RP-191293, TSG RAN#84
Newport Beach, CA, USA, June 03 – June 07, 2019
Agenda Item 8

Summary of LG's View on REL-17 NR Evolution

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Rel-17 General overview [1/2]

- **General direction of Rel-17 evolution for NR**
  - **Enhanced basic functionality** to support continuous evolution of eMBB and URLLC
  - Enhanced support for **diverse vertical applications**
  - Enhanced support for **diverse device types**
  - Enhanced support for **diverse network deployments**
  - Expansion into **new spectrum**
- **Continuation vs. New area for Rel-17**
  - Balance between "continuation" and "new area" should be ensured
    - Carefully check necessity of continuation for Rel-16 items
    - Open the opportunity for new areas for leveraging the flexibility of 5G NR

- **Rel-17 time schedule**
  - Even though 15 months release was agreed for Rel-17, 3GPP should further check the necessity of extending it to18 months after carefully assessing the WI/SI proposals to RAN #84 and RAN #85 and their industry needs.
  - Final schedule should be fixed in RAN #86

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Rel-17 General overview [2/2]

Enhancing basic functionalities	• Flexible UL/DL Resource Allocation and Interference Mitigation • NR MIMO enhancements, Positioning enhancements • Connection-free data transfer, TCP boosting • Mobility enhancements, MR-DC enhancements
Supporting diverse vertical applications	• Enhanced NR V2X/sidelink • Public Safety (UE relaying) • Enhanced IIoT/URLLC • NR-U enhancements • NR broadcast/multicast
Supporting diverse device types	• IoT over NR
Supporting diverse deployment	• IAB enhancements • NPN enhancements
Expanding into new spectrum	• NR support above 52.6GHz

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RAN1-led topics [1/2]

- **New area**
  - **Flexible UL/DL Resource Allocation and Interference Mitigation [1]**
    - Intra/Inter-cell/Inter-link CLI management (which can be seen as continuation for CLI WI in Rel-16) and study for full duplex radio
    - Operating scenarios
      - Distributed RUs with RU-wise independent tx/rx, Full duplex based gNB Uu
      - Half duplex IAB with SDM/FDM, Full duplex IAB node
  - **NR-IoT [2]**
    - Supporting minimum UE costs in terms of implementation/computational complexity and power consumption for Rel-15(and 16) NR
  - New RAT for above 52.6GHz
    - Studying applicability of one or both of single carrier system and multi-carrier system for NR beyond 52.6GHz

[1] Motivation paper and draft SID in RP-191295 and RP-191294
[2] Draft SID in RP-191296

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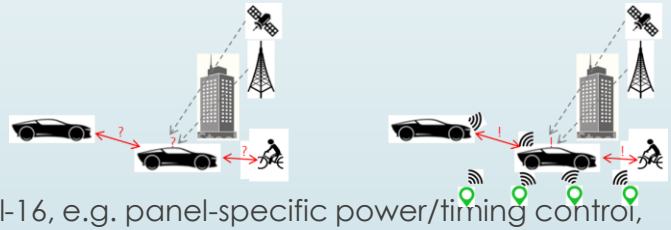
RAN1-led topics [2/2]

- **Continuation of Rel-16 projects**
  - **NR-V2X/sidelink enhancements**
    - A Rel-17 WI with the objective of NR sidelink enhancement should be approved as a part of Rel-17 package with the clear focus on V2X
    - Other use cases (e.g., public safety, gaming, etc.) can be supported using the solution of this WI
  - Positioning enhancement
    - Sidelink based positioning techniques, covering V2X use cases, e.g., RSU-based positioning, UE-cooperative relative positioning, etc.
    - Use of unlicensed band for high accuracy positioning
    - Real-time positioning for high mobility



  - **NR-MIMO enhancements [3]**
    - UL enhancements for multi-panel UE including potential leftovers from Rel-16, e.g. panel-specific power/timing control, support for simultaneous transmission across multiple panels
    - DL enhancements for multi-TRP including potential leftovers from Rel-16, e.g. beam management enhancement for FR2, CSI feedback enhancement
  - NR-U enhancements
    - Directional LBT, multi-beam operation
    - Potential left-overs from Rel-16, e.g., 2-step RACH in u-band

[3] Draft WID in RP-191297

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RAN2-led topics [1/2]

- **New area**
  - **Connection free data transfer [4]**
    - Supporting data transmission/reception in RRC_INACTIVE
  - NR broadcast/multicast
    - Supporting more reliable broadcast with low latency and higher speed with low overhead and high capacity at small areas in REL-17, especially for V2X and URLLC
  - **TCP boosting [5]**
    - Supporting UL TCP ACK prioritization to boost up DL TCP throughput
  - UE relaying for public safety use cases
    - Focusing on the relay protocol architecture and procedure essential to support UE-NW and UE-UE relaying operations based on sidelink

