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Title: **Simulation results on RLC/MAC signalling**

1 Introduction

There have been several discussions in TSG GERAN on integrity protection for RLC/MAC signalling. Several issues have been identified. The two main issues are the limited segmentation function and the frequency of RLC/MAC signalling. The segmentation function for RLC/MAC signalling is limited to two radio blocks on the downlink and there is no segmentation function on the uplink. This might be a problem whan adding the MAC-I field to the RLC/MAC signalling. However, it should be noted that there are other features in release 5 that might require enhancements of the segmentation function without considering integrity protection, e.g. multiple TBFs.

This document addresses the issue regarding the frequency of RLC/MAC signalling. RLC/MAC signalling will be very frequent in R99 since it is dealing with establishment and release of the shared resources in GERAN and establishment and release of the resources might occur as often as for every TCP/IP packet. In order to increase the performance of EGPRS several approaches are currently investigated and some being standardised. One of them is the so called ‘Delayed TBF release’. This document presents some simulation results, which show the performance gain that can be obtained by delaying the TBF release after the successful transmission of all PDUs in the RLC buffer.

The considered delays are in the order of one second which seems to be both resource efficient and performance increasing. The delay timer avoids TBF releases during short idle periods caused by higher layer transport protocols as for example TCP. The intention is not to keep the TBF established while waiting for user input or comparable actions.

2 Simulation Parameters

The countdown procedure was disabled and after transmitting the last RLC PDU of the RLC buffer a timer is started instead of releasing the TBF. The timer for the UL TBF is started in the MS and the timer for the DL TBF is placed in the BSS. The Final Block Indicator (FBI) bit is not set in the last RLC PDU if the delayed TBF release mode is active. Data packets arriving at the sender (UL as well as DL) enter the RLC buffer and restart the delayed TBF release timer. To release the TBF the last RLC PDU is retransmitted with the FBI bit set to 1. Each TBF keeps its identifiers (TFI in DL and USF in UL) and in DL the transmission starts at any time according to the DL scheduling. In uplink several new access procedures are currently discussed as for example using a new contention based channel. In these simulations it is assumed that much more traffic will occur in DL than in UL. Therefore and due to the fact that the delay is rather short (500 ms; 1000 ms) the UL is scheduled using a fair scheduling, which means that all available slots are evenly distributed between the active MSs. Four PDCHs are available in UL as well as in DL. The MSs are assumed to be 4+1 devices which means that they can access four time slots in downlink but only one in uplink.

Modulation and coding scheme (MCS) 9 was used with an error free air link, which provides a user data rate of 59.2 kbps per time slot.

To measure the performance of the system a number of WWW sessions have been modeled. Each user (mobile station) handles one WWW process. Each WWW session is followed by an idle period (reading time) of 90 s mean. HTTP1.1 has been used without pipelining. The measured session bit rate is the overall size of all objects transferred in the downlink within one session divided by the overall delay from requesting the WWW page until receiving the last object. The session bit rate is measured in kbps.

Table 2.1: WWW parameters

Number of WWW processes	1 per user
Idle time between consecutive sessions	Exponentially distributed (mean = 90 s)

Number of objects per session	Geometrically distributed (p = 0.1)
Object size	max = 130 kbyte
Mean session size	57.2 kByte
HTTP-Version	1.1 without Pipelining

Furthermore, the number of TBFs was measured for both modes standard and delayed TBF release. The number of active users is shown in a cumulative distribution function (CDF) which allows detecting shortage of USFs or TFIs. The number of unused UL blocks is the measure to show the efficiency of this realization. Unused UL blocks mainly occur if the TBF release is delayed and the mobile station is scheduled by the network to allow further uplink transmission.

In Table 2.2 some important parameter settings are listed.

Table 2.2: Important simulation parameters

Modulation and Coding Scheme	9
Physical link	Error free
Link data rate	UL = 59.2 kbps; DL = 4 * 59.2 kbps = 236.8 kbps
Delayed TBF mode	Off (0 ms delay); On (500 ms, 1000 ms delay)
Number of users	1, 2, 4, 6, 8, 10, 15, 20, 25, 30, 35, 40
Number of available PDCH:s (= TS reserved for data traffic)	UL = DL = 4
MS capabilities	1 time slot UL + 4 time slots DL
Simulated Time	50 minutes, i.e. 150000 blocks 20 ms each

3 Simulation Results

Measures for standard TBF release as well as for TBF release delays of 500 ms and 1000 ms are presented. Furthermore, the influence of the number of users mapped to the 4 PDCHs in UL and DL is depicted in the graphs.

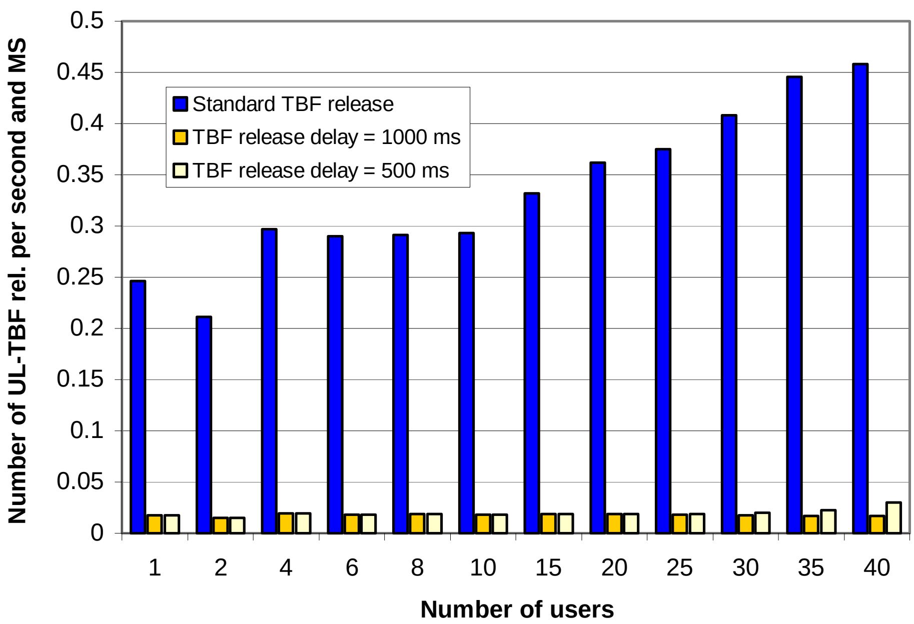

Figure 3.1: Number of TBFs per mobile station and second (UL)

