中国移动
China Mobile

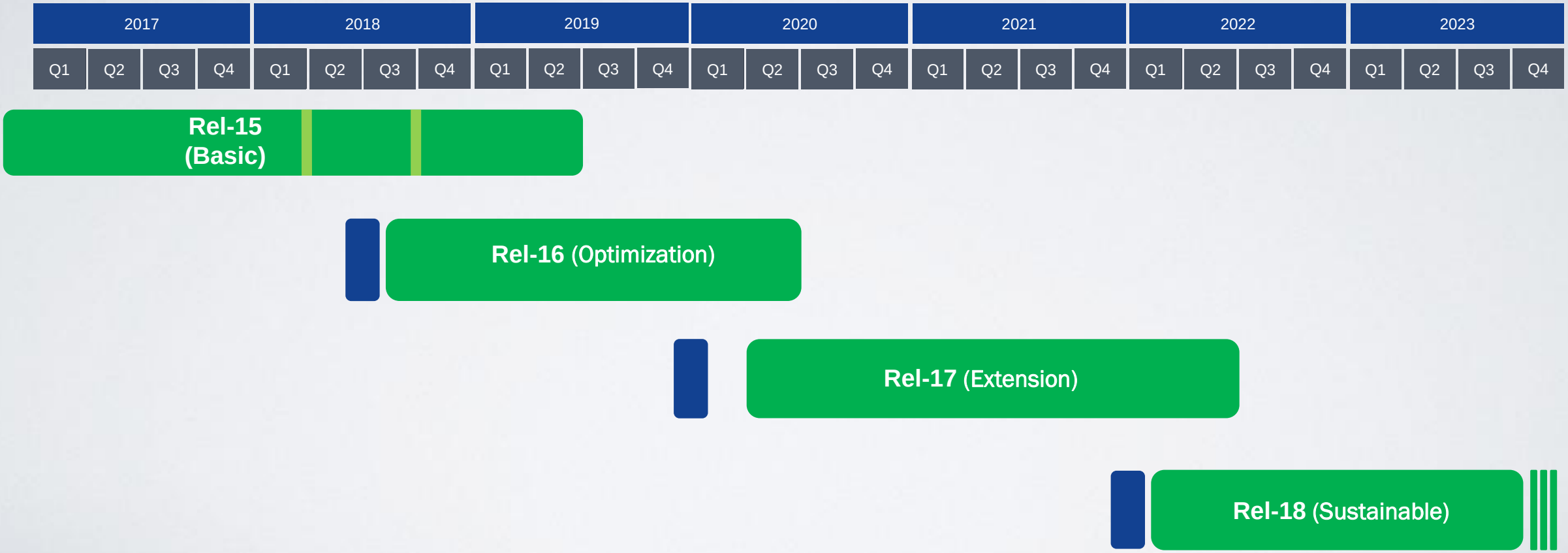
3GPP TSG RAN Rel-18 workshop
Electronic Meeting, June 28 - July 2, 2021

RWS-210331

CMCC views on Rel-18

Agenda Item: 4
Source: CMCC

R18 EVOLUTION: 5G ADVANCED



R18 Evolution	
eMBB	Frequency combination based elastic cell, MBS enhancement, SON/MDT further enhancement, Air-to-ground (ATG) , Home base station (HBS), Smart repeater
Non-eMBB	URLLC through dual UEs, RSU-like network node, Inter-UE handover for the same user, Further enhancement of RAN slicing, Requirements from automotive industry
Cross-Functionalities	Full duplex, UE aggregation, Network energy saving, AI/ML enabled RAN

Outline

- **eMBB**
  - Frequency combination based elastic cell
  - MBS enhancement
  - SON/MDT further enhancement
  - Air-to-ground (ATG)
  - Home base station (HBS)
  - Smart repeater
- **Non-eMBB**
  - URLLC through dual UEs
  - RSU-like network node
  - Inter-UE handover for the same user
  - Further enhancement of RAN slicing
  - Requirements from automotive industry
- **Cross-Functionalities**
  - Full duplex
  - UE aggregation
  - Network energy saving
  - AI/ML enabled RANs