[4] Draft WID in RP-191298
[5] Draft WID in RP-191299

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RAN2-led topics [2/2]

- **Continuation of Rel-16 projects**
  - Enhanced mobility
    - Consistent E2E performance on mobility
    - Predictive Mobility Control
    - MSE (Mobility State Estimation) enhancement
    - Ultra-fast and Reliable Failure Recovery
  - Enhanced IIOT
    - Throughput enhancement
    - Critical data transmission
  - Enhanced MR-DC
    - Further reduced SCG setup time
    - Reliable SCG setup

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RAN3-led topics [1/1]

- **Continuation of Rel-16 projects**
  - Enhanced IAB
    - Support of Multi-connectivity for IAB Node
    - Support of NGEN-DC
  - Enhanced NPN (Non Public Network)
    - Support of MR-DC
    - Mobility Enhancement for CAG
  - SON
    - Active Antenna System Optimization
    - Energy Saving

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Annex: More detailed proposals for some selected topics

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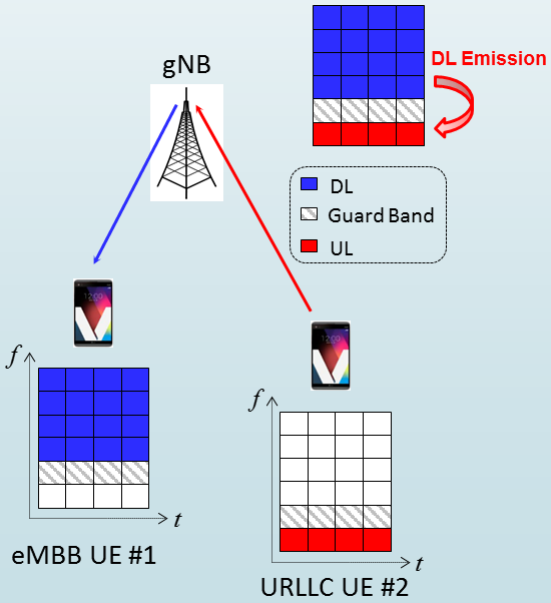
Flexible Resource Allocation and Interference Mitigation

- **Motivation**
  - Better adaptability to the DL/UL resource allocation based on different DL/UL traffics situations
  - Better latency by relaxing DL-UL half-duplex constrains
  - Potential throughput enhancement by allowing in-band simultaneous Tx-Rx in a same carrier
- **Scenarios for potential enhancements:**
  - Distributed RUs with RU-wise independent Tx/Rx
  - gNB in-band inter-UE full duplex
  - Half duplex based IAB node with SDM/FDM
  - Full duplex based IAB node
- **Potential technical candidates**
  - Cross-link interference handling
    - Power control, Resource configuration, CLI measurement and reporting
  - In-band self-interference mitigation



<Example of gNB in-band inter-UE full duplex>

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NR V2X/Sidelink Enhancements

- **Motivation**
  - Rel-16 V2X WI is ongoing but a lot of enhancement areas have been identified during the study phase and WI approval.
  - A Rel-17 WI with the objective of NR sidelink enhancement should be approved as a part of Rel-17 package with the clear focus on V2X.
  - Coexistence and compatibility with Rel-16 NR sidelink should be ensured.

- **Potential technical candidates**
  - Sidelink carrier aggregation (e.g, handling limited TX/RX capability, sidelink cross-carrier scheduling, …)
  - Power saving mechanism for pedestrian UE
  - Enhancement for multiple UE antenna panels (e.g., panel-selective transmission, sensing and measurement for multi-panel, …)
  - Enhancement for sidleink operations in FR2 (e.g., beam management, assistance from FR1, …)
  - Enhancement to CSI acquisition (e.g., more antenna ports, CSI report to gNB, …)
  - Enhancement to resource allocation (e.g., the solutions discussed in the context of mode 2(b) and 2(d))

- **Other use cases (e.g., public safety, gaming, etc.) can be supported using the solution of this WI (designed for V2X)** when the service requirement can be met.

