3GPP TSG RAN Rel-18 workshop
Electronic Meeting, June 28 - July 2, 2021

RWS-210250

LG’s View on Rel-18 5G-Advanced

LG Electronics

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Rel-18 general overview [1/2]

- **Rel-18 time schedule**
  - 18 months is basic assumption
  - Open for further discussion on longer period (e.g. 21 months) depending on industry needs
- **Areas of further evolution for 5G-Advanced**
  - eMBB evolution
    - Further enhanced performance in terms of performance such as throughput, coverage, etc
  - Non eMBB evolution
    - Further proliferation of 5G NR to more diverse vertical applications
  - Cross Functionalities
    - Introduction of new functionalities applicable both for eMBB and non-eMBB use cases
- **General consideration on 5G-Advanced**
  - Playing role of stepping stone to next generation communication system (a.k.a. 6G)
  - Ensuring balance between shorter term commercial requirements and longer term market potential
  - Ensuring balance between “continuation” and “new area”
    - Carefully check necessity of continuation for Rel-17 items
    - Open the opportunity for new areas for leveraging the longer term market potential of 5G NR and smooth continuity to next generation technologies

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Rel-18 general overview [2/2]

eMBB evolution

- TCP boosting (RWS-210226)

- Enhancement for MIMO (RWS-210240)
- Enhancement for mobility (RWS-210227)
- Enhancement for SON
- Enhancement for NR QoE

Non-MBB evolution

Supporting diverse vertical applications

- Factory IAB (RWS-210228)
- Inter-UE duplication avoidance (RWS-210229)

- Enhancement for sidelink operation (RWS-210244)
- Enhancement for RAN slicing (RWS-210230)
- Enhancement for SDT (RWS-210231)
- Enhancement for NTN (RWS-210232)
- Enhancement for RedCap

Cross Functionalities

Both for eMBB & non-eMBB

- Full duplex operation (RWS-210241, RWS-210242)
- Physical layer aspects for AI/ML operation (RWS-210243)
- ML-aided predictive mobility (RWS-210233)
- AI/ML enabled NG-RAN

- Enhancement for positioning (RWS-210245)
- Enhancement for device requirement (RWS-210249)
- Enhancement for XR operation

* Separate Tdocs submitted for items in red color

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eMBB related [1/2]

- **TCP boosting (RWS-210226)**
  - UL TCP ACK prioritization to boost up DL TCP throughput
  - Prioritized TCP ACK transmission/reception, low latency TCP ACK transmission

- **Enhancement for MIMO (RWS-210240)**
  - Support of simultaneous UL transmission across multiple UE panels
  - Enhanced UL synchronization for multi-panels/TRPs
  - Cross-link interference mitigation in FR2
  - Reliability enhancement for multi-DCI based MTRP transmission
  - Enhancements for vehicular Distributed Antenna System (DAS) UE transmission

- **Enhancement for mobility (RWS-210227)**
  - Fast recovery for PCell connection failure via multi-cell mTRP
  - Fast recovery with CHO/CPAC capabilities in DC
  - Support of more than two cell groups and enhancement of CG deactivation/activation for dual connectivity

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eMBB related [2/2]

- **Enhancement for SON**
  - RACH report retrieval from DU to CU
  - Enhancement of MRO for CHO/DAPS
  - Enhancement of load information signaling for Inter-system load balancing

- **Enhancement for NR QoE**
  - Support of QoE continuity for inter-system/inter-RAT mobility
  - Support of QoE in MR-DC
  - Support of QoE measurement in RRC_IDLE

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non-eMBB related [1/3]

- **Factory IAB (RWS-210228)**
  - Support factory IAB including topology adaptation with zero-interruption mobility, duplication/express routing for much higher reliability.
  - Support dynamic interference coordination to overcome interference by full mobility.

- **Inter-UE duplication avoidance (RWS-210229)**
  - In order to reduce resource waste when multiple UEs are given to a same mission in an automated system, RAN2 studies and develops enhancements for transmission of high quality image/video with the help of inter-UE duplication avoidance.