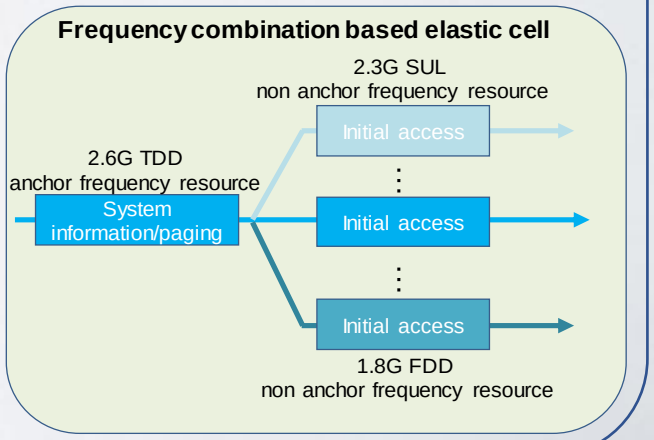
Frequency combination based elastic cell

Motivations

- Flexibly utilize scattered carries with small bandwidth, e.g. too narrow to carrier SSB.
- Efficiently utilize the spectrums re-farmed from LTE, no need to carrier system information since no legacy NR UEs served.
- Reduce cell management overhead while keeping flexible access carrier selection, …

Potential solution and objectives

- Multiple frequency resources configured in single cell
  - Different frequency resources, regardless of intra-band, or inter-band, can be configured in a cell, named **frequency combination based Elastic Cell**
  - System information can be broadcast only on one frequency resource(anchor frequency resource) , non anchor frequency resources can be used for initial access and data transmission by UE
    - Extension of SUL scheme as a universal solution for multiple carrier operation
      - Regular TDD/FDD carriers can be configured as additional access frequency resources
  - UE can only monitor paging on anchor frequency resource while the access frequency resources are selective to the UE
  - Reuse legacy CA behavior or BWP framework for connected operation
- Potential study objectives
  - Study mechanisms for supporting configuring multiple consecutive or non-consecutive frequency resources in a cell;
  - Study mechanism for supporting idle/inactive state for frequency combination based elastic cell, e.g., cell selection/reselection, paging, initial access;
  - Study possible enhancement of connected state for flexible multiple frequency resource operation



MBS enhancement

Motivations

- Further to improve spectrum efficiency and reliability for UEs in RRC_CONNECTED state;
- Expand multicast service and multiple MCCHs for UEs in RRC_IDLE/INACTIVE states;
- Support of SFN, Free to Air, 100% resource allocation for MBS.

Objectives

- Specify enhancement for broadcast/multicast service for UEs in RRC_CONNECTED state [RAN1, RAN2]:
  - Specify group scheduling mechanism enhancement to further improve spectrum efficiency, e.g., beam management for multicast service, especially for FR2, carrier aggregation for multicast service, dynamic HARQ process management/share between broadcast/multicast service and unicast service [RAN1, RAN2];
  - Specify reliability improvement enhancement, e.g., HARQ-ACK feedback enhancement, CSI measurement/report enhancement for multicast service, support of ARQ in Layer 2 for PTM [RAN1, RAN2];
  - Other Rel-17 leftovers.
- Specify enhancement for broadcast/multicast service for UEs in RRC_IDLE/INACTIVE states [RAN2, RAN1, RAN3]:
  - Support of multicast service for UEs in RRC_IDLE/INACIVE states [RAN2, RAN1, RAN3];
  - Specify the multiple MCCHs for broadcast service per cell [RAN2, RAN1].
- Specify enhancement to expand deployment scenarios for broadcast/multicast service for UEs in RRC_ IDLE/INACIVE/CONNECTED states [RAN1, RAN2, RAN3]:
  - Standardised support of SFN over multiple cells above gNB-DU level [RAN1, RAN2, RAN3];
  - Support of Free-to-Air/receive only mode [RAN2];
  - Support of up to 100% resource allocation to broadcast/multicast service [RAN1, RAN2].
- Specify UE power saving and battery lifetime enhancement for UEs in RRC_ IDLE/INACIVE/CONNECTED states [RAN1, RAN2]:
  - Specify power saving techniques with power saving signal/channel in triggering UE adaptation to the DRX operation for broadcast/multicast service [RAN1, RAN2].