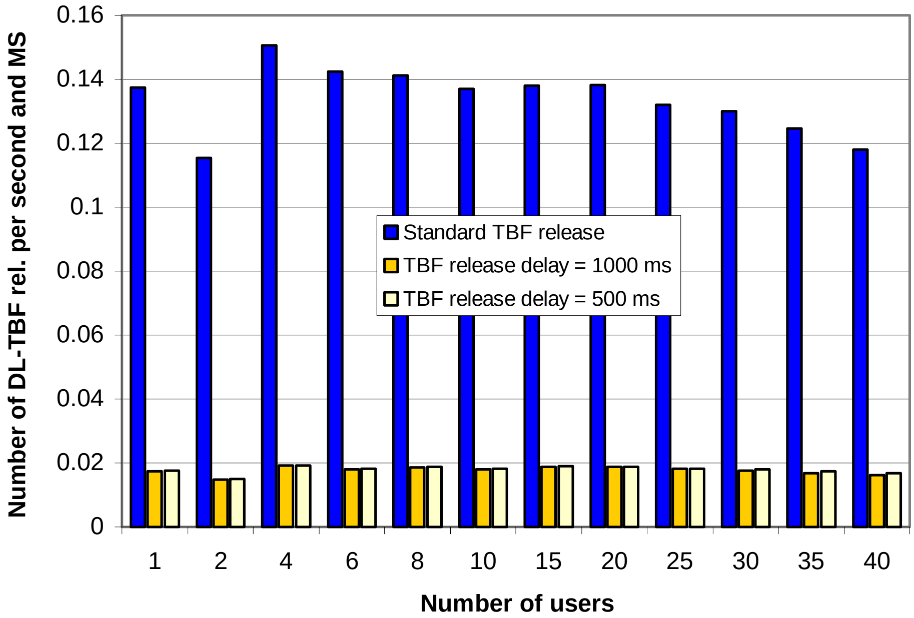

Figure 3.2: Number of TBFs per mobile station and second (DL)

Figure 3.1 and Figure 3.2 show the average number of TBF releases per second simulation time. I.e. the number of all TBF releases during one simulation was divided by the total simulation time (50 minutes). It has to be noted that a mobile station is not active continuously but only if a web-session is active. The idle period between two web-sessions is set to 90 s mean. Since traffic characteristics have strong influence on the absolute values, these results should be mainly used to compare the different modes. Furthermore, they allow rough estimations of the amount of required signalling messages for TBF handling.

As can be seen in the diagrams, the standard TBF release procedure ends up in a huge number of TBFs especially in uplink. This behaviour is caused by interactions with higher layer protocols (TCP). To provide a reliable connection between application server and client, the TCP client acknowledges every or at least every second TCP segment (512 Byte (Windows)). During the idle period between two consecutive TCP acknowledgements the RLC buffer runs empty and the TBF is released without the ‘Delayed TBF release’ option. Additional idle periods occur between consecutive TCP data segments as long as the TCP sender window is small. Consequently, a high number of TBFs are established especially in uplink direction (if DL WWW traffic is assumed). Considering that at least two control messages have to be transmitted to handle one TBF (UL TBF handling: Packet uplink assignment (DL); Packet Control Acknowledgement final (UL); DL TBF handling: Packet downlink assignment (DL); Packet control acknowledgement(UL)) this ends up in a huge amount of signalling that could be avoided by using delayed TBF release.

Similar behaviour can be found for every interactive protocol on top of RLC. E.g. HTTP1.0 requests consecutive objects of a web page after the previous objects was received successfully instead of sending a combined requests for all objects like HTTP1.1 does. So, it is not only a problem with TCP but with many interactive protocols.

4 Conclusion

Simulations have been performed to investigate the ‘delayed TBF release’ mode. A simple implementation was considered where the TBFs and the corresponding identifiers in uplink as well as in downlink are kept after transmitting the last RLC PDU. The mobile station has to listen to the assigned downlink resources so that the network can transmit further data within the delay period without any further signalling. Uplink resources (slots) have to be scheduled to each mobile station as long as the TBF is ongoing.

It can be seen from the figures that the amount of signalling decreases significantly with delayed TBF release. Especially for downlink TCP traffic a huge number of UL TCP acknowledgements has to be transmitted, each of them requesting a new TBF if the TBF release is not delayed.

However, it has to be noted that all results are so far preliminary and that further study is be needed to verify the results. For instance, using a more realistic radio model instead of an error free MCS 9 radio link might end up in another conclusion. Another question is what happens in a more mixed traffic model. The network might need more information from the mobile stations to guide the scheduling of UL blocks. A "fair scheduling", which is applied here, might not be applicable in a mixture of different kinds of applications.

Therefor it is difficult to conclude on the frequency of RLC/MAC messages and the real impact of integrity protection, but it is clear that the introduction of delayed TBF release will reduce the amount RLC/MAC signalling and therefor also the impact of integrity protection on the system performance.