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UE Relaying

- **UE relaying mainly targeting public safety use cases**
  - A separate SI with a follow-up WI is considered for UE relaying in Rel-17, targeting public safety use cases.
    - This can include UE-NW relaying (BS - relay UE - remote UE) and UE-UE relaying (source UE - relay UE - destination UE).
    - This SI/WI should focus on the relay protocol architecture and procedure essential to support UE relaying operations based on sidelink (e.g., relay UE discovery and association, …).
      - General sidelink TX/RX aspects are to be discussed in the Rel-17 V2X/sidelink WI in order to keep the commonality.
    - Other relaying operations (e.g., for commercial use cases, IoT use cases) could be considered after Rel-17 potentially with other candidates (e.g., BS-type relay, use of unlicensed band, …)

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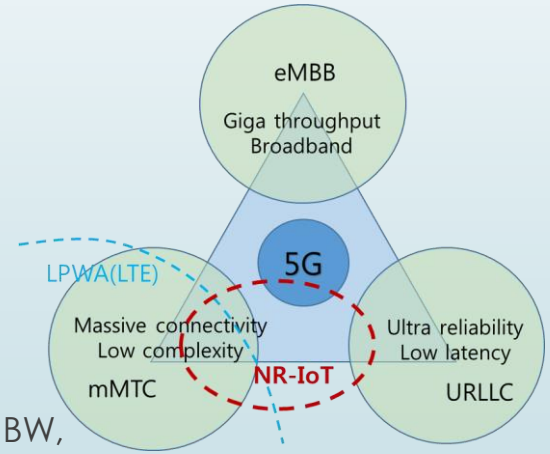
IoT over NR

- **Motivation for NR-IoT**
  - **Minimum UE costs** in terms of implementation/computational complexity and power consumption for Rel-15(and 16) NR is very high due to, e.g., 100MHz BW for FR1, at least 2 or 4 receiving antennas, dynamic TDD, URLLC, 15/30/60kHz SCSs for FR1, no always-on signals, and so on.
  - For those of use-cases and device types that were traditionally based non-cellular communications but recently have been considered **a new cellular market** by service providers, eg., wearable devices, video surveillance cameras, industrial sensors, vehicle navigators, and so forth, the downside due to NR UE costs and power consumption need to be addressed sooner.
- **Scope of NR-IoT in Rel-17**
  - Much lower UE complexity and power consumption than Rel-15/16 NR
    - Narrower operating bandwidth, e.g., **Type A for BW >5MHz**, and **Type B for BW from around [3]MHz to 5MHz**
    - Simplified **beam related operation** (e.g., for < 4 Rx. antennas)
    - Measurement relaxation
  - Moderate coverage enhancement
    - At least to **compensate for a coverage loss** mainly due to narrower operating BW, reduced # receiving antennas, and so on
  - A unified technology (separate solutions, e.g, LTE-M and NB-IoT, should be sublated)
    - **Scalable** in terms of bandwidth, capability, complexity and so on, but not as much as NR
    - Fast and efficient **mode switching** in terms of power saving level, data rate, coverage, and so on



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NR beyond 52.6GHz

- **Potential issue in frequency band over 52.6GHz**
  - Low PAE (power added efficiency) in power amplifier
  - High phase noise due to VCO and PLL in high frequency band
  - Transceiver complexity in order to support high data rate of tens of Gbps
  - Too many transmitting beams for compensating severe pathloss in over 60GHz
- **Approach to be considered for NR beyond 52.6GHz**
  - Single carrier system
    - Low implementation cost of gNodeB/AP
      - Low PAPR and Robustness to phase noise
      - Simple receiver in case of small delay spread
    - Big change in standard and Low reusability of NR transceiver for frequency band below 52.6GHz
  - Multi-carrier system
    - Higher spectral efficiency from resource usage flexibility
    - Simple extension with minimum effort for evolving NR standard
    - Decreasing component cost with advances in technology
  - Study applicability of one or both of single carrier system and multi-carrier system for NR beyond 52.6GHz`

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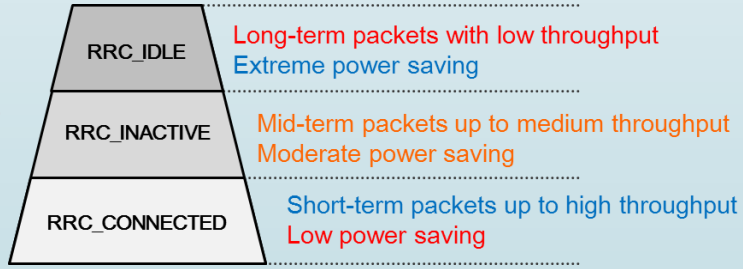
Connection Free Data Transfer

Motivation

- RRC_INACTIVE is good state for UE power saving. But, data transmission/reception in RRC_INACTIVE is not allowed for REL-15/16 NR UE.
- There are many scenarios where UEs transmit or receive a data burst in mid-term basis. In the scenarios, UEs should consume power to resume the RRC connection for every packet transmission.
- For resource efficient transmission of small data with limited radio resources, L2 overhead of PDU should be minimized.