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non-eMBB related [2/3]

- **Enhancement for sidelink operations (RWS-210244)**
  - Sidelink carrier aggregation
  - Co-channel coexistence of LTE and NR sidelinks
  - Sidelink beam management or multi-panel management
  - Enhancements for sidelink operation in FR2
- **Enhancement for RAN slicing (RWS-210230)**
  - RAN solutions to support new (Rel-18) slice restrictions and requirements identified by SA1
  - Slice aware mobility when usage of network slices is restricted
  - Power saving mechanisms based on slice priority or disjoint network slices information
- **Enhancement for SDT (RWS-210231)**
  - Support DL data transmission in RRC_INACTIVE
  - Paging enhancement, co-existence with UL SDT
- **Enhancement for NTN (RWS-210232)**
  - Support CA and DC in NTN networks, including scenarios:
    - CA with LEO PCell + SCell
    - DC with GEO (MN)+LEO (SN)
    - DC with LEO(MN)+LEO (SN)
    - DC with TN (MN) + NTN (SN)
  - Support inter-satellite link(ISL) using regenerative payload.

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non-eMBB related [3/3]

- **Enhancement for RedCap**
  - Enhancements for low end use cases (e.g. narrower band operation, DRX/SDT enhancements)
  - Application of power saving and NTN features for RedCap UEs

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Cross-function related [1/4]

- **Full duplex operation (RWS-210241, RWP-210242)**
  - Study feasibility of full duplex operation in NR for candidate scenarios/implementations. Study standardization impact to support full duplex operation in NR
  - gNB full duplex & UE half- or full- duplex operation
  - Sub-band full duplex & spectrum-shared full duplex operation

- **Physical layer aspects for AI/ML operation (RWS-210243)**
  - Identify use cases, deployment scenarios, and solutions for AI based physical layer enhancements
  - Study performance evaluation methodology for AI based solutions

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Cross-function related [2/4]

- **ML-aided Predictive Mobility (RWS-210233)**
  - Identify possible scenarios that benefit from ML-aided mobility and link management
  - Evaluate performance benefits and feasibility of ML-aided mobility and link management
  - Study necessary enhancements to support ML-aided mobility and link management in areas including but not limited to RRM, RLM, and mobility procedures
  - Study possible methodologies for testing and evaluation of ML-aided mobility and link management procedures

- **AI/ML enabled NG-RAN**
  - Support for Intelligent Energy Saving
  - Support for Intelligent Load Balancing
  - Support for Intelligent Traffic Steering/Mobility Optimization
  - Support for Intelligent MDT/QoE

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Cross-function related [3/4]

- **Enhancement for positioning (RWS-210245)**
  - Support of sidelink based and sidelink assisted positioning
  - Enhancements for UEs equipped with distributed antenna system

- **Enhancement for device requirement (RWS-210249)**
  - FR1 RF
    - Simultaneous Rx/Tx for Intra-band non-contiguous CA/DC in TDD band
  - FR2 RF
    - Vehicular UE requirement for
      - Power Class in 39GHz
      - Inter-band UL/DL CA (e.g. 28GHz + 39GHz)
    - Inter-band UL CA based on CBM
  - RRM
    - Different RX beam sets in FR2

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Cross-function related [4/4]

- **Enhancement for XR operation**
  - Rel-18 WI can be started based on the Rel-17 SI outcome, if Rel-17 SI concludes enhancements in the NR standards is necessary
  - Main candidate area for enhancements can be latency reduction, UE power consumption reduction and capacity enhancements.

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Annex

More detailed proposals for some selected topics

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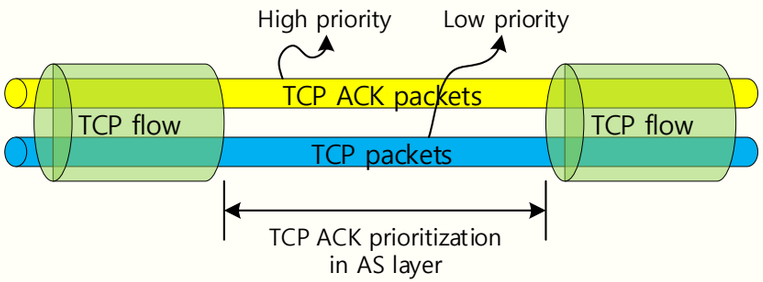
TCP boosting[1]

[1] RWS-210226

- **Motivation**
  - Up to Rel-17, 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-18.



