

3GPP TSG RAN Rel-19 workshop
Taipei, June 15 - 16, 2023

Source: ZTE, Sanechips

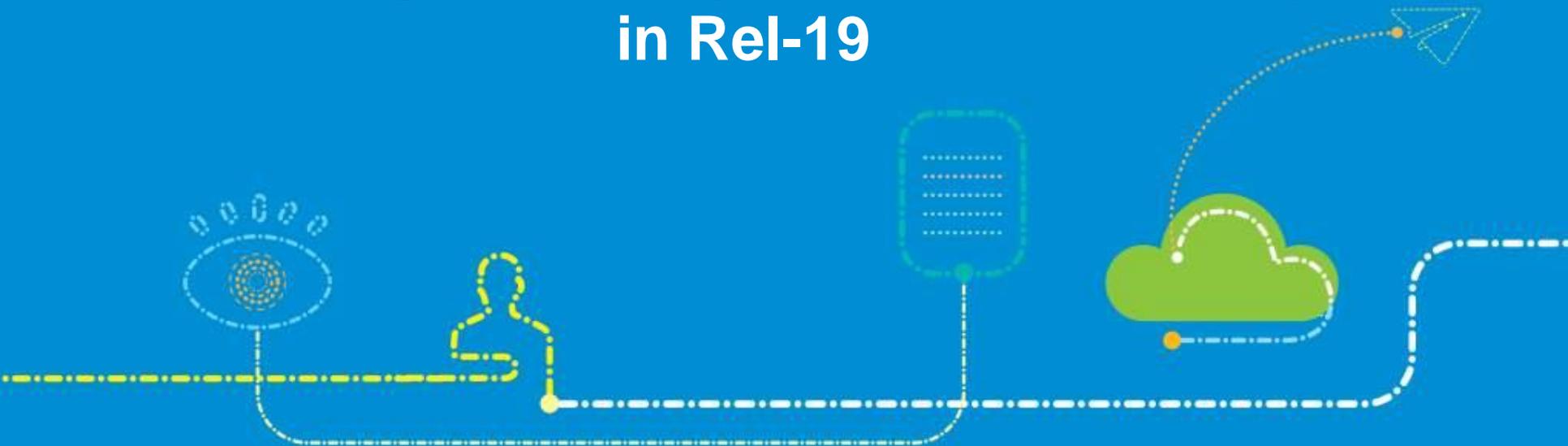
Agenda: 5

RWS-230303

ZTE

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Views on high reliability and low complexity IoT in Rel-19



Background

- High reliability transmission with UE experienced data rate less than 10Mbps is required for many use cases in vertical applications.
- Large number of connected UEs is required in some use cases according to the table as below.
- RedCap UEs with low cost and complexity can be applied to these use cases. However, the reliability of RedCap UE is restricted due to reduced number of UE Rx antennas and bandwidth reduction from 100MHz to 20MHz.

Communication service availability	User-experienced data rate	Message size (byte)	Transfer interval	End-to-end latency	Number of connected UE	Use Case
99,9999% to 99,999999%		≤ 1 k	≥ 4 ms	< transfer interval	≤ 10	Factories of the future: Motion control and control-to-control
>99,9999%		40 to 150 k	1 to 500 ms	< transfer interval	≤ 100	Factories of the future: Mobile control panels, mobile robots Electric power distribution: Differential protection
99,9999% to 99,999999%	> 5 Mbps			< 30 ms		Factories of the future: Mobile control panels with safety functions, bi-directional communication
99,9999%	10 Mbps			≤ 30ms	1000/km2	Intelligent transport system: Wireless road-side infrastructure backhaul

Observation: Reliability and capacity enhancements should be considered for RedCap UEs.

Enhancements to improve reliability for Redcap UEs

- **Motivation:** The maximum bandwidth of RedCap UE is reduced from 100MHz to 20MHz. Consequently, UL frequency hopping can only be performed within bandwidth of 20MHz. The frequency domain resource allocation for DL channel is also limited within 20MHz. These would restrict RedCap UE to acquire more frequency diversity gain. Moreover, the existing CSI measurement for active BWP cannot provide accurate CSI information for other BWPs .
- **Proposal:** Consider reliability enhancement for RedCap UEs in Rel-19, including:
 - Frequency hopping between BWPs in a band for DL and UL.
 - CSI measurement for inactive BWP.

