entity, in order to retransmit a poll. When the timer expires, the protocol entity determines the PDU having the lowest SN among one or more PDUs for which positive acknowledgment has not been received, as shown in step 120. In some embodiments of step 120, even though no positive acknowledgement may be received, a negative acknowledgment can be received and the PDU having a lowest SN may still be determined. As discussed above, VT(A) may hold the value of the sequence number of the next AMD PDU for which a positive acknowledgment is going to be received in-sequence. In certain embodiments, therefore, the AMD PDU with $SN = VT(A)$ represents the oldest PDU still waiting to be positively acknowledged.

In some other embodiments, as shown in step 130, when the timer expires, the RLC entity determines the PDU having the lowest SN among one or more PDUs for which no acknowledgment, either positive or negative, has been received. In other words, while in step 120 no positive acknowledgment may have been received for a qualifying PDU, a negative acknowledgement may have been received in step 120. In step 130, on the other hand, no acknowledgment feedback, whether positive or negative, can have been received for a qualifying PDU.

In some embodiments, there can be more than one condition that leads the RLC entity to consider the AMD PDU with a SN equal to VT(A) for retransmission. For example, the condition $VT(A) = VT(S) - 1$ can hold when no new data can be transmitted. In some embodiments, the RLC entity should not repeatedly retransmit the same AMD PDU.

In step 140, the RLC entity may consider for retransmission the AMD PDU having the lowest SN, determined in the steps 120 and/or 130. Considering for retransmission may mean that the RLC entity places the PDU in a buffer waiting to be transmitted. Actual transmission may be done at a later point in time, when the underlying MAC layer indicates an actual transmission opportunity.

Step 140 may be undergone regardless of whether a new RLC data PDU can be transmitted and regardless of whether any RLC data PDUs are awaiting transmission. The RLC data PDUs may

await transmission in either a transmission buffer or a retransmission buffer. For example, the RLC entity may consider for retransmission the AMD PDU with SN equal to VT(A) regardless of whether window stalling or an overflow of the UE's L2 buffer occurs.

5 In step 150, the PDU having the lowest SN may be retransmitted by the protocol entity, such as an RLC. In certain embodiments, this retransmission can be undergone after the consideration in step 140. Once the PDU has been considered for retransmission, it may be placed in a transmission buffer by the protocol entity. The PDU may then be retransmitted after the underlying MAC layer indicates to the RLC entity an actual transmission opportunity.

10 In certain embodiments, the AMD PDU with SN equal to VT(A) may include a poll when being retransmitted. Carrying the repeated poll in the retransmitted AMD PDU with SN equal to VT(A), may avoid delaying the STATUS PDU at the peer RLC entity, as discussed above. In such an embodiment, the polled STATUS PDU may not have to wait until the reordering timer expires for the STATUS PDU to be transmitted. In addition, steps 120, 130, and 140 allow for
15 the retransmission of the poll in the next PDU to be transmitted. Since in certain embodiments the retransmitted AMD PDU can include a poll, the repeated poll may be transmitted in the next PDU to be transmitted by the RLC entity.

20 Figure 2 illustrates a table according to certain embodiments. In certain embodiments, when the retransmission timer expires, the RLC entity determines the PDU having the lowest SN among one or more PDUs for which positive acknowledgment has not been received, similar to step 120 in Figure 1. In other words, upon expiration of the timer, the RLC entity determines the PDU having the lowest SN among one or more PDUs for which positive acknowledgment has
25 not been received. In some embodiments, although a positive acknowledgment has not been received, a negative acknowledgment may have been received. As shown in Figure 2, once the t-PollRetransmit expires, the RLC entity may consider for retransmission at least the AMD PDU with a SN equal to VT(A), regardless of whether a new RLC data PDU can be transmitted and regardless of whether any RLC data PDUs are awaiting transmission.