- **Objective**
  - 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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Enhancement for MIMO[2]

[2] RWS-210240

- **Motivation**
  - UL performance in FR2 is still vulnerable to UE mobility, rotation and beam blockage due to the limitation of single beam/panel transmission
  - Usage of MTRP transmission is limited due to the limitation of using same TA for different TRPs even though separate TA can be manageable per UE panel.
  - Cross-link interference becomes more severe in FR2 TDD due to beamforming based transmission/reception
  - MTRP reliability schemes are useful tool for coverage and reliability in FR2, but these schemes are only supported with single DCI based MTRP
  - Based on input from 5GAA, it is desired to improve MIMO performance for vehicular DAS UE
- **Objective**
  - Support of simultaneous UL transmission across multiple UE panels
  - Enhanced UL synchronization for multi-panels/TRPs
  - Cross-link interference mitigation in FR2
  - Reliability enhancement for multi-DCI based MTRP transmission
  - Enhancements for vehicular Distributed Antenna System (DAS) UE transmission

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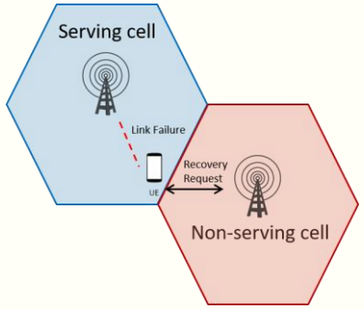
Enhancement for mobility[3]

[3] RWS-210227

- **Motivation**
  - There is a potential for faster recovery via exploiting CHO/CPAC candidates and inter-cell mTRP resources.
  - Current dual connectivity is restricted to two cell groups. Lifting this restriction can provide a possibility for better performance. Further enhancement of CG deactivation/activation is beneficial for balancing performance and UE power consumption.
  - Further enhancement of Dual Active Protocol Stack to support CA/DC would be desirable for meaningful performance benefit

- **Objective**
  - Enhancement for fast recovery
    - Fast recovery with CHO/CPAC capabilities in DC
    - Fast recovery via non-serving cell or SCell with inter-cell mTRP capabilities
  - Extension of Dual Connectivity
    - Support of multi-connectivity beyond dual connectivity
    - Enhancement of CG deactivation/activation scheme
  - Support of CA/DC for Dual Active Protocol Stack



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Factory IAB[4]

[4] RWS-210228

- **Motivation**
  - New market demands for a private network, e.g. factory, is growing and this requires more stringent latency/reliability requirement.
  - A backhaul link blockage causes severe performance degradation. Factory IAB would encounter dynamic blockages by mobility of IAB nodes and moving objects. Zero-interruption would be an important factor to increase system performance.
  - Mobility of IAB nodes decreases overall network stability as well as packet routing performance. However, topological redundancy in IAB Rel-16/17 has limitation to satisfy stringent reliability/latency requirement of factory IAB. More proactive topological redundancy scheme, e.g., duplication and express routing, should be considered. In addition, interference situation changes dynamically due to mobility. Dynamic interference coordination among IAB nodes is needed to sustain low interference level.

- **Objective**
  - Support dynamic topology adaptation with zero-interruption mobility.
  - Support dynamic topological redundancy with controlled duplication and express routing.
  - Support dynamic interference coordination for intra- or inter-IAB networks.

