

Agenda item: 5.2.2
Source: Motorola
Title: RLC Window Related Operations
Document for: Discussion and Approval

1 Introduction

This document discusses several RLC window related operations, including reordering window operation for AM/UM mode, and transmit/receive window operation for AM data transfer. Also included are proposals on the following issues: baseline ARQ protocol, identification of transmission success or failure, triggers of retransmissions and update of transmission/receiving window.

2 Discussion

2.1 Reordering Window Operation for AM/UM mode.

For LTE, the receiving MAC entity does not perform reordering of out-of-sequence RLC PDUs that is caused by HARQ. Therefore, a mechanism is necessary at the receiving UM/AM RLC entities to detect missing RLC PDUs and deliver PDUs to upper layer in sequence.

We propose two timers for reordering window operation: *T_release* and *T_status*. Each timer is associated with a PDU sequence number *N*. Upon the expiry of *T_release* timer, all data PDUs in buffer with sequence number greater than *N* are forwarded to upper layer up to the next outstanding PDU. This timer is used for both UM and AM mode. Upon the expiry of *T_status* timer, the PDU of sequence number *N* is determined to be missing and a status report NACKing that PDU is prepared for transmission when possible. *T_status* is used for AM mode only.

The operation details are specified as follows:

UM Mode Reordering Window Operation

At RLC UM receiving entity, *T_release* timer is started for sequence number *N* when a PDU of SN (*N+1*) is received without receiving PDU with SN *N*. It is stopped if still running when a PDU with SN *N* is received. If a PDU with SN *N* is not received before the expiry of *T_release*, the receiver determines that the PDU of SN *N* is lost permanently (because there is no RLC retransmission in UM mode), forwards all data with SN > *N* to upper layer up to the next outstanding PDU, and moves the lower edge of receiving window to the next expected in-sequence missing PDU.

AM Mode Reordering Window Operation

At RLC AM receiving entity, *T_status* timer is started for sequence number *N* when a PDU of SN (*N+1*) is received without receiving PDU of SN *N*. It is stopped if still running when a PDU with SN *N* is received. If a PDU with SN *N* is not received prior to the expiry of *T_status*, the receiver determines that the PDU of SN *N* is lost temporarily, and a status report is prepared to indicate the missing PDU to be transmitted whenever the resource is available. Upon the successful transmission of the status report as determined by the reception of a HARQ ACK, *T_release* timer is started for sequence number *N*. It is stopped if a PDU with SN *N* is received. If a PDU with SN *N* is not received prior to the expiry of *T_release*, the receiver determines that the PDU of SN *N* is lost permanently and forwards all data with SN > *N* to upper layer up to the next expected in-sequence missing PDU. Regarding the advancement of the lower edge of receiving window, two approaches may be adopted:

Approach 1: the receiver notifies the sender explicitly to move the transmission window accordingly. This can be done through MTW SUFI. The receiver will move the receiving window after getting the MTW_ACK. Alternatively, the sender may transmit a MRW command to the receiver.

Approach 2: the receiver moves the receiving window autonomously without notifying the sender explicitly. To ensure that the transmission window is updated accordingly, a timer should be started at the transmitter when the STATUS report with the NACK of PDU with SN N is received. Upon the expiration of the timer, the sender shall abort the retransmissions of PDU with SN N , and update the transmission window accordingly.

Approach 1 guarantees the explicit synchronization between transmission and receiving window, at the cost of extra signalling over the radio interface. Approach 2 does not require packet exchanges over the air, while an extra timer is needed at the transmitter.

2.2 Transmit/Receive Window Operation for AM Data Transfer

To provide lossless data transfer among AM entities, it is necessary to implement ARQ protocol between sender and receiver. For a radio link with low error rate, Selective Repeat ARQ is well known for its efficiency and simplicity.

It is important to choose the window size appropriately for Selective Repeat ARQ, so that there is no ambiguity in RLC PDU sequence number, and the transmission will not be stalled unnecessarily due to the choice of a small window size. As shown in [4], the window size configuration should take into account not only the available sequence number space, but also the difference between the maximal and minimal delays experienced by a Transmission Block.