30 In the embodiment shown in Figure 2, even if the transmission buffer is not empty, and the window is not stalled, the AMD PDU with a SN equal to VT(A) can be considered for retransmission upon the expiration of the t-PollRetransmit. In addition, a retransmission of the PDU may include a poll. In certain embodiments, the PDU may not be retransmitted as a whole
35 because it may not fit in the PDU size granted by the underlying MAC layer. In these embodiments, the PDU will undergo re-segmentation, meaning that it will be retransmitted in segments.

40 Figure 3 illustrates a table according to certain embodiments. In certain embodiments, when a timer for the retransmission of a poll at an RLC entity expires, the RLC entity may consider for

retransmission the lowest-numbered AMD PDU for which no acknowledgment, positive or negative, has been received, similar to step 130. A retransmission of a certain PDU may also include a poll.

5 The lowest-numbered PDU, for example, may have a sequence number (X) that minimizes $(X - VT(A)) \bmod 2^{[SN-FieldLength]}$. A modulus can be used when performing arithmetic comparisons of state variables or SN values. VT(A) may be the modulus base at the transmitting side of an AM RLC entity. In some embodiments, this lowest-numbered PDU may be in line with the RLC conventions described in section 7.1 of 3GPP TS 36.322.

10 In some embodiments, carrying the repeated poll in the chosen retransmitted AMD PDU may avoid delaying the STATUS PDU at the peer RLC entity, as discussed above. In such an embodiment, the polled STATUS PDU may not have to wait until the reordering timer expires for the STATUS PDU to be transmitted.

15 Figure 4 illustrates a system according to certain embodiments. It should be understood that each block of the flowchart of Figures 1, or any combination thereof, may be implemented by various means or their combinations, such as hardware, software, firmware, one or more processors and/or circuitry. In one embodiment, a system may include several devices, such as, for
20 example, network entity 420 or UE or user equipment 410. An RLC entity may be included in both network entity 420 and user equipment 410. The transmitting side of the RLC entity may be included in the UE and the receiving side of the RLC entity may be included in the network, and/or vice versa. The system may include more than one UE 410 and more one network entity 420, although only one access node shown for the purposes of illustration. A network entity can
25 be a network node, a base station, an eNB, server, host, or any of the other access or network node.

Each of these devices may include at least one processor or control unit or module, respectively indicated as 411 and 421. At least one memory may be provided in each device, and indicated as
30 412 and 422, respectively. The memory may include computer program instructions or computer code contained therein. One or more transceiver 413 and 423 may be provided, and each device may also include an antenna, respectively illustrated as 414 and 424. Although only one antenna each is shown, many antennas and multiple antenna elements may be provided to each of the devices. Other configurations of these devices, for example, may be provided. For
35 example, network entity 420 and UE 410 may be additionally configured for wired communication, in addition to wireless communication, and in such a case antennas 414 and 424 may illustrate any form of communication hardware, without being limited to merely an antenna.

40 Transceivers 413 and 423 may each, independently, be a transmitter, a receiver, or both a

transmitter and a receiver, or a unit or device that may be configured both for transmission and reception. The transmitter and/or receiver (as far as radio parts are concerned) may also be implemented as a remote radio head which is not located in the device itself, but in a mast, for example. The operations and functionalities may be performed in different entities, such as nodes, hosts or servers, in a flexible manner. In other words, division of labor may vary case by case. One possible use is to make a network node deliver local content. One or more functionalities may also be implemented as virtual application(s) in software that can run on a server.

A user device or user equipment 410 may be a mobile station (MS) such as a mobile phone or smart phone or multimedia device, a computer, such as a tablet, provided with wireless communication capabilities, personal data or digital assistant (PDA) provided with wireless communication capabilities, portable media player, digital camera, pocket video camera, navigation unit provided with wireless communication capabilities or any combinations thereof.

In some embodiment, an apparatus, such as an access node, may include means for carrying out embodiments described above in relation to Figures 1, 2, and 3. In certain embodiments, at least one memory including computer program code can be configured to, with the at least one processor, cause the apparatus at least to perform any of the processes described herein.