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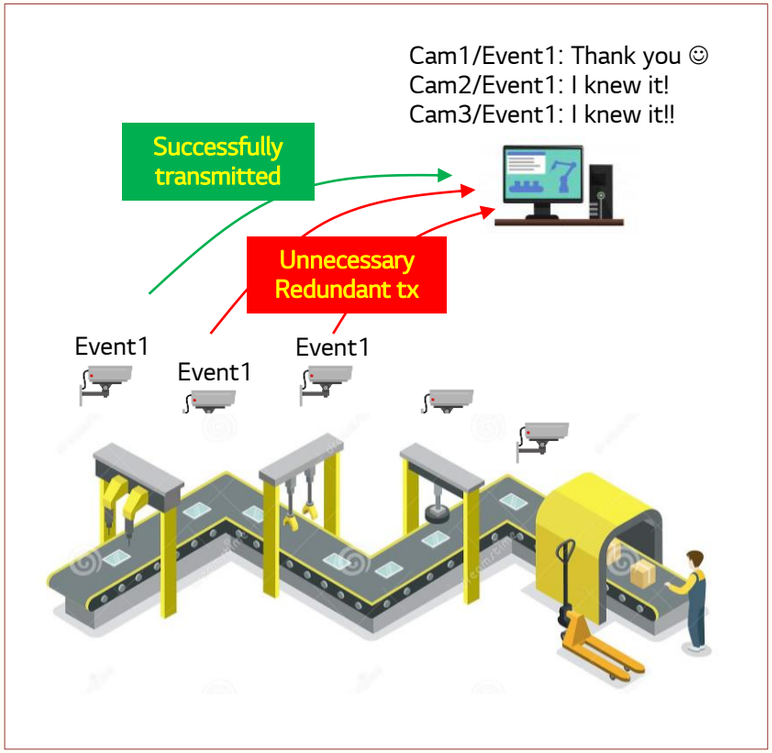
Inter-UE duplication avoidance[5]

[5] RWS-210229

- **Motivation**
  - In an automated system, e.g., smart factory/city, transport/logistic system, multiple UEs in different locations transmit the same message/information for the same event which occurs at the same time in order to achieve higher reliability. It would cause huge waste of radio resource in URLLC transmission.
  - A mechanism should be considered improve resource efficiency by reducing redundant transmission of the same message/information from multiple UEs for a same event.

- **Objective**
  - Enhancements for resource-efficient transmission of high quality image/video in a small/large group working on the same mission with the help of inter-UE duplication avoidance.
    - To provide a feedback of the received message/information to multiple UEs in the same group
    - To avoid redundant transmission of the same message/information based on the feedback



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Enhancements on sidelink operation[6]

[6] RWS-210244

- **Sidelink carrier aggregation**
  - For bandwidth expansion when configuring a single large sidelink bandwidth is not possible
    - For example, ITS band consisting of 10 or 20 MHz channels or simultaneous sidelink operation over multiple frequency bands (one in an ITS band and another in a licensed band)
- **Co-channel coexistence of LTE and NR sidelinks**
  - For migration from LTE to NR in an ITS band
  - For better utilization of the spectrum allocated to LTE sidelink
- **Sidelink beam management or multi-panel management**
  - Only omni-directional transmission is supported in sidelink while multi-panel vehicles were included in the V2X evaluation methodology
    - "Option 2: Two panels are placed in the vehicle as follows and the antenna pattern for each location is given by …" [TR 37.885]
  - Selection of the sidelink transmission beam or panel with the best channel quality to the target receiver
    - This is to improve the link quality and avoid unnecessary interference.
- **Enhancements for sidelink operation in FR2**
  - For high data rate in V2X or commercial services which grows up to 1~10 Gbps [TS 22.186, TS 22.261]

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Enhancement for RAN slicing[7]

[7] RWS-210230

- **Motivation**
  - In Rel-17, RAN slicing solutions are being discussed for the scenarios where all cells within a tracking area support the same slice availability.
  - SA1 identified new use cases and new requirements in Rel-18.
  - In Rel-18, RAN should work on enhancements for RAN slicing to support new use cases and new requirements according to SA1, including:
    - Multiple and different slices are supported on different frequencies or geographical area (regardless of tracking area).
    - Restriction on simultaneously supported network slices at UE.
    - Different users or services have different priority for the available network slices.
  - A mechanism to efficiently minimize power consumption (e.g., cell search, cell measurement) should be discussed considering different types of slice restrictions and priority.

