

Agenda item: 7.10.1

Source: Huawei, HiSilicon

Title: Contention based uplink transmission

Document for: Discussion and Decision

1 Introduction

In RAN#67, a new Study Item on “Latency reduction techniques for LTE” [1] was approved, and one of the objectives is to reduce the user plane latency and get a more resource efficient solution compared to the pre-scheduling scheme allowed by the standard today.

In this contribution, we will first present a possible framework for the contention based uplink transmission, and then perform the performance evaluation under different collision possibilities.

2 Framework

As proposed in [2] at RAN2#91, the key point of contention based uplink transmission is to assign one PUSCH resource to multiple UEs in the pre-scheduling scheme so as to achieve the statistical multiplexing. There are several possible ways to assign one PUSCH resource to multiple UEs, for example, the eNB may assign the same UL grant to multiple UEs via individual PDCCHs by dynamic scheduling, or assign the same UL grant to multiple UEs via individual PDCCHs during SPS activation if SPS is configured. By allocating different DMRS resources (i.e. different DMRS Cyclic Shifts) to different UEs that share the same PUSCH resource (the maximum number is 4 in the current specification), the eNB can identify the exact UE that performed the uplink transmission.

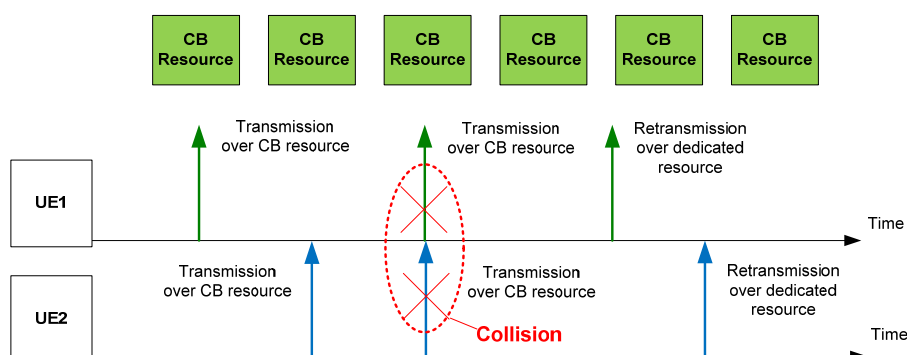


Figure 1: Contention based uplink transmission

Figure 1 illustrates the contention based uplink transmission when the UE has available data to transmit. A UE will only be allowed to transmit on a contention based PUSCH resource if it does not have a dedicated PUSCH resource. Contention based uplink transmission is kind of opportunistic uplink transmission, and collision may or may not happen. Collision happens when two or more UEs use the same contention based resource for uplink transmission, and in this case it is very likely that the eNB can't successfully decode all of the uplink transmissions. Since the eNB can distinguish different UEs by the DMRS resources, it can respond the colliding UEs with ACK on PHICH to hold the initial uplink transmission, and then schedule the retransmission on a dedicated PUSCH resource to avoid further collision. When no collision happens, the initial transmission is identical with the existing contention free uplink transmission. However, when the initial transmission failed, same as the retransmission in case of collision, the eNB will schedule the retransmission on a dedicated PUSCH resource to avoid collision.

To support the above solution, changes to the current specifications are expected to be quite small. If the contention based PUSCH resource is assigned by dynamic scheduling, then there is no impact to the current specifications, as the DMRS Cyclic Shift can be provided in the DCI for uplink scheduling. If the contention based PUSCH resource is assigned during SPS activation, considering that the DMRS Cyclic Shift provided in the DCI for SPS activation is fixed to '000', RRC specification need to be updated so that the eNB can provide the DMRS Cyclic Shift to the UE in SPS configuration.

Observation 1: To support contention based uplink transmission, changes to the current specifications are expected to be quite small. If contention based PUSCH resource is assigned by dynamic scheduling, then there is no impact to the current specifications. If contention based PUSCH resource is assigned during SPS activation, then only RRC specification will be impacted.

3 Performance evaluation

It is quite obvious that contention based uplink transmission can mitigate the PUSCH resource waste of the pre-scheduling scheme, since one PUSCH resource will be shared by multiple UEs. Contention based uplink transmission can also reduce the uplink transmission latency, which will be further discussed as below.