According to certain embodiments, an apparatus 410, 420 may include at least one memory 412, 422 including computer program code, and at least one processor 411, 421. The at least one memory 412, 422 and the computer program code are configured, with the at least one processor 411, 421, to cause the apparatus 410, 420 at least to starting a timer for the retransmission of a poll at a protocol entity in an acknowledged mode. The at least one memory 412, 422 and the computer program code are configured, with the at least one processor 411, 421, to also cause the apparatus 410, 420 at least to determine, when the timer expires, at the protocol entity the data packet having a lowest sequence number among one or more data packets, and consider for retransmission the data packet having the lowest sequence number by the protocol entity, regardless of whether new data can be transmitted and of whether any data packets are awaiting transmission. In addition, the at least one memory 412, 422 and the computer program code are configured, with the at least one processor 411, 421, to cause the apparatus 410, 420 at least to transmit the data packet having the lowest sequence number by the protocol entity.

Processors 411 and 421 may be embodied by any computational or data processing device, such as a central processing unit (CPU), digital signal processor (DSP), application specific integrated circuit (ASIC), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), digitally enhanced circuits, or comparable device or a combination thereof. The processors may be implemented as a single controller, or a plurality of controllers or processors.

For firmware or software, the implementation may include modules or unit of at least one chip set (for example, procedures, functions, and so on). Memories 412 and 422 may independently be any suitable storage device, such as a non-transitory computer-readable medium. A hard disk drive (HDD), random access memory (RAM), flash memory, or other suitable memory may be used. The memories may be combined on a single integrated circuit as the processor, or may be separate therefrom. Furthermore, the computer program instructions may be stored in the memory and which may be processed by the processors can be any suitable form of computer program code, for example, a compiled or interpreted computer program written in any suitable programming language. The memory or data storage entity is typically internal but may also be external or a combination thereof, such as in the case when additional memory capacity is obtained from a service provider. The memory may be fixed or removable.

The memory and the computer program instructions may be configured, with the processor for the particular device, to cause a hardware apparatus such as network entity 420 or UE 410, to perform any of the processes described above (see, for example, Figures 1, 2, and 3). Therefore, in certain embodiments, a non-transitory computer-readable medium may be encoded with computer instructions or one or more computer program (such as added or updated software routine, applet or macro) that, when executed in hardware, may perform a process such as one of the processes described herein. Computer programs may be coded by a programming language, which may be a high-level programming language, such as objective-C, C, C++, C#, Java, etc., or a low-level programming language, such as a machine language, or assembler. Alternatively, certain embodiments may be performed entirely in hardware.

Furthermore, although Figure 4 illustrates a system including a network entity 420 and UE 430, certain embodiments may be applicable to other configurations, and configurations involving additional elements, as illustrated and discussed herein. For example, multiple user equipment devices and multiple network entities may be present, or other nodes providing similar functionality, such as nodes that combine the functionality of a user equipment and a network entity, such as a relay node.

The above embodiments allow for an expedited acknowledgment feedback, or an acknowledgment feedback within an acceptable time period. The acknowledgment feedback can be requested by a transmitting side of an RLC entity, and sent as soon as possible or immediately by a receiving side of a peer RLC entity in response to a poll repeated by the RLC entity because no previous response to the poll was received. This may allow for reducing the risk of window stalling and overflow of UE's L2 buffer.

The features, structures, or characteristics of certain embodiments described throughout this specification may be combined in any suitable manner in one or more embodiments. For example, the usage of the phrases "certain embodiments," "some embodiments," "other

embodiments,” or other similar language, throughout this specification refers to the fact that a particular feature, structure, or characteristic described in connection with the embodiment may be included in at least one embodiment of the present invention. Thus, appearance of the phrases “in certain embodiments,” “in some embodiments,” “in other embodiments,” or other similar language, throughout this specification does not necessarily refer to the same group of embodiments, and the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

One having ordinary skill in the art will readily understand that the invention as discussed above may be practiced with steps in a different order, and/or with hardware elements in configurations which are different than those which are disclosed. Therefore, although the invention has been described based upon these preferred embodiments, it would be apparent to those of skill in the art that certain modifications, variations, and alternative constructions would be apparent, while remaining within the spirit and scope of the invention.

