

Content

- NR Rel-15 URLLC overview
- Motivations for NR Rel-16 URLLC enhancement
- Objectives for NR Rel-16 URLLC WI

NR Rel-15 URLLC overview

- **NR Rel-15 URLLC only focused on basic requirements (i.e., 1e-5 transmission for 32 Bytes within 1 ms)**
 - Non-slot based scheduling and transmission
 - UL grant free transmission
 - DL preemption indication based DL eMBB and URLLC multiplexing
 - Basic reliability related features such as PDSCH/PUSCH/PUCCH slot repetition/aggregation, etc.
 - NR Rel-15 phase 2 is still ongoing, focusing on the following URLLC related work:
 - URLLC specific CQI/MCS tables
 - PDCCH enhancement, e.g., compact DCI format and PDCCH repetition
 - UL eMBB and URLLC multiplexing

Motivations for NR Rel-16 URLLC enhancement (1)

- **Further enhance transmission reliability and efficiency for low SNR UEs, e.g., cell edge UEs**
 - URLLC services would require that cell edge UEs may need to be served as similar data rate as cell center UEs
 - Low SNR UEs would consume much more resources and the resource allocation is sensitive to the CSI measurement and report
 - CSI measurement/report, UCI transmission and diversity can be considered
- **The URLLC enhancement should consider real diverse use cases and requirements**
 - Medium to large data rates may need to be considered
 - For example, about 25Mbps with 99.999% reliability within E2E 5-ms latency bound could be required for remote driving
- **Further enhance transmission reliability and efficiency for UL grant free transmission**
 - No explicit DL ACK/NACK is introduced in NR Rel-15 for UL GF transmission
 - More UL grant overhead for grant based retransmission

Motivations for NR Rel-16 URLLC enhancement (2)

- **Other URLLC enhancements related to non-RRC-connected mode**
 - Reduce latency to less than 10ms low-latency connection from idle mode to connected mode
 - To save the power consumption of URLLC users and reduce network overhead, URLLC users should be allowed to turn to idle mode. In this case, when a UL/DL URLLC burst is triggered, low-latency connection should be supported
 - Data transfer in inactive state
 - GF in inactive mode could save the power consumption of URLLC devices without the signaling overhead for connection establishment
 - Optimization of the packet delivery latency during handover
 - Service continuity is even more important for URLLC UEs

Motivations for NR Rel-16 URLLC enhancement (3)

- **Highly accurate time synchronization between devices for industrial applications with network assistance [TR22.804]**
 - To provide high accuracy time synchronization service between different nodes, e.g. mobile robots for industry automation scenario, which can support a collision-free operation of autonomous mobile robots and synchronized actions between multiple mobile robots.
 - Time synchronization requirement also exists in Smart Grid scenario, e.g. synchronised phasor measurement for dynamic monitoring and fault isolation.
 - Better than ± 500 ns accuracy time synchronization needs to be supported.
- **Deterministic transmissions with low latency, high reliability and jitter control [TR22.804]**
 - Delay between transmission of a message at the source and receipt of the message at the destination should be stable to support the consecutive control operations for industry automation scenario.
 - For cyclic service, In case a jitter for the delay is more than a predefined threshold, a fault or even production downtime may be introduced.
 - Support $< 50\%$ cycle time for cyclic deterministic transmission, e.g., 0.5 ms jitter for 1ms cycle time

Objectives for NR Rel-16 URLLC WI (1)

- **Identify and specify solutions to further enhance the latency, reliability and transmission efficiency for URLLC transmission [RAN1, RAN2, RAN4]**
 - Enhance transmission reliability and resource utilization efficiency for low SNR UEs, considering scheduling, CSI measurement and report, UCI transmission, diversity, etc.
 - Support high reliable transmission with medium to high data rate
 - Enhanced transmission reliability and resource utilization efficiency UL grant free transmission, e.g., DL ACK feedback, etc.
 - Reduce latency to less than 10ms low-latency connection from idle mode to connected mode
 - Data transfer in inactive state
 - Optimization of the packet delivery latency during handover

Objectives for NR Rel-16 URLLC WI (2)

- **Support methods allowing UE to synchronize to an absolute time provided by gNB. [RAN1, RAN2, RAN4]**
 - Support high-accuracy timing indication from gNB to UE.
 - Specify the mechanism of the timing-information indication from gNB to UE.
 - Specify the corresponding UE procedures.
 - Enable more accurate time-synchronization between gNB and UE.
 - Identify the enhanced synchronization mechanism to realize reliable higher-accuracy time synchronization between gNB and UE.
 - Support the efficient management for synchronization service.
 - Support high accuracy time synchronization in mobility.
 - Support UE Authorization for the synchronization service.

Objectives for NR Rel-16 URLLC WI (3)

- **Support deterministic transmissions for cyclic traffic [RAN2, RAN3]**
 - Support jitter <50% cycle time for cyclic deterministic transmission, e.g., 0.5 ms jitter for 1ms cycle time
 - Specify the time control functionality and location for the deterministic transmission.
 - Specify related Qos parameters for the deterministic transmission.
 - Avoid too early arrival or too late arrival for deterministic transmission
 - Support time aware scheduling in RAN
 - Support avoiding consecutive application packets failure
 - Identify the potential consecutive application packets failure and improve the reliability accordingly

Thank You

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