Table 1 provides a latency analysis of an uplink data transmission in the current LTE system, assuming FDD frame structure and a PUCCH cycle of 5ms. The analysis shows that the uplink data transmission can be achieved within 11.5ms.

Table 1: Uplink transmission latency in the current LTE system (error free, copy from Table B.1.2.1.1-1 in TS 36.912 [3])

Component	Description	Time [ms]
1	Average delay to next SR opportunity	2.5
2	UE sends Scheduling Request	1
3	eNB decodes Scheduling Request and generates the Scheduling Grant	3
4	Transmission of Scheduling Grant	1
5	UE Processing Delay (decoding of scheduling grant + L1 encoding of UL data)	3
6	Transmission of UL data	1
	Total delay	11.5

Table 2 provides a latency analysis of a contention based uplink transmission if no collision happens, assuming that the contention based PUSCH resource is provided by dynamic scheduling every 1ms. The analysis shows that the uplink data transmission can be achieved within 5.5ms. Note that in case the contention based PUSCH resource is provided with SPS, the total delay will be shorter (i.e. 2.5ms) as the UE doesn't need to receive and decode the UL grant on PDCCH.

Table 2: Uplink transmission latency for contention based uplink transmission if no collision happens (error free)

Component	Description	Time [ms]
1	Average delay to TTI border	0.5
2	eNB transmits UL Grant on PDCCH	1
3	UE Processing Delay (decoding of scheduling grant + L1 encoding of UL data)	3
4	Transmission of UL data	1
	Total delay	5.5

If collision happens for contention based uplink transmission, the colliding UEs will suffer additional delay caused by the retransmission on dedicated PUSCH resource. The total uplink transmission latency can be calculated as follow:

$$T_{latency,CB} = 5.5ms + 8ms * P_{collision}$$

Table 3 provides a latency analysis of a contention based uplink transmission for different collision probabilities. The analysis shows that even with 70% collision probability the uplink transmission latency is still shorter than that in the current LTE system with SR procedure. In the real deployment, by carefully configuring the number of UEs that share one contention base PUSCH resource taken into account the UE's traffic pattern, the collision probability would be moderate (e.g. 10%), and in this case the uplink transmission latency is only 6.3ms. If the contention based PUSCH resource is provided with SPS, the uplink transmission latency will be even shorter (i.e. 3.3ms).

Table 3: Uplink transmission latency for contention based uplink transmission if collision happens (error free)

Collision probability	Time [ms]
1%	5.6
5%	5.9
10%	6.3
15%	6.7
20%	7.1
25%	7.5
30%	7.9
50%	9.5
70%	11.1

Observation 2: Assuming a moderate collision probability (e.g. 10%) for contention based uplink transmission, the uplink transmission latency is 6.3ms if the contention based PUSCH resource is provided by dynamic scheduling, and the uplink transmission latency is 3.3ms if the contention based PUSCH resource is provided by SPS.

4 Conclusion

In this contribution, we first presented a possible framework for the contention based uplink transmission, and then performed the performance evaluation under different collision possibilities. The performance evaluation shows that contention based uplink transmission offers the possibility to mitigate the uplink PUSCH resource waste for the pre-scheduling scheme, and at the same time reduce the uplink transmission latency.

We have the following observations:

Observation 1: To support contention based uplink transmission, changes to the current specifications are expected to be quite small. If contention based PUSCH resource is assigned by dynamic scheduling, then there is no impact to the current specifications. If contention based PUSCH resource is assigned during SPS activation, then only RRC specification will be impacted.

Observation 2: Assuming a moderate collision probability (e.g. 10%) for contention based uplink transmission, the uplink transmission latency is 6.3ms if the contention based PUSCH resource is provided by dynamic scheduling, and the uplink transmission latency is 3.3ms if the contention based PUSCH resource is provided by SPS.

Therefore, we propose:

Proposal: Introduce the contention based uplink transmission scheme, for which different UEs that share one PUSCH resource are distinguished by different DMRS resources.

5 References

- [1] RP-150465, New SI proposal: Study on Latency reduction techniques for LTE; Ericsson, Huawei
- [2] R2-153374, Uplink latency reduction for synchronized UEs; Huawei, HiSilicon
- [3] 3GPP TR36.912, Feasibility study for Further Advancements for E-UTRA (LTE-Advanced)