Partial Glossary

ACK Positive Acknowledgment

AM Acknowledged Mode

AMD AM Data

ARQ Automatic Repeat reQuest

NACK Negative Acknowledgement

PDU Protocol Data Unit

RLC Radio Link Control

SN Sequence Number

UE User Equipment

CLAIMS:

1. A method comprising:
starting a timer for retransmission of a poll at a protocol entity in an acknowledged
5 mode;
determining at the protocol entity, upon expiration of the timer, a data packet having a
lowest sequence number among one or more data packets;
considering for the retransmission the data packet having the lowest sequence number by
the protocol entity, regardless of whether new data can be transmitted and regardless of whether
10 any data packets are awaiting transmission; and
transmitting the data packet having the lowest sequence number by the protocol entity.
2. The method according to claim 1, wherein the one or more data packets are data
15 packets for which a positive acknowledgement has not been received.
3. The method according to claim 1, wherein the one or more data packets are data
packets for which a positive acknowledgement has not been received and a negative
acknowledgment has not been received.
- 20 4. The method according to any of claims 1, 2, or 3, wherein the data packet having a
lowest sequence number is considered for the retransmission if the data packet is not already
considered for the retransmission.
- 25 5. The method according to claim 1, wherein the transmitted data packet comprises a
poll.
6. The method according to claim 1, wherein the data packet is stored in a radio link
control entity.
- 30 7. The method according to claim 1, wherein the data packet is retransmitted regardless
of window stalling.
8. The method according to claim 1, wherein the protocol entity is a radio link control
entity.
- 35 9. The method according to claim 1, wherein the protocol entity is located in at least
one of a user equipment and a network entity.
- 40 10. The method according to claim 1, wherein the considering for the retransmission
includes placing the data packet in a buffer.

11. The method according to claim 1, wherein the data packet is retransmitted as a segmented data packet.

5 12. An apparatus comprising:
at least one memory comprising computer program code;
at least one processor;
wherein the at least one memory and the computer program code are configured, with
the at least one processor, to cause the apparatus at least to perform a process according to:
10 start a timer for retransmission of a poll at a protocol entity in an acknowledged mode;
determine at the protocol entity, upon expiration of the timer, a data packet having a
lowest sequence number among one or more data packets;
consider for retransmission the data packet having the lowest sequence number by the
protocol entity, regardless of whether new data can be transmitted and regardless of whether any
15 data packets are awaiting transmission; and
transmit the data packet having the lowest sequence number by the protocol entity.

13. The apparatus according to claim 12, wherein the one or more data packets are data
packets for which a positive acknowledgement has not been received.

20 14. The apparatus according to claim 12, wherein the one or more data packets are data
packets for which a positive acknowledgement has not been received and a negative
acknowledgment has not been received.

25 15. The apparatus according to any of claims 12, 13, or 14, wherein the data packet
having a lowest sequence number is considered for the retransmission if the data packet is not
already considered for the retransmission.

30 16. The apparatus according to claim 12, wherein the transmitted data packet comprises
a poll.

17. The apparatus according to claim 12, wherein the data packet is stored in a radio link
control entity.

35 18. The apparatus according to claim 12, wherein the data packet is retransmitted
regardless of window stalling.

19. The apparatus according to claim 12, wherein the protocol entity is a radio link
control entity.

20. The apparatus according to claim 12, wherein the protocol entity is located in at least one of a user equipment or a network entity.

5 21. The apparatus according to claim 12, wherein the considering for retransmission includes placing the data packet in a buffer.

22. The apparatus according to claim 12, wherein the data packet is retransmitted as a segmented data packet.

10 23. An apparatus comprising means for performing a process according to any of claims 1-11.

