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Title: **The Estimated PDU Counter**

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The Estimated PDU Counter

1 Introduction

Timers are often used in retransmission protocols. For instance, timers can be used to detect when a retransmitted PDU should be retransmitted once more. The timer is set when a PDU is transmitted. After the timer has expired and if no acknowledgement of the PDU has been received the PDU will be retransmitted. It is important to set the timer to the right value. If the timer value is set too small the timer will expire before any acknowledgement is received, which could generate an undesired retransmission. On the other hand if the timer value is set too large the protocol will generate unnecessarily large retransmission delays.

Due to the fact that the bit rate of the physical channel and thus the transport channel can vary every 10 ms frame it is difficult to assign such a timer the right value. A solution to this problem is to use a counter instead of a timer. The counter is placed at the receiver side and is used to decide when to retransmit STAT PDUs. The mechanism for this is explained below.

2 Estimated PDU Counter

In order to describe the mechanism, we first note that within a transmission time interval, an integer number of PDUs can be transmitted. This number depends on the size of the PDU and the rate with which the PDUs are transmitted. After every transmission time interval, the rate may change and thus the number of transmitted PDUs may change as well accordingly. Due to the TFI bits, which are transmitted in parallel with the data, the receiving RLC is able to estimate how many PDUs should have been sent during a transmission time interval.

The EPC is a counter, which is decremented every transmission time interval with the estimated number of PDUs that should have been transmitted during that transmission time interval.

The EPC_{timer} sets the maximum time that the EPC needs to wait before it will start counting down. This timer starts immediately after a transmission of a retransmission request from the receiver (STAT PDU). The EPC_{timer} typically depends on the roundtrip delay, which consists of the propagation delay, processing time in the transmitter and receiver and the frame structure. This timer can also be implemented as a counter, which counts the number of 10 ms radio frames that could be expected to elapse before the first requested DATA PDU is received.

When the EPC exceeds the number of outstanding PDUs (i.e. the PDUs which were requested to be retransmitted) and not all of these requested PDUs have been received correctly, a new status report (STAT PDU) will be transmitted and the EPC will be reset to zero. The EPC timer will be started once more.

In Figure 1 the EPC and the EPC timer are illustrated. Each arrow in the figure corresponds to a transmission time interval.

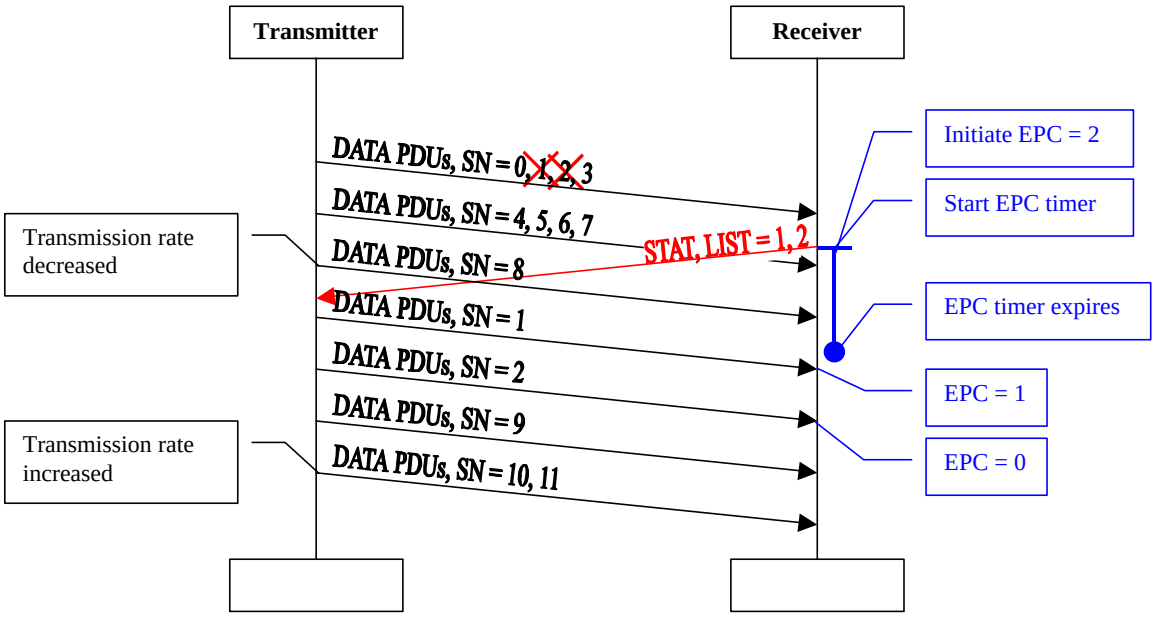

Figure 1. The estimated PDU counter and EPC timer.