SON/MDT further enhancement

Motivations

- RAN Optimization via data collection has the remarkable benefits, e.g., reduce CAPEX & OPEX of operators significantly, enhance the user experience and enable efficient network planning and optimization
- A Rel-17 WI for SON/MDT enhancement is on-going.
- During the Rel-17 WID drafting phase, optimization of some Rel-16 features via SON/MDT was not included in Rel-17 WI due to the TU constrains.
- Some Rel-17 new features could also benefits from data collection.
- Further enhancement of SON/MDT in NR in Rel-18 is necessary

Objectives

- Rel-17 leftovers (pending on progress of Rel-17)
- Optimization of some Rel-16 features enabled by SON/MDT, but has not been covered by Rel-17 WI, e.g., IAB, NPN, V2X
- Optimization of Rel-17 new features enabled by SON/MDT, e.g., MR-DC (CPAC), SDT, Redcap, MBS

Air-to-ground (ATG)

Objectives

ATG scenarios and RF requirements

Specify features to core specifications of RF requirements for coexistence between ATG and IMT terrestrial network [RAN4]

- Identify key characteristics where it is absolutely necessary to differentiate ATG BS and UEs from ground based BS and UEs
  - Aim to reuse existing requirements for BS and UE where possible.
- Study and specify the framework how ATG core requirements are defined.
  - This includes identifying whether the requirements are captured within the existing specifications or new specifications are created.
  - Determine whether conducted, OTA or both types of requirement are required for both the BS and UE
- Identify the FR1 potential band(s) to be used as example for ATG
- Perform FR1 co-existence evaluation for ATG network (e.g. ACLR, ACS)
- Specify new UE/BS type(s) for ATG network if necessary
  - Taking into account identified differences between ATG and ground based systems
- Specify RF requirements for ATG UE/BS
  - Considering the results of co-existence simulations in terms of impact on emissions and RX requirements, cell sizes and link budgets, technology capabilities, likely BS and UE architectures and other relevant aspects.
- Specify test procedures for ATG BS conformance testing
  - Determine at an early phase whether conducted, OTA or both types of testing are needed

RRM/Demod requirements

Indentify and specify RRM/Demod requirements for ATG, taking into account the decisions/outcome of Rel-17 NTN work item.

- RRM core requirements for ATG UE. [RAN4]
- RRM performance requirements and test cases for ATG UE type. [RAN4]
- Demodulation performance requirements and test cases for ATG UE/BS. [RAN4]

Home Base Station (HBS)

Motivations

- Considering that Wide Area BS and indoor power distribution system in some scenarios cannot meet the coverage of 5G network deployment, the home base station (HBS) can be utilized to enhance indoor coverage without requiring high base station output power. The application of Home Base Station for NR is a cost-effective solution in some scenarios.
- However, the existing NR BS class does not specify the RF requirements of HBS. In order to meet the increasing popularity of large capacity and high reliability of data services and indoor deep coverage deployment applications, the intention of this Work Item is to introduce HBS and specify related RF specifications in Rel-18.
- **It is proposed to specify RF requirements for NR FR1 supporting Home Baste Station (HBS) in R18. The Work Item is to develop a new feature to enable HBS application in home scenarios for NR FR1.**

Objectives

- The core objectives of the work item is to specify the necessary features to support NR deployment for Home Base Station (HBS) application in Rel-18.
- Specify features to core specifications of RF requirements for Home BS [RAN4]
  - Identify the frequency range (FR1) and operating bands to be used for HBS
  - Identify key characteristics where it is absolutely necessary to introduce HBS
  - Perform FR1 co-existence evaluation for HBS network (e.g. ACLR, ACS)
  - Specify new BS type(s) for HBS if necessary
  - Specify RF requirements for HBS in TS 38.104 and TS 37.104
  - Specify HBS conformance testing

Smart Repeater

Motivations

- RF repeaters have been used in 2G, 3G and 4G deployments to supplement the coverage. They constitute the simplest and most cost-effective way to improve network coverage.
- A Rel-17 WI for NR repeaters is on-going. Only RF requirements are included in Rel-17 WID.
- In order to support dynamic TDD, multi-beam operation and so on, some additional information can be considered to enable a more intelligent amplify-and-forward operation for NR smart repeaters

Objectives

Assess the following candidate side control information to intelligently apply amplify-and-forward operation for NR repeaters [RAN1, RAN4]

- Timing information to support dynamic TDD, i.e., slot and symbol UL/DL configuration
- Transmitter and receiver spatial information, i.e., beam information
- Bandwidth information, i.e. configurable repeater bandwidth
- Others are not precluded.