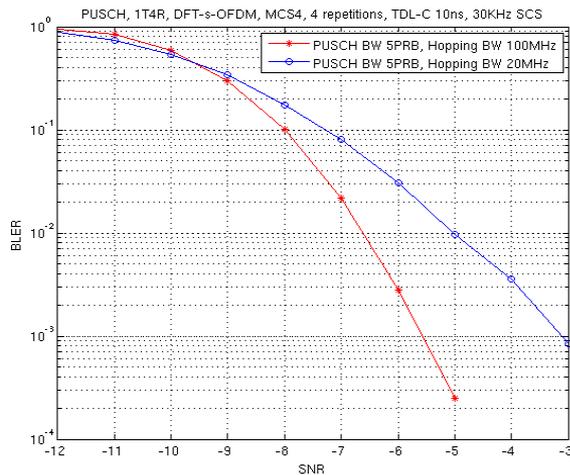
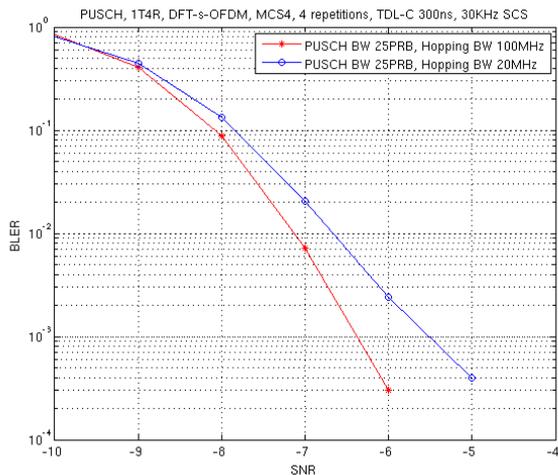


Fig.1, LLS results of PUSCH with hopping BW of 20 MHz vs 100 MHz

OCC-based PUSCH repetition (1/2)

- **Motivation:** PUSCH repetition is one straightforward way for coverage and reliability enhancement. However, it is resource consuming by applying repetitions and results in low cell capacity, i.e., less number of connections in the cell.
- **Proposal:** To improve the efficiency, an orthogonal cover code (OCC) can be performed across PUSCH repetitions and different UEs can apply different OCC for multiplexing.
 - The frequency resources can be fully or partially overlapped as shown in Fig.2.

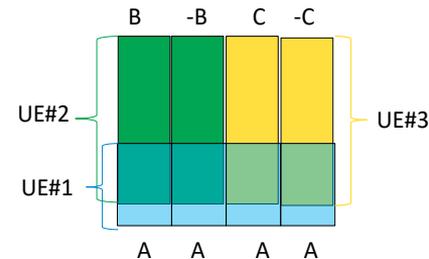


Fig.2: OCC-based PUSCH repetition

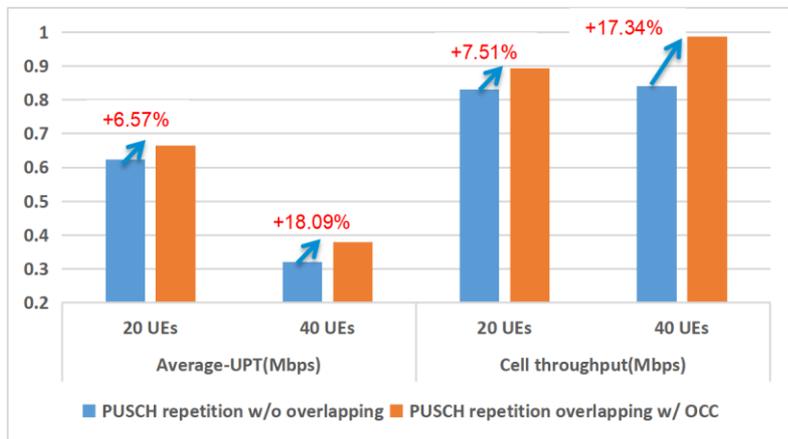


Fig.3: SLS result for PUSCH repetition w/o overlapping vs. PUSCH repetition overlapping w/ OCC

- **Observation from SLS:** Comparing with PUSCH repetition w/o overlapping, clear gain can be observed by performing OCC across PUSCH repetitions for inter UEs multiplexing,
 - For 20 UEs per cell, the average-UPT and cell throughput gain is 6.57% and 7.51%, respectively;
 - For 40 UEs per cell, the average-UPT and cell throughput gain is 18.09% and 17.34%, respectively.

OCC-based PUSCH repetition (2/2)

• Observations from LLS:

- For PUSCH repetition without OCC, the SNR performance will degrade rapidly as the ratio of overlapping resources increases. For PUSCH repetition with OCC, similar performance is observed under different overlapping cases.
- For non-overlapping case, OCC based solution have similar performance in case of MCS#0, and has only 1 dB loss in case of high coding rate (MCS#9) which is not typical in coverage limited scenario.
- For 50% overlapping case, OCC based solution can provide 0.71 dB and 2.17 dB SNR gain at 0.1 target BLER for MCS=0 and MCS=9, respectively.
- Error floor is observed for full overlapping cases for both MCS=0 and MCS=9.