Focused objectives

- Data transmission/reception in RRC_INACTIVE
  - UL data transmission on pre-allocated UL resources
  - DL data reception triggered by enhanced paging
- L2 overhead reduction
  - Compact PDU generation with minimized L2 header



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NR Broadcast

- **Motivation**
  - LTE MBMS was enhanced to support delay sensitive V2X services in REL-14. However, 5G system would require more stringent requirements on broadcast.
  - For NR radio, it is important to support more reliable broadcast with low latency and higher speed with low overhead and high capacity at small areas in REL-17, especially for V2X and URLLC.
- **Focused objectives**
  - DL broadcast transmission at least for a small area
  - High reliable transmissions with low latency e.g. for URLLC and V2X
  - Support of higher speed broadcast with low overhead and high capacity
  - Support interworking with LTE MBMS in MR-DC

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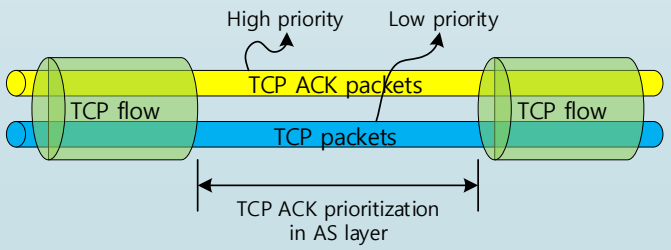
TCP boosting

Motivation

- Up to Rel-16, NR is mainly designed for eMBB, which is well-suited for DL TCP transmission. However, NR is not optimized for UL TCP ACK transmission.
- NR aims at DL TCP throughput of ~20 Gbps. However, actual throughput in TCP layer is much less than 20 Gbps due to limitation by TCP ACK in UL.
- To boost up the DL TCP throughput, UL TCP ACK prioritization should be studied in NR Rel-17.

Focused objectives

- Prioritized TCP ACK processing in the transmitter side
  - Head-of-line blocking problem of TCP ACK should be addressed.
  - Mechanism can be considered in SDAP/PDCP/RLC/MAC depending on the targeted granularity for TCP ACK prioritization.
    - E.g. Radio Bearer level, RLC bearer level, Logical channel level, etc.
- Low latency TCP ACK transmission in the radio interface
  - Scheduling and resource allocation enhancement for TCP ACK.
- Prioritized TCP ACK processing in the receiver side
  - Out-of-order delivery for TCP ACK.



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Further Mobility Performance Optimization FUMOP

- **Motivation**
  - Variance of packet delay as well as IP throughput variance are key factors for satisfaction of very stringent QoS requirements. Such variance becomes large during mobility.
    - ➔ QoE of 5G applications can be consistently ensured by further optimizing end-to-end mobility performance.
  - Prevention of mobility failure as well as ultra-fast failure recovery benefits end-to-end user performance.
    - ➔ Exploitation of predictive information on UE mobility and enhanced MSE are considered beneficial.
    - ➔ Ultra-fast recovery from mobility failure is essential to ensure always-on satisfaction of QoE.

- **Focused objectives**
  - Consistent E2E Performance on Mobility
    - Minimal variance of E2E packet delay and consistent data rate during mobility are targeted.
  - Predictive Mobility Control
    - Proactive RRM and mobility control based on predictive information are investigated to cope with both macro-level and micro-level mobility.
  - MSE (Mobility State Estimation) Enhancement
    - Enhancement of MSE accuracy and utilization of enhanced MSE for better RRM are investigated.
  - Ultra-fast and Reliable Failure Recovery
    - Close-to-zero service interruption upon connection failure is aimed.

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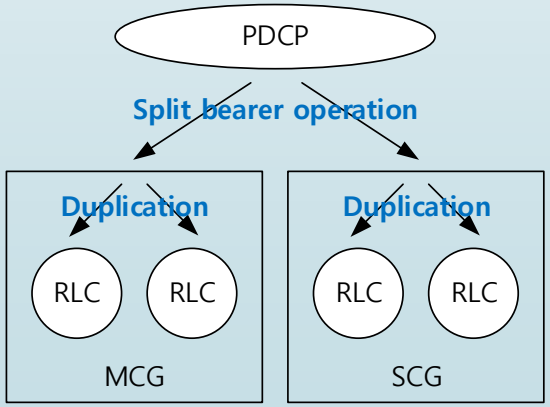
Enhanced IIOT

Motivation

- Throughput enhancement
  - A split bearer is used to increase the throughput by utilizing radio resources of different cell groups. On the other hand, a duplicate bearer is used to increase the reliability by transmitting a same packet to different cell groups. To support high data rate with ultra-low latency traffic such as AR/VR data or mobile robot, a mechanism to combine split bearer operation and duplicate bearer operation is required.
- Critical data transmission
  - Packets belonging to a single TSN flow are transmitted through a single RB, and there are no differentiation between those packets. However, the TSN flow may also contain critical packets, which need to be prioritized in radio transmission.

Focused objectives

- Throughput enhancement
  - Duplication over split bearer
- Critical data transmission
  - Packet prioritization within a single QoS flow



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