Specify RF requirements for NR repeaters [RAN4]

- Pending on progress of Rel-17.
- Specify necessary RF requirements considering the side control information.

Outline

- **eMBB**
  - Frequency combination based elastic cell
  - MBS enhancement
  - SON/MDT further enhancement
  - Air-to-ground (ATG)
  - Home base station (HBS)
  - Smart repeater
- **Non-eMBB**
  - URLLC through dual UEs
  - RSU-like network node
  - Inter-UE handover for the same user
  - Further enhancement of RAN slicing
  - Requirements from automotive industry
- **Cross-Functionalities**
  - Full duplex
  - UE aggregation
  - Network energy saving
  - AI/ML enabled RANs

URLLC through dual UEs(1)

Scenarios

- One important objective of 5G is to enable connected industries are as follows,
  - Motion control
  - Control-to-control communication for industrial controller communication for industrial controller
  - High data rate video for monitoring/ diagnostics
- The scenarios are prevalently exist in factory automation, transport industry and Electrical power distribution automotive

PLC

Freight Forwarding

AGV

Motivations

- To ensure the high reliability, URLLC was introduced in Release 15, further enhanced in Rel-16/Rel-17
  - But it still faces the challenge of failing to meet the high reliability depends on the successful reception just relying on only one terminal in real scenarios, e.g. sudden machine breakdown, or suffering intensive interference
- Therefore, actually, multiple terminal is deployed and utilized to receive repetitive content to ensure the reliability as backup
  - This results in high cost of existing backup mechanism for high reliability, e.g., battery consumption, radio resource, transport resource, and processing resource and redundant signalling/data overhead

URLLC through dual UEs (2)

Potential Enhancements

- The UEs are deployed as real-time backup to each other
  - The UEs can determine whether to take over or start/activate the data/signalling transmitted/received by associated UE for backup
    - Depending on the associated terminal's state
      - i.e. whether the data/signalling can be still successfully received by the associated terminal or not
  - Under normal circumstances, UE and paired UE are responsible for different services respectively
  - If the data/signalling can not be successfully received by the UE, then the subsequent paired UE action is that the paired UE is to take over or start/activate the service(s) of the terminal1 declaring in abnormal state
  - In this case, how to ensure the minimal UP interruption and rapid completion of data forwarding between Ues and reduce the transmission overhead will become an issue to be addressed