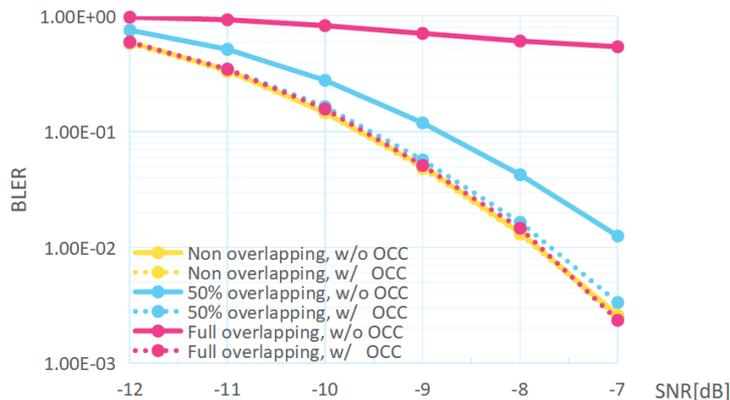


Fig.4: LLS result for PUSCH repetition w/ RV {0, 2}(w/o OCC) vs. RV {0, 0}(w/ OCC) under MCS=0

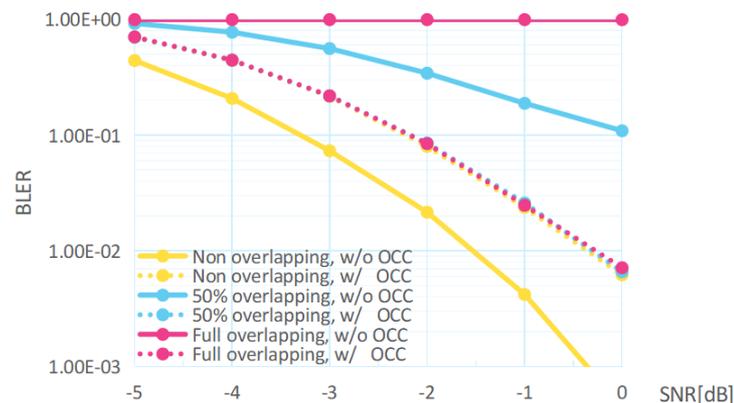


Fig.5: LLS result for PUSCH repetition w/ RV {0, 2}(w/o OCC) vs. RV {0, 0}(w/ OCC) under MCS=9

Capability relaxation for IoT/Redcap UEs supporting URLLC

- **Motivation:** Implementation of some URLLC features could be too challenging for IoT/Redcap UEs, e.g., some mini-slot operations like span-based PDCCH monitoring capability. Capability relaxation can be considered for better support of these features for IoT/Redcap UEs.
- **Proposal:** Support capability relaxation for IoT/Redcap UEs with URLLC services.
 - E.g., capability relaxation of mini-slot based features.

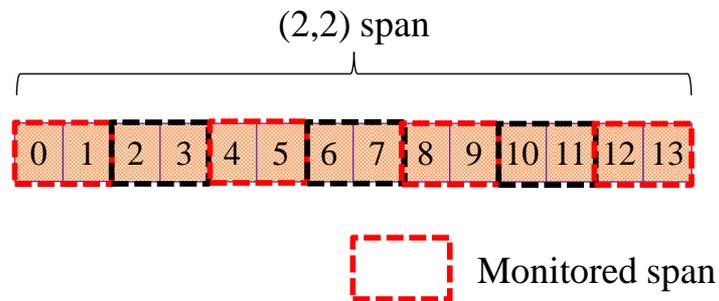


Fig.6: Complexity reduction of span based PDCCH monitoring by allowing IoT/Redcap UEs only to monitor some of the spans.

Enhancements to collision handling between PUCCH repetition and PUCCH

- **Motivation:** PUCCH repetition for better coverage is supported from NR Rel-15. But current specification has many restrictions leading to difficulty for implementing PUCCH repetitions, e.g., the following restrictions in Clause 9.2.6 in 38.213.
 - ‘A UE does not multiplex different UCI types in a PUCCH transmission with repetitions over $N_{PUCCH}^{repeat} > 1$ slots.’
 - ‘The UE does not expect more than one PUCCH from the first PUCCH and the second PUCCHs to start at a same slot and include a UCI type with same priority’
- **Proposal:** UCI multiplexing for the same or different UCI types in case of PUCCH with repetition overlapping PUCCH with/without repetition should be supported at least for the following case.
 - Case 1: The overlapping PUCCHs have the same starting slot and the same repetition factor ($N > 1$) in the time domain.