- **Objective**
  - Support slice aware mobility when usage of network slices is restricted.
    - Restriction is based on frequency, geographical area, timely-manner, simultaneous usage of network slices.
    - Consider both idle mode and connected mode mobility.
  - Support power saving mechanisms based on slice priority and/or disjoint network slices information
    - RRM relaxation and DRX optimization in consideration of slices.

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Enhancement for SDT[8]

[8] RWS-210231

- **Motivation**
  - In Rel-17, SDT is introduced to support UL data transmission in RRC_INACTIVE. However, data transfer is not limited to UL but should cover DL.
  - To avoid unnecessary signaling overhead due to transition of RRC state, a mechanism needs to be introduced to support for DL data transmission in RRC_INACTIVE.
    - To trigger RRC_INACTIVE UE to receive DL data, paging mechanism needs to be enhanced.
    - Resource-efficient and power-efficient scheme should be considered.
    - Co-existence with UL SDT should be considered.

- **Objective**
  - Paging enhancement for DL SDT
  - DL SPS utilization for DL SDT
  - DRX enhancement for DL SDT
  - Co-existence with UL SDT

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Enhancement for NTN[9]

[9] RWS-210232

- **Motivation**
  - Since there are numerous NTN UEs in a single NTN cell, average per-UE throughput is quite restricted. To meet the NR service requirements (e.g. 15Mbit/s DL for Airplanes connectivity), CA/DC should be supported to increase the per-UE throughput from NTN cell.
  - Upon radio link failure due to feeder-link switch, disappearance of LEO satellite, or bad weather, re-establishment in a NTN cell is the fastest recovery mechanism, but the service interruption time is very long due to long propagation delay. If CA/DC is supported, UE can recover the link failure faster via alternative node.
  - In Rel-17, only transparent payload is considered which results long signaling delay between two satellites because the satellites should communicate through gNBs on the ground. If regenerative payload using inter-satellite link(ISL) is supported, the satellites can communicate directly each other so the signaling delay is reduced when a satellite coordinates with neighbor satellites for DC configuration.

- **Objective**
  - Support CA and DC in NTN networks, including:
    - CA with LEO PCell + SCell: Increase data throughput
    - DC with GEO (MN)+LEO (SN): MN manages UE mobility and MN takes role of data transmission
    - DC with LEO(MN)+LEO (SN): Increase data throughput
    - DC with TN (MN) + NTN (SN): SN complements weak signal area of MN
  - Support inter-satellite link(ISL) using regenerative payload to reduce signaling latency between satellites for faster DC configuration.

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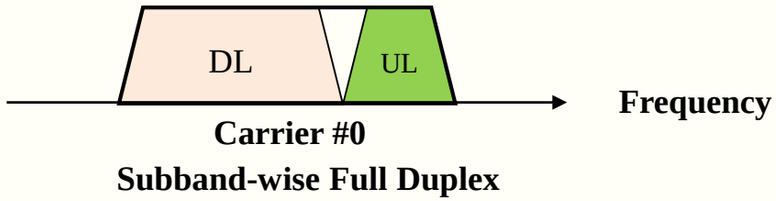
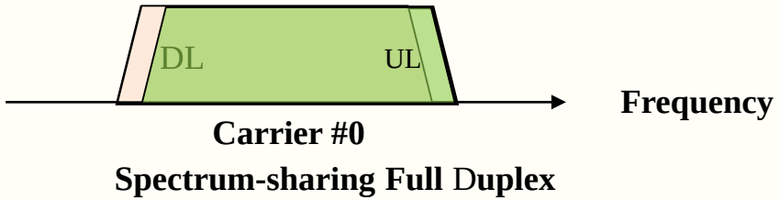
Full duplex operation[10][11]

[10] RWS-210241
[11] RWS-210242

- **Motivation**
  - For 5G, low latency packet delivery and efficient frequency resource utilization are especially important due to emerging various use cases and new service types (e.g., XR service, AI based service, self-driving car, etc.)
  - To enhance the packet delivery latency and frequency resource utilization, full duplex operation is a good technical candidate