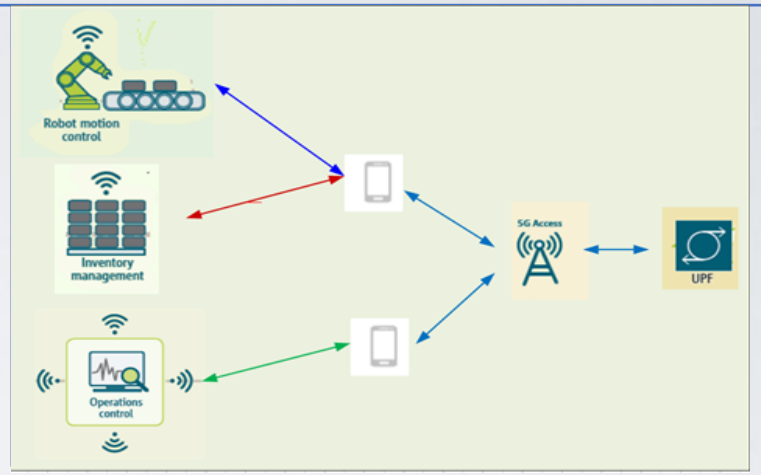


Fig. Real time multiple-UE backup in normal case

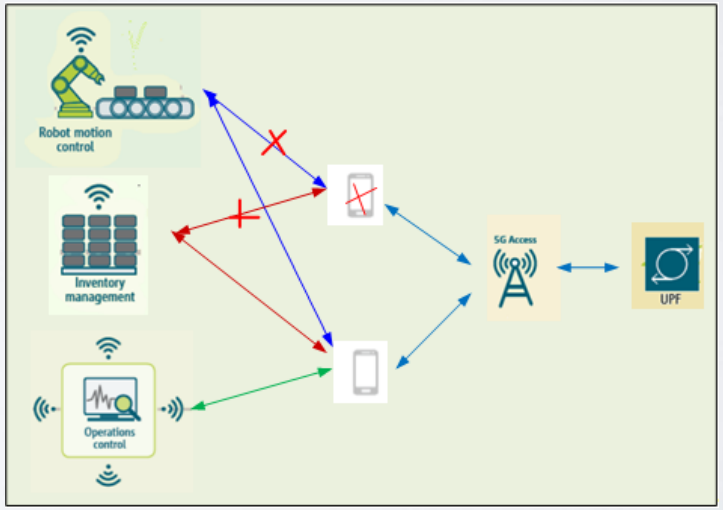


Fig. Real time multiple-UE backup in abnormal case

URLLC through dual UEs(3)

Potential Objectives

- Study the use cases and benefits of real-time multiple-UE backup
- Study necessary procedures and/or information to support for real-time multiple-UE backup of data/signalling delivery and reception (e.g. how a given UE to determine whether to take over or start the data/signalling transmitted/received by associated UE for backup) without data disorder or data duplication
- Identify required specification changes on the group scheduling options to allow multiple UEs to receive signalling/data in Multicast mode
- Study the support for basic mobility with service continuity
- Identify required specification changes on the RAN that the necessary coordination function (e.g., heartbeat packet between the involved terminals, if any) amongst the associated UEs for backup, considering the results of the NR Sidelink

Outline

- **eMBB**
  - Frequency combination based elastic cell
  - MBS enhancement
  - SON/MDT further enhancement
  - Air-to-ground (ATG)
  - Home base station (HBS)
  - Smart repeater
- **Non-eMBB**
  - URLLC through dual UEs
  - RSU-like network node
  - Inter-UE handover for the same user
  - Further enhancement of RAN slicing
  - Requirements from automotive industry
- **Cross-Functionalities**
  - Full duplex
  - UE aggregation
  - Network energy saving
  - AI/ML enabled RANs

RSU-like network node

Motivations

- To ensure the network coverage, especially for indoor scenario, pico-RRU-BBUs are deployed, which is not cost effective. Instead, we could consider RSU-like network node plus lite gNB to support low cost flexible deployment and reduces the air interface latency, achieves network controlled traffic balance/local breakout between PC5 link and uu connection.

Potential Objectives

- NR sidelink relay in Rel 16 and 17 can be reused as baseline
- Serving RSU-like node / gNB selection criterion and procedure
- Connection establishment procedure (PC5 and connection between RSU and gNB)
- Network Interface design between RSU and gNB
- Service continuity (mobility between RSUs and direct Uu) and dual connectivity
- Network controlled traffic balance/local breakout between PC5 link and uu connection

Outline

- **eMBB**
  - Frequency combination based elastic cell
  - MBS enhancement
  - SON/MDT further enhancement
  - Air-to-ground (ATG)
  - Home base station (HBS)
  - Smart repeater
- **Non-eMBB**
  - URLLC through dual UEs
  - RSU-like network node
  - Inter-UE handover for the same user
  - Further enhancement of RAN slicing
  - Requirements from automotive industry
- **Cross-Functionalities**
  - Full duplex
  - UE aggregation
  - Network energy saving
  - AI/ML enabled RANs

Inter-UE Handover or Replication for Same User(1)

Motivations

- User are no longer just own smart phone and computer, but are now owns several devices for communication for various requirement in different scenarios
- This requires the network can enable the users to initiate, handover (transfer/ switch), or sometimes replicate communication streaming (e.g. video, speech, audio) between multiple devices of the same end-user for a variety of reasons
- Moreover, this requires the service/traffic/packet can be switched among different type devices of a same end-user
  - in seamless and lossless mode