24. A non-transitory computer-readable medium encoding instructions that, when executed in hardware, perform a process according to any of claims 1-11.

15

25. A computer program product encoding instructions for performing a process according to any of claims 1-11.

1/4

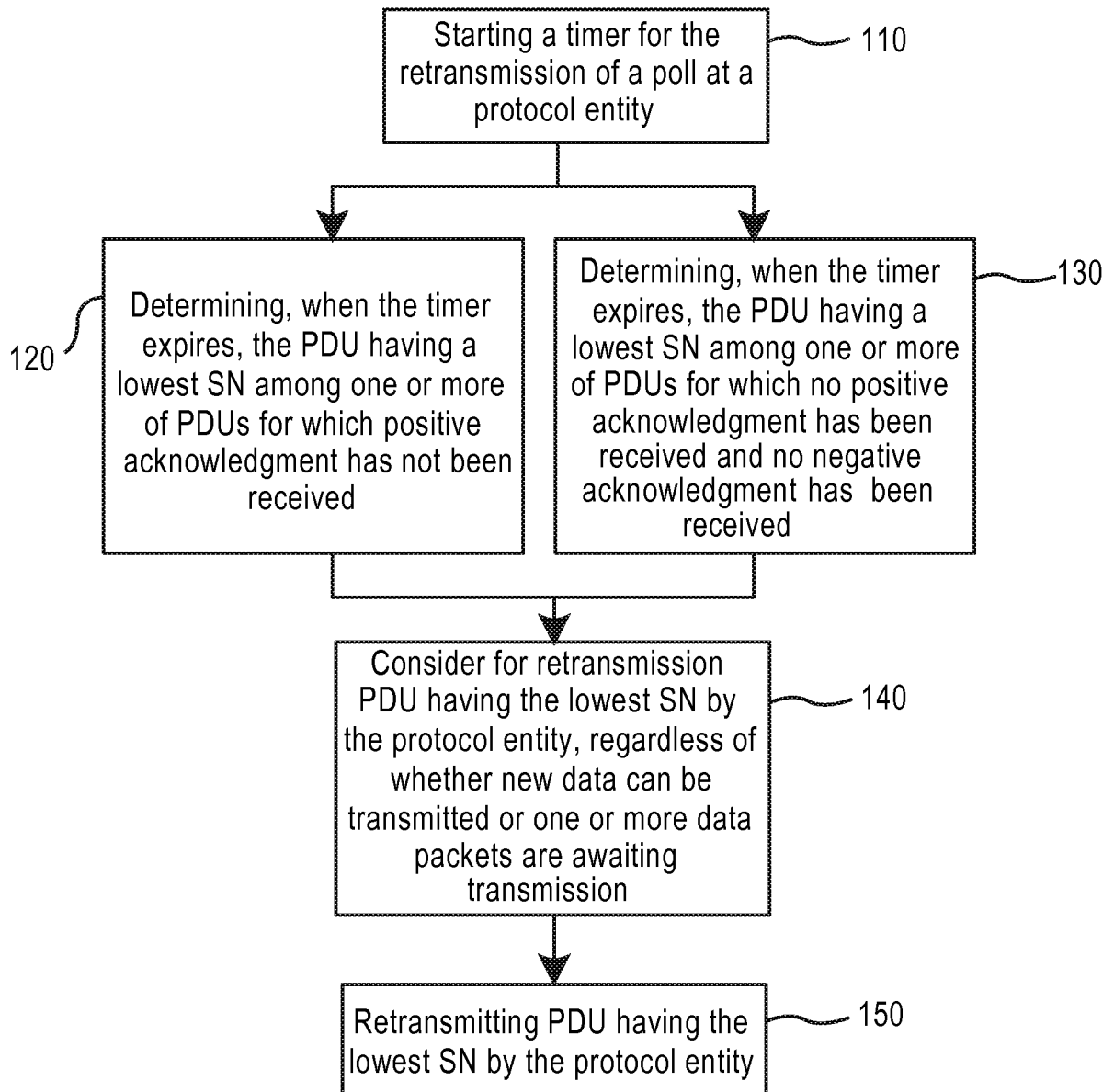


Figure 1

Upon Expiry of the t-PollRetransmit, the transmitting side of an AM RLC entity shall:

- if both the transmission buffer and the retransmission buffer are empty (excluding the transmitted RLC data PDU awaiting for acknowledgements); or
 - if no new RLC data PDU can be transmitted (e.g. due to window stalling)
 - consider the AMD PDU with $SN = VT(S) - 1$ for retransmission if not yet positively acknowledged;
 - consider the AMD PDU with $SN = VT(A)$ for retransmission if not considered already, and include a poll in the retransmission of this PDU;
-

Figure 2

Upon Expiry of the t-PollRetransmit, the transmitting side of an AM RLC entity shall:

- if both the transmission buffer and the retransmission buffer are empty (excluding transmitted RLC data PDU awaiting for acknowledgements); or
 - if no new RLC data PDU can be transmitted (e.g. due to window stalling):
 - consider the AMD PDU with $SN = VT(S) - 1$ for retransmission if not yet positively acknowledged;
 - if not considered already, consider for retransmission the lowest-numbered AMD PDU for which no acknowledgement (positive or negative) has been received, and include a poll in the retransmission of this PDU.
-

Figure 3

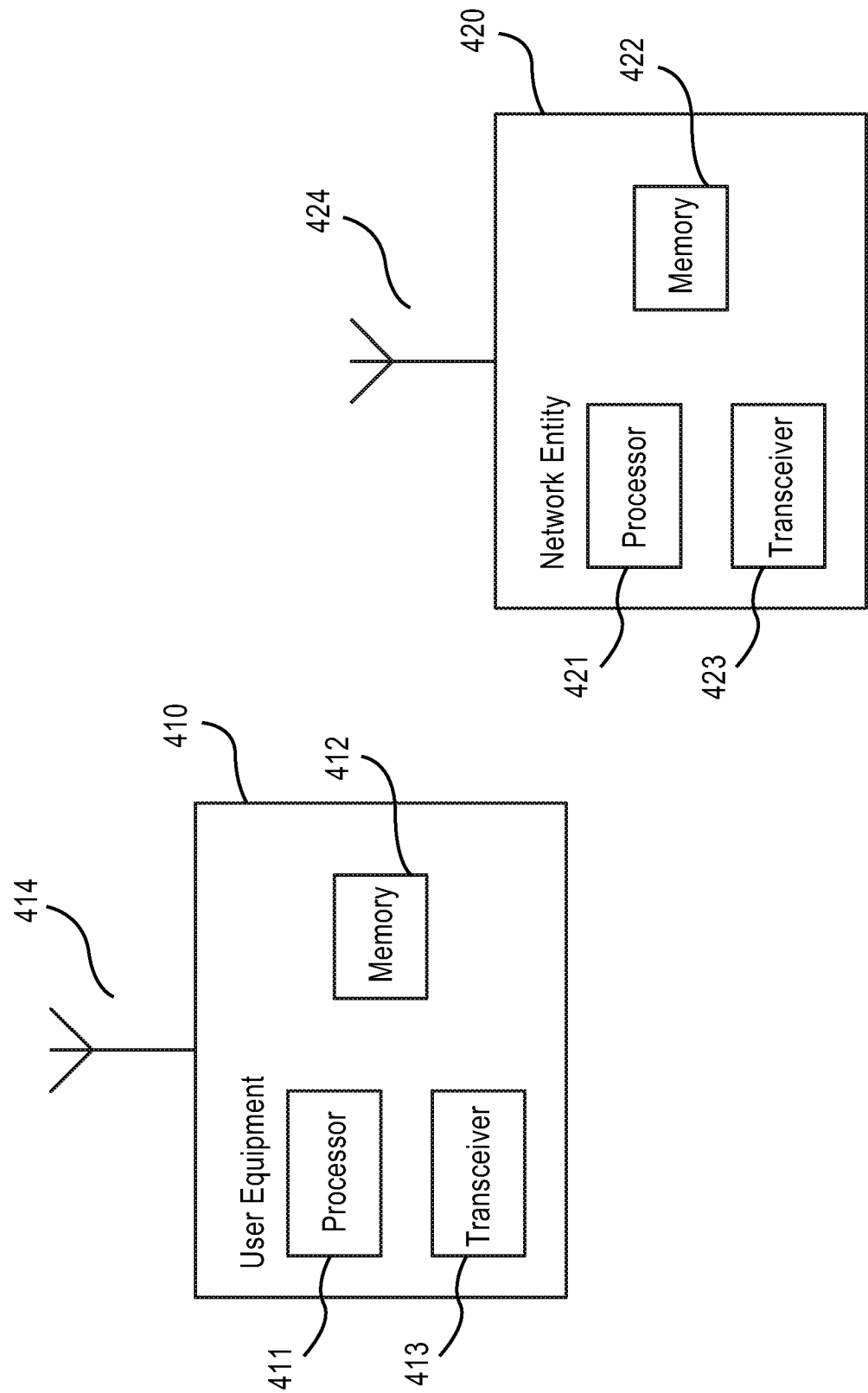


Figure 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2017/050173

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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: H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
FI, SE, NO, DK

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

EPODOC, EPO-Internal full-text databases, Full-text translation databases from Asian languages, WPIAP, PRH-Internal, XP3GPP, XPAIP, XPESP, XPETSI, XPI3E, XPIEE, XPIETF, XPIOP, XPIPCOM, XPJPEG, XPMISC, XPOAC, XPRD, XPTK, COMPD, INSPEC, TDB, NPL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010278179 A1 (ZHAO YONGDONG [US] et al.) 04 November 2010 (04.11.2010) abstract; par. [0009], [0027], [0029], [0032], [0042]-[0043]	1-25