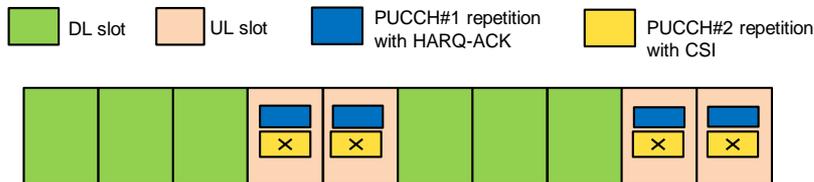


Fig.7: Collision of PUCCH repetition with HARQ-ACK and PUCCH repetition with CSI

Enhancement to collision handling between PUCCH repetition and PUSCH

- **Motivation:** In current specification, PUSCH is always dropped in case of overlapping with a PUCCH with repetitions. This is too restrictive and leads to almost impossible for implementing PUCCH repetitions and PUSCH repetitions.
 - *'If a UE would transmit a PUCCH over a first number $N_{PUCCH}^{repeat} > 1$ of slots and the UE would transmit a PUSCH with repetition Type A over a second number of slots, and the PUCCH transmission would overlap with the PUSCH transmission in one or more slots, and the conditions in clause 9.2.5 for multiplexing the UCI in the PUSCH are satisfied in the overlapping slots, the UE transmits the PUCCH and does not transmit the PUSCH in the overlapping slots.'*
- **Proposal:** UCI multiplexing in case of PUCCH with repetition overlapping PUSCH with/without repetition should be supported at least for the following cases.
 - Case 1: The overlapping PUCCH and PUSCH have the same starting slot and the same repetition factor ($N > 1$) in the time domain.
 - Case 2: The overlapping PUCCH and PUSCH have the same starting slot, and PUCCH repetition factor N_1 ($N_1 > 1$) is less than PUSCH repetition factor N_2 ($N_2 > 1$).

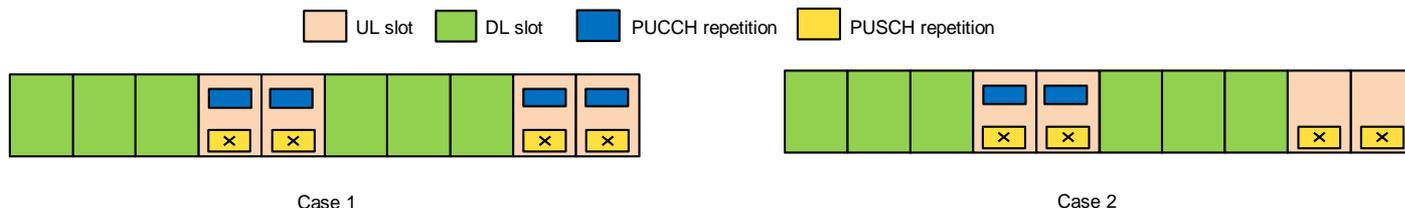


Fig.8: Two collision cases of PUCCH repetition and PUSCH repetition

WI scope

- Specify support for the following enhancements:
 - Reliability enhancement for RedCap UEs, including:
 - Frequency hopping between BWPs in a band for DL and UL.
 - CSI measurement for inactive BWP.
 - OCC-based PUSCH repetition
 - Apply OCC across PUSCH repetitions and different UEs can use different OCC for inter-UE multiplexing.
 - Capability relaxation for IoT/Redcap UEs supporting URLLC services
 - E.g., capability relaxation of mini-slot based features.
 - Enhancements to collision handling for better support of PUCCH/PUSCH repetition
 - UCI multiplexing for the same or different UCI types in case of in case of PUCCH with repetition overlapping PUCCH with/without repetition should be supported at least for the following case.
 - Case 1: The overlapping PUCCHs have the same starting slot and the same repetition factor ($N > 1$) in the time domain.
 - UCI multiplexing in case of PUCCH with repetition overlapping PUSCH with/without repetition should be supported at least for the following cases.
 - Case 1: The overlapping PUCCH and PUSCH have the same starting slot and the same repetition factor ($N > 1$) in the time domain.
 - Case 2: The overlapping PUCCH and PUSCH have the same starting slot, and PUCCH repetition factor $N1$ ($N1 > 1$) is less than PUSCH repetition factor $N2$ ($N2 > 1$).

Thanks



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