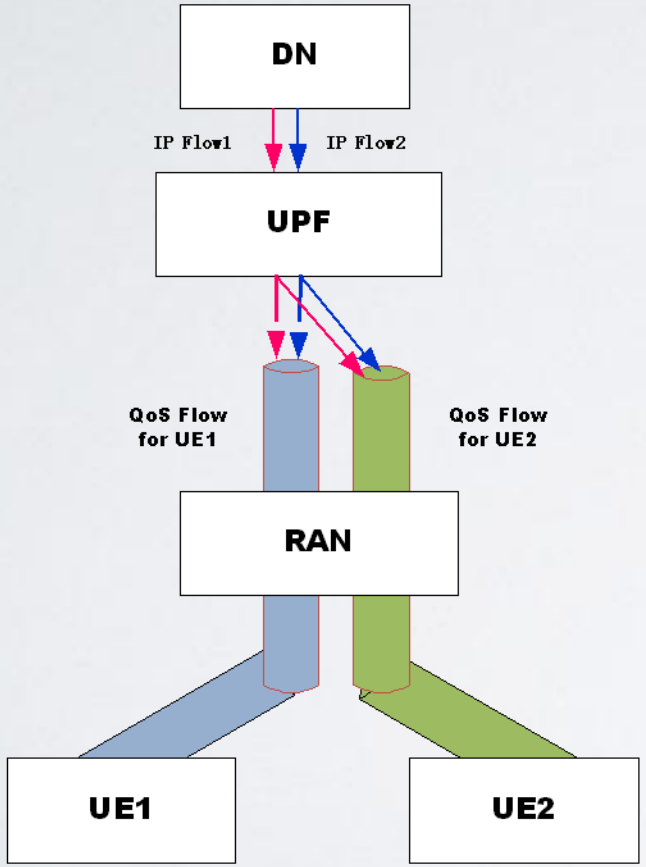
Use cases

- A User is having a call (audio/video stream) on his mobile while he is goanna to get on a car. After getting on the car, then he would like to switch the connection with the network for the video stream from his mobile to another device equipped in the car that belongs to him, and transfer the data of audio/video steam from his mobile to another device equipped in the car as well.
- A User is listening to his favorite music on line on his mobile while he is goanna to a jog. After start the jog, then he would like to switch the connection with the network for the music stream from his mobile to the smart watch, and transfer the data of music steam from his mobile to smart watch as well.
- A User is watching a video on her mobile while coming home. After arriving at home, he starts to clean the rooms and need to frequently moving amongst the rooms in the house. In this case, the user starts the replicate the data of video steam on her mobile to the other devices located in each room in the house, and keep the synchronization of the data of video steam amongst the other devices.

Inter-UE Handover or Replication for Same User(2)

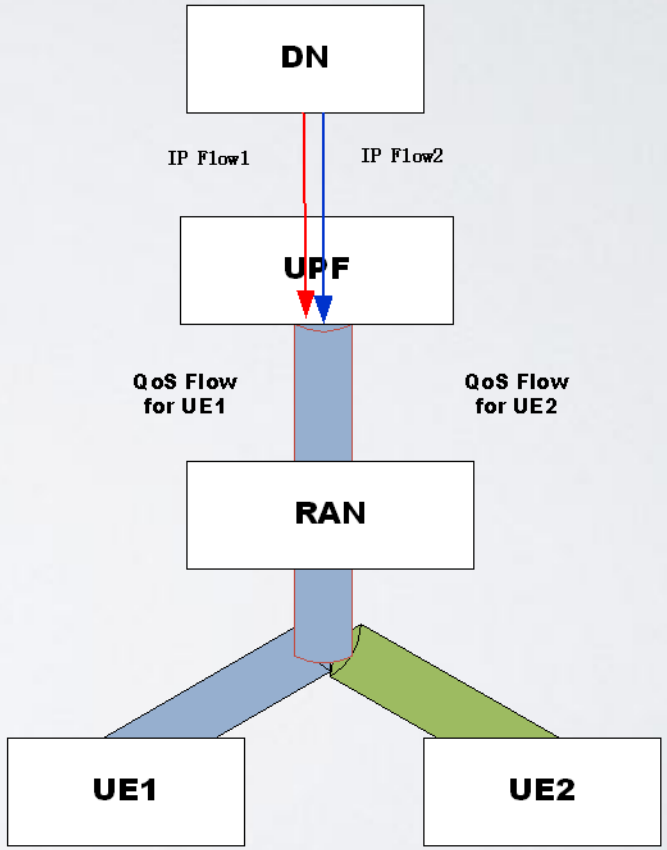
Potential Enhancements

- CN is response for the transfer/replication of the data via the separate tunnel to the associated devices