- **Potential categories for full duplex operation**
  - "gNB full duplex + UE half duplex", "gNB full duplex + UE full duplex"
  - "subband-wise full duplex", "spectrum-sharing full duplex"





- **Proposal**
  - Introduce Rel-18 study item for full duplex operation, which targets:
    - Study feasibility of full duplex operation; scenarios for full duplex operation are defined/prioritized
    - Study standardization impacts and potential enhancements for the selected scenarios for full duplex operation

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Physical layer aspects for AI/ML operation[12]

[12] RWS-210243

- **Motivation**
  - AI/ML is a powerful tool to address challenges for air interface designs even though there are challenges such as performance verification/evaluation and difficulties on generalization/learning
- **Categorization**
  - Network AI based approaches (e.g. MTRP, interference management)
  - UE AI based approaches (e.g. channel prediction, UE-centric BM/link adaptation)
  - Joint operation of UE AI and NW AI (e.g. positioning)
- **Objective**
  - Identify use cases, deployment scenarios, and solutions for AI based physical layer enhancements
  - Study performance evaluation methodology for AI based solutions
  - Evaluate potential performance gain of AI based solutions

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ML-aided predictive mobility[13]

[13] RWS-210233

- **Motivation**
  - The whole communication industry including ITU, 3GPP, IEEE, 5GAA, etc. is paving ways to incorporate Machine Learning (ML) into communication systems to tackle challenges of jointly optimizing stringent and diverse KPIs of communication networks.
  - 3GPP SA1 already studied use cases and potential performance requirements for 5G system support of ML. 3GPP RAN3 is studying ML applications to NG-RAN in Rel-17.
  - However, adoption of ML into radio interface is still uncharted. Rel-18 is the right time for 3GPP RAN to study achievable gain of adopting ML in radio interface as well as necessary enhancements of radio interfaces.
  - Link stability and mobility performance are more challenged as operating frequencies are getting higher. Adopting prediction capabilities of ML can provide significant performance benefits on these areas.

- **Objective**
  - Identify possible scenarios that benefit from ML-aided mobility and link management.
    - Consider network-centric prediction, UE-centric prediction and its hybrid form as prediction entities, based on prediction of beam and cell qualities.
    - Consider utilization of UE's local real-time information as prediction input.
  - Evaluate potential benefits and feasibility of ML-aided mobility and link management.
    - Investigate the necessity of consolidating prediction models between UE and network, including update of prediction model parameter and/or prediction model replacement.
  - Study necessary enhancements to support ML-aided mobility and link management
    - Establish predictive mobility procedure with a predictive RLM/RRM framework.
  - Study possible methodologies for testing and evaluation of ML-aided mobility and link management procedures.

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Enhancement for positioning[14]

[14] RWS-210245

- **Support of sidelink based positioning**
  - Solution to provide absolute and relative position of a UE regardless of the network coverage
- **Support of sidelink assisted positioning**
  - Measurement in sidelink can improve the positioning accuracy provided by a Uu-based solution, e.g., by additionally providing the distance and/or angle from a UE placed in a known location and used as an anchor node.
- **Enhancements for UEs equipped with distributed antenna system**
  - A vehicle may be equipped with multiple antenna panels placed in different position and the distance between two panels can be several meters as shown in TR 37.885.
    - The current positioning solution may have limitation in achieving a positioning error smaller than the inter-panel distance as it is not supported to separate PRS transmission or reception in different antenna panels.
  - This aspect should be considered both in Uu and sidelink positioning.

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Enhancement for device requirement [15]

[15] RWS-210249

- **Further enhancement for FR1 RF**
  - Simultaneous Rx/Tx for Intra-band non-contiguous CA/DC in TDD band
- **Further enhancement for FR2 RF**
  - PC2 (Vehicular UE) requirement on 39GHz(n259, n260) and inter-band DL/UL CA for PC2 in RF need to be introduced in FR2.
  - FR2 inter-band UL CA based on CBM needs to be specified in Rel-18
- **Further enhancement for RRM**
  - Study and specify RRM requirements related to different sets of RX beams between different MOs in FR2

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