

Agenda item: 8.8
Source: Sequans Communications
Title: Remaining issues with skipping of UL padding TX
Document for: Discussion and Decision

1. Introduction

In RAN#71, the work item [1] was agreed. In RAN2#93bis and RAN2#94 meetings, progress has been made and stage3 is being finalized. In this contribution, we address two potential issues which could not be handled in previous meetings: periodic BSR transmission while in “No data”, and UL lost issue.

2. Discussion

2.1. BSR / PHR

Our previous contribution [2] explains the usage of BSR / PHR by MAC. In legacy operation, BSR / PHR have several triggers. Once triggered, they can be sent if UL resources are allocated.

2.1.1. Inactive / active phases

In this discussion, it is useful to consider the typical usage of fast UL. It is nicely described in [3]. The UE without data to send can be considered in an “inactive” phase. When it has data to send, it can use the pre-scheduled SPS resources to quickly transmit the BSR and the first packets. However, unless the amount of data to send is very low (e.g. TCP ACK only), the eNB will then allocate UL resources through dynamic grant as in legacy operation. UE can then be considered in “active” state while it has data to send. This is illustrated in Figure 1 from [3].

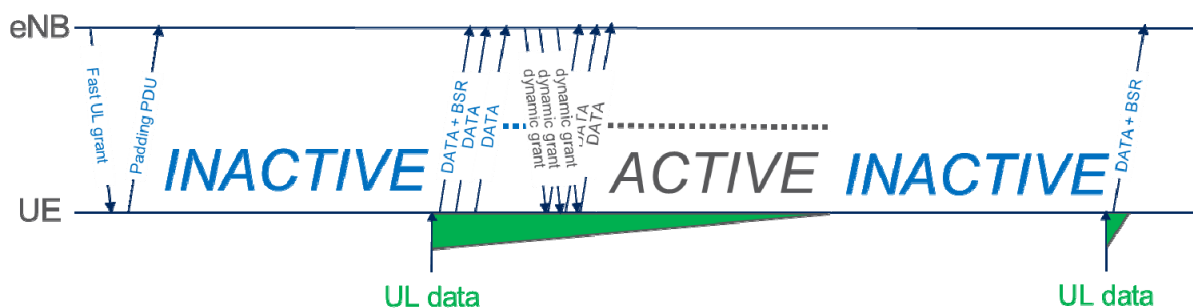


Figure 1

In legacy operation, the UE typically also alternate Inactive/Active phase. The main difference is:

- In legacy operation, pre-scheduling is typically not used. This means that while in inactive phase, there are no resources allocated, while in active phase, resources are allocated
- In fast UL operation, resources are always allocated: by pre-scheduling during inactive phase, by dynamic allocation during active phase

2.1.2.Periodic BSR and PHR issue

The legacy BSR / PHR design is as follows:

- Regular and ReTx BSR can trigger a SR procedure if UL resources are not available, i.e. while in “inactive” phase, to transition to the “active” phase. In case of fast UL, this does not happen as resources are available.
- Periodic BSR, PHR (periodic or event triggered) do not trigger SR. They are sent only when resources are available, i.e. normally during “active” phase. During inactive phase, resources are not allocated and they are not sent.

As it can be seen, periodic BSR and PHR were designed to be sent while in “active” phase only. However with fast UL they would be sent even during “inactive” phase, contrary to legacy behavior.

In RAN2#93, this was shortly discussed and the following assumption was made:

=> RAN2 assumption is that the UE will send the BSR/PHR according to legacy trigger (e.g. we will not specify skipping of BSR/PHR when no data is available in the buffer).