CN-based approach

- RAN is response for the splitting/ transfer/replication of the data from the shared tunnel with separate DRB to the associated devices



RAN-based approach

Inter-UE Handover or Replication for Same User(3)

Potential Objectives

- The objective of this SI is to investigate how to handover/replicate at the RAN-level or Core Network level of all or some of the services between UEs under the control of the same end-user while maintaining service continuity. The specific objectives of this study item are as follows
  - Target device(s) discovery [RAN2]
  - Study the control plane procedure design, including RRC connection management, paging mechanism and access control for initiating inter-UE handover and replication for the same end-user. [RAN2, RAN3]
  - Study user plan functionalities that will support data forwarding/data replication of communication data amongst multiple devices of the same end-user. [RAN2, RAN3]

Outline

- **eMBB**
  - Frequency combination based elastic cell
  - MBS enhancement
  - SON/MDT further enhancement
  - Air-to-ground (ATG)
  - Home base station (HBS)
  - Smart repeater
- **Non-eMBB**
  - URLLC through dual UEs
  - RSU-like network node
  - Inter-UE handover for the same user
  - Further enhancement of RAN slicing
  - Requirements from automotive industry
- **Cross-Functionalities**
  - Full duplex
  - UE aggregation
  - Network energy saving
  - AI/ML enabled RANs

Further enhancement of RAN slicing--Motivation

There is ongoing WI of *"Enhancement of RAN slicing for NR"* in RAN. RAN2 is discussing on the slice specific cell reselection and RACH configuration. And RAN3 objectives which are related to slice service continuity are to be added according to the SI conclusions in Jun 2021. In this contribution, we share some initial thinking and may be updated based on the outcome of Rel-17 WI.

It can be foreseen that, some R17 leftover issues can be further discussed in Rel-18. In RAN2, MO triggered slice based reselection was de-prioritized and can be further studied. In RAN3, solutions for slice remapping decisions in NG-RAN may be considered in next release.

SA1 also working on an WI "*Enhanced Access to and Support of Network Slice"* which captures some consolidated potential requirements to meet Rel-18 new use cases. One of the requirements that UE fast access to suitable slices when multiple slices are deployed on different frequencies, is currently under discussion in RAN2 slicing WI. After RAN2's stage 3 specification becomes more clear, we can check whether SA1's requirement can be met by RAN2 specification or need further enhancement in Rel-18.

SA2 also have several SID proposals on Rel-18 slicing enhancement but haven't been approved for now. We think Rel-18 slicing enhancement in RAN should also take SA2's new SID into consideration.

Further enhancement of RAN slicing--Objectives

Further enhancement of RAN slicing for NR in Rel-18

- Leftover issues in Rel-17
  - MO triggered slice based cell reselection, which was de-prioritized in Rel-17 RAN Slicing WI. [RAN2]
  - For non-supported slice by target NG-RAN node in case of inter-RA mobility scenario, the solutions to support slice remapping for which the remapping decision is made in NG-RAN node as described in TR 38.832, section 6.2.1 can be considered if end-to-end feasibility is addressed. [RAN3]
  - For non-supported slice by the serving cell, the solutions to support UE to access to the intended slice by setting up DC or CA can be considered.

- Corresponding work to meet SA1 R18 requirements to enhance UE access to the slices, such as
  - UE fast access to the slices that deployed on different frequencies, and minimize service interruption time when UE changes the access from one slice to another.
  - Note: This part can be reviewed after R17 RAN slicing WI is concluded.

- Potential RAN impacts of SA2 slicing enhancement in Rel-18
  - To be added after SA2 Rel-18 proposals are approved.