X	WO 0113542 A1 (SAMSUNG ELECTRONICS CO LTD [KR]) 22 February 2001 (22.02.2001) page 6, lines 4-20	1-25
A	US 7000021 B1 (RADHAKRISHNAN RAMESH [US] et al.) 14 February 2006 (14.02.2006) abstract; col. 7, par. 1	

☐ Further documents are listed in the continuation of Box C.
☒ See patent family annex.

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search 17 May 2017 (17.05.2017)	Date of mailing of the international search report 19 May 2017 (19.05.2017)
Name and mailing address of the ISA/FI Finnish Patent and Registration Office P.O. Box 1160, FI-00101 HELSINKI, Finland Facsimile No. +358 9 6939 5328	Authorized officer Patrik Pousi Telephone No. +358 9 6939 500

INTERNATIONAL SEARCH REPORT
Information on Patent Family Members

International application No.
PCT/FI2017/050173

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
US 2010278179 A1	04/11/2010	US 8040891 B2 US 2009003360 A1 US 7782851 B2	18/10/2011 01/01/2009 24/08/2010
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WO 0113542 A1	22/02/2001	AU 6188300 A AU 766940 B2 BR 0012600 A CA 2381073 A1 CA 2381073 C CN 1364353 A CN 1165122 C EP 1201047 A1 EP 1201047 B1 JP 2003507928 A JP 4220154 B2 KR 20010035467 A KR 100424654 B1 RU 2221339 C2 US 6956855 B1	13/03/2001 23/10/2003 09/04/2002 22/02/2001 30/12/2008 14/08/2002 01/09/2004 02/05/2002 10/10/2012 25/02/2003 04/02/2009 07/05/2001 24/03/2004 10/01/2004 18/10/2005
.....			
US 7000021 B1	14/02/2006	None	
.....			

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2017/050173

CLASSIFICATION OF SUBJECT MATTER

IPC

H04L 1/08 (2006.01)

H04L 1/16 (2006.01)

H04L 1/18 (2006.01)

H04L 29/06 (2006.01)