Proposal 1: Selective Repeat ARQ[1] shall be adopted as the baseline framework for transmit and receive operations for AM data transfer.

Proposal 2: The failure of the transmission of PDU/PDU segment can be indicated by either a notification of HARQ delivery failure from the transmitting MAC entity, or an explicit RLC NACK carried by STATUS report SUFIs from the receiver for missing PDUs/PDU segments.

Note that a data PDU/PDU segment can be acknowledged not only through ACK, but also through BITMAP, RLIST, etc. as well.

Proposal 3: The successful transmission of a data PDU/PDU segment is indicated by explicit acknowledgement carried by STATUS report SUFIs from the receiver.

Proposal 4: Upon the indication of a transmission failure (by RLC NACK or HARQ NACK), a PDU/PDU segment shall be retransmitted and RLC ARQ retransmission counter shall be incremented, as long as the following conditions are satisfied:

- 4.1 the number of RLC ARQ retransmissions is below the maximum number allowed (MaxDAT in Release 7 [5]);**
- 4.2 the sequence number is within current transmission window;**
- 4.3 the PDU/PDU segment is not outdated.**

In [2] a mechanism was proposed to advance the transmission window upon the expiry of NACK timer of an associated PDU (proposal 1). It was based on the reasoning that an RLC PDU/PDU segment is assumed to be correctly received if no RLC NACK is received within a certain time. However, we have the following concerns with such a proposal:

1. The NACK timer value needs to be set large enough to provision for the potential delays that the receiver may experience until getting the resource to send NACK report. However, a large NACK timer will slow down the update of the transmit window if the transmission is successful, because the lower edge of the transmission window cannot be moved until the NACK timer expired and no NACK is received. This may lead to window stalling effect.
2. From implementation perspective, there might be potentially a large number of outstanding timers at the sender side, since each PDU sent needs to be associated with a timer.
3. Reliable delivery of the data through AM mode transmission cannot be guaranteed. If the original PDU and the RLC NACK is lost without been noticed by the sender (such as NACK->ACK error), the corresponding PDU is assumed to be transmitted successfully at the sender side upon the NACK timer expiration. Note that with the retransmission trigger specified in Proposal 4, the probability of this error scenario is reduced to $1e-8$. When this error happens, the transmission window will be updated mistakenly, even though the receiver might

still wait for the PDU to be retransmitted. The asynchronicity between sender and receiver could lead to sequence number ambiguity.

Therefore, we do not think that the NACK timer based criteria should be used to advance the transmit window.

Proposal 5: The transmission window shall be updated upon the indication of the successful reception of a data PDU, or the decision to move transmission window from RLC entity or upper layer.

Proposal 6: The receiving window shall be updated upon the successful reception of a PDU, or upon the decision of moving receiving window from RLC entity or upper layer.

The decision to move transmission or receiving window from RLC entity as stated in Proposal 5 and 6 may be the consequence of a number of procedures, including SDU discard or reset. The exact triggering commands may be MRW or MRW_ACK SUFIs. Since the details of these procedures are still FFS [3], Proposals 5 and 6 can be further specified when agreements on related procedures are reached.

3 Conclusions

In this document, we discuss several RLC window related operations.

For reordering window operations, two timers are proposed to be used: $T_{release}$ and T_{status} . For UM mode, $T_{release}$ is required. For AM mode, both $T_{release}$ and T_{status} are needed. The operation details are outlined in Section 2.1.

Regarding the transmit/receive window operation of AM data transfer, it is suggested to agree on the above six proposals in Section 2.2.

Motorola can provide text proposal for inclusion into the Stage 3 specification based on agreements.

References

- [1] D. Pertsekas and R. Gallagar, *Data Networks (2nd Edition)*, Prentice-Hall, 1991
- [2] R2-072568, "RLC Status Reporting Mechanisms", Ericsson
- [3] 3GPP TS 36.322, "Radio Link Control (RLC) protocol specification (Release 8)"
- [4] R2-073537, "RLC SN field size", Motorola
- [5] 3GPP TS 25.322, "Radio Link Control (RLC) protocol specification (Release 7)"