Outline

- **eMBB**
  - Frequency combination based elastic cell
  - MBS enhancement
  - SON/MDT further enhancement
  - Air-to-ground (ATG)
  - Home base station (HBS)
  - Smart repeater
- **Non-eMBB**
  - URLLC through dual UEs
  - RSU-like network node
  - Inter-UE handover for the same user
  - Further enhancement of RAN slicing
  - Requirements from automotive industry
- **Cross-Functionalities**
  - Full duplex
  - UE aggregation
  - Network energy saving
  - AI/ML enabled RANs

Requirements to URLLC, Positioning and Perception for Automotive Industry

Automotive industry expects to deploy one single 5G network to provide capabilities of URLLC connection, positioning and material perception.

	Requirements for 5G Advanced
URLLC	• **Low latency and high reliability at high density factory:** 4ms, 99.9999% @ 400UE/5000m^2
Positioning	• **Accuracy for NLOS indoor scenario:** 0.1m(Horizontal)@90%, 0.5m(Horizontal)@99.99% • **Battery life:** ~ 1 year • Low positioning interruption time when switching from indoor cellular positioning to outdoor GPS positioning.
Perception (passive IoT)	• **Coverage capability:** communication distance should support more than 30 meters to construct a feasible network coverage in the 5000 m^2 warehouse. • **UE power consumption:** <0.1mW to support working without battery. • **Low cost:** <0.1 ¥ (~0.02$) to meet cost-sensitive applications. • **Positioning accuracy**： 3~5m(Horizontal&Vertical) @90% for positioning .

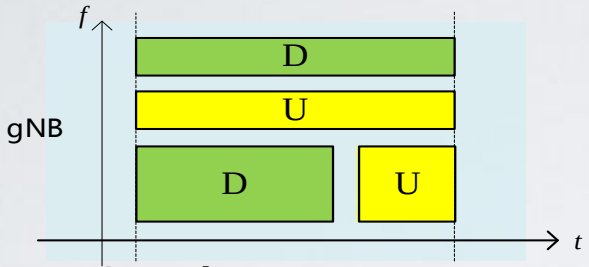
Outline

- **eMBB**
  - Frequency combination based elastic cell
  - MBS enhancement
  - SON/MDT further enhancement
  - Air-to-ground (ATG)
  - Home base station (HBS)
  - Smart repeater
- **Non-eMBB**
  - URLLC through dual UEs
  - RSU-like network node
  - Inter-UE handover for the same user
  - Further enhancement of RAN slicing
- **Cross-Functionalities**
  - Full duplex
  - UE aggregation
  - Network energy saving
  - AI/ML enabled RANs

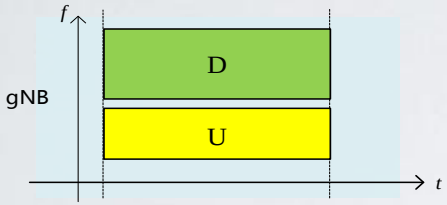
Full duplex: Motivation

- **UL coverage needs further enhancement for TDD due to limited UL duty cycle**
- **UL heavy and/or latency sensitive applications are pervasive in ToC and ToB**
  - ToC: HD video calls, XR gaming
  - ToB: smart steel, smart coal mining, smart port, PLC in Industrial-IoT
  - Requirements: Up to >30Mbps UL date rate and/or ~ 4ms E2E latency
- **Full duplex is a promising solution for UL coverage improvement, UL capacity improvement and latency reduction**

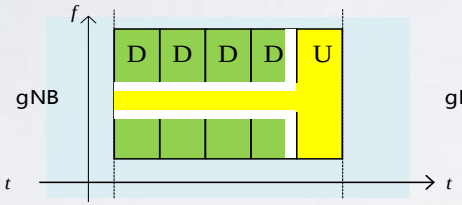
Full Duplex operations



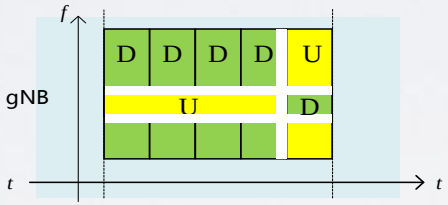
General concept



Example 1