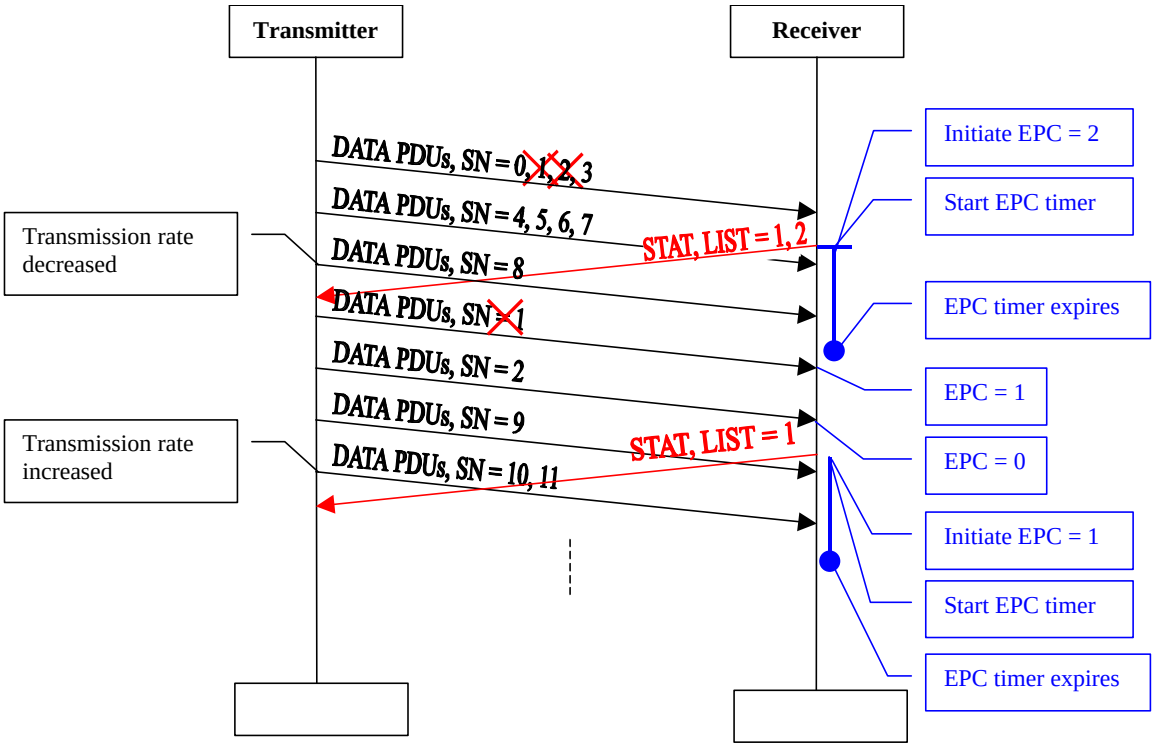

Figure 2. The Estimated PDU counter and EPC timer

The transmitter sends the PDUs 0, 1, 2 and 3 to the receiver. The PDUs 1 and 2 are lost. When the receiver detects that the PDUs are missing it generates and sends a STAT PDU to the transmitter. Simultaneously it sets EPC equal to the number of requested PDUs (in this case 2) and starts the EPC_{timer}.

In the next radio frame the transmitter sends the DATA PDUs 4, 5, 6 and 7. After that the transmission rate is decreased and the transmitter continues by sending DATA PDU 8. The transmitter then receives the STAT PDU. It processes the STAT PDU and, as a response, it retransmits the DATA PDUs 1 and 2. However, in this case it sends the PDUs in separate transmission time intervals, due to the low rates on the channel.

The receiver receives the DATA PDUs 4, 5, 6, 7 and 8 without decreasing the EPC. During this time, the EPC_{timer} is still ticking, meaning that the receiver could not expect retransmitted PDUs. The receiver starts to decrease the EPC when the EPC_{timer} has expired. In this case it starts after DATA PDU 8 but before DATA PDU 1 has been received. EPC is then decreased for each virtually received DATA PDU. To be able to do this the receiver can use the Transport Format Information (TFI) provided by MAC. The TFI indicates how many RLC PDUs should be received in each transmission time interval. When the receiver receives DATA PDU 1 it decreases the EPC by 1and when it receives DATA PDU 2 the EPC reaches 0.

In the case where any of the retransmitted DATA PDUs 1 or/and 2 is lost a new STAT PDU (or ACK/NACK PDU) will be transmitted to the transmitter. This is illustrated in Figure 2. The EPC would even in this case reach 0, due to its estimation of the number of PDUs transmitted in the transmission time intervals. But due to the fact that PDU 1 is not received correctly, the receiver would transmit a new STAT message requesting once more for PDU1.

3 Conclusion

We propose to include the retransmission mechanism of feedback messages as presented in this paper in the specification. We thus propose to include the description of the EPC scheme as described in Chapter 12 of S2.22.