It was considered in the discussion that regarding periodic BSR/PHR, they can be configured by RRC, and typically be set to a large periodicity. Indeed the possible entries reach quite large values:

```
PeriodicBSR-Timer-r12 ::= ENUMERATED {
    sf5, sf10, sf16, sf20, sf32, sf40, sf64, sf80,
    sf128, sf160, sf320, sf640, sf1280, sf2560,
    infinity, spare1}
```

```
periodicPHR-Timer          ENUMERATED {sf10, sf20, sf50, sf100, sf200,
    sf500, sf1000, infinity},
prohibitPHR-Timer          ENUMERATED {sf0, sf10, sf20, sf50, sf100,
    sf200, sf500, sf1000},
dl-PathlossChange          ENUMERATED {dB1, dB3, dB6, infinity}
```

However, it is important to keep in mind how periodic BSR/PHR is typically configured. We have checked a few NW configurations and compiled the results in Table 1.

Operator	periodicBSR (sf)	periodicPHR (sf) / prohibitPHR (sf) / dl_PathlossChange (dB)
NA operator 1	5	200 / 200 / 3
NA operator 2	20	20 / 0 / 3
EU operator 1	10	20 / 0 / 3
EU operator 2	10	1000 / 100 / 3
AS operator 1	5	10 / 100 / 1

Table 1

Periodic BSR

As it can be seen, the periodic BSR is always configured with small values. This can be explained by the way LTE BSR procedure works. The regular BSR is only triggered when new data is received from upper layers while L2 buffer was empty (or when higher priority data than buffered data is received, but we do not need to consider this use case). Without periodic BSR, the eNB is not updated about the arrival of additional data during the transmission. It will schedule up to the amount of data signaled in the initial BSR, which would create gaps in the transmission, at least equal to the scheduling delay (delay between BSR is triggered and corresponding UL data can actually be sent, 8ms in legacy). This is shown in Figure 2.

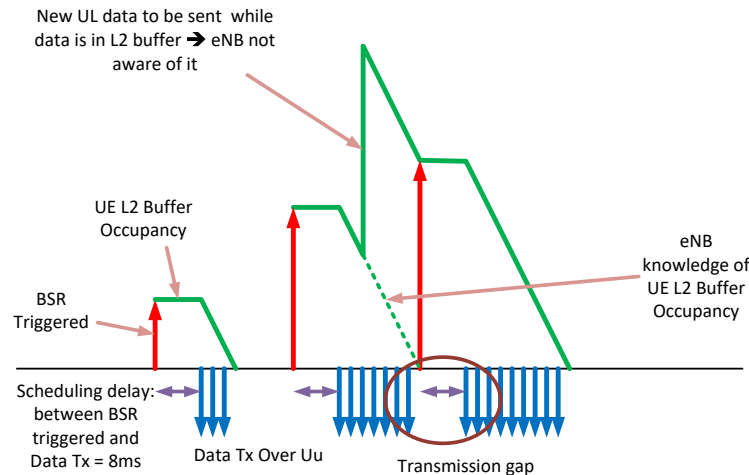


Figure 2

This is where periodic BSR is useful. It allows eNB to have a better knowledge of UE L2 buffer occupancy during the active phase, and enable to avoid transmission gaps. More precisely, assuming a periodic BSR period of x ms, transmission gaps can be completely avoided at the expense of a maximum eNB prescheduling time of x ms. E.g. with a 5ms BSR periodicity, then the eNB can avoid transmission gaps (ensure minimum latency/maximum throughput) with a maximum prescheduling duration of 5ms. Smart scheduling algorithms can also use this periodic BSR information to estimate the evolution of UE L2 BO and reduce the amount of prescheduling needed for optimal behavior.

It could be possible to introduce a new BSR trigger, for instance to report new data received when buffer is not empty. However this would have significant MAC impacts, and is likely not desired as periodic BSR was meant to avoid the need of such trigger.

Observation 1a: large periodicity of periodic BSR (>20ms) can significantly degrade UL data transfer, including increasing latency of such transfers.

Observation 1b: to avoid transmissions gaps (and ensure minimal UL latency during active phase), periodic BSR should be configured with a short periodicity, typically 5ms

It seems clearly not acceptable to have UE transmits useless 5ms periodic BSR during inactive phase. Currently the only way to handle this is for the eNB to reconfigure the BSR periodic timer through RRC at each active/inactive phase transitions, which does not seem very attractive. Hence we make the following proposal:

Proposal 1: do not send periodic BSR when skip UL padding is enabled and no UL data is to be sent

PHR

Regarding PHR, and especially periodic PHR, its configuration seems much more variable, as it ranges at least from 20ms to 1s in actual deployments. In our view, since it does not appear to be useful when no UL data is sent, it would also make sense to avoid sending too frequent PHR when skip UL padding is enabled and no UL data is sent. However, this seems less critical than for periodic BSR.

Proposal 2: do not send PHR when skip UL padding is enabled and no UL data is to be sent

2.2. UL lost handling

Issue description (from [2])

In legacy operation, when UE needs to transmit UL data, there are basically two cases:

- **No scheduled resources available:** UE uses SR (if time aligned) or PRACH (if not time aligned). In both cases, UE will notify upper layers in case of failure. Typically, a SR procedure failure will trigger a PRACH procedure, and a PRACH procedure failure will trigger a radio link failure procedure from RRC.
 - The eNB is not aware that UE is transmitting. Hence, failure handling is important at UE side to solve the issue.
- **Scheduled resources available:** UE can transmit data on PUSCH. The eNB is responsible for requesting HARQ retransmissions when required. However, in case where the maximum number of HARQ retransmissions is reached on UE side, there is no specific action at MAC level. The transmission goes on with a new transport block. RLC AM bearers will eventually reach maximum number of retransmissions, and trigger a RLF. But if there are only RLC UM bearer(s), then no RLF is triggered at all.
 - The eNB is aware that UE is transmitting. Hence, failure handling is less important at UE side since eNB can detect UL issues and take appropriate actions

With configured UL grant every subframe, UE is always in the “scheduled resources available” use case and does not use SR procedure. Instead, PUSCH is used. If skipping of UL padding transmission is enabled, the eNB is not aware that UE is transmitting. If UL is lost, eNB will not take any action since it is unaware of it. And in current specification, UE won’t either. In case RLC UM bearer is used, the UE may go on transmitting till TAT expiry (which is expected to be set to a high value, possibly infinity, in order to avoid unneeded timing advance updates).

Solution

The simplest way to handle this issue is to consider periodic UL transmissions, which are used as a “keep alive”. This could be realized with periodic BSR/PHR. However, as discussed above, it may be better to skip them during “no data”. Moreover the periodicity required might not be the one desired for UL data transfer. It is preferred to have a dedicated way to configure periodic UL transmissions while skipping of UL padding transmission is used. This can be implemented for instance using a fix pattern [4] or a prohibit timer [5].

Proposal 3: Introduce periodic UL transmissions (in which legacy operation applies)

3. Conclusion

In this contribution, we have made the following observations and proposals:

Observation 1a: large periodicity of periodic BSR (>20ms) can significantly degrade UL data transfer, including increasing latency of such transfers.

Observation 1b: to avoid transmissions gaps (and ensure minimal UL latency during active phase), periodic BSR should be configured with a short periodicity, typically 5ms

Proposal 1: do not send periodic BSR when skip UL padding is enabled and no UL data is to be sent

Proposal 2: do not send PHR when skip UL padding is enabled and no UL data is to be sent

Proposal 3: Introduce periodic UL transmissions (in which legacy operation applies)

References

- [1] RP-160667, “New WI proposal: L2 latency reduction techniques for LTE”, Ericsson
- [2] R2-162735, “Considerations on skipping UL padding transmissions”, Sequans Communications
- [3] R2-154742, “Skipping padding in SPS and dynamic grants”, Ericsson
- [4] R2-164116, “On issues with skipping of UL padding transmissions”, Sequans Communications
- [5] R2-165149, “UL lost handling when UE configured to skip UL transmission”, Nokia, Alcatel-Lucent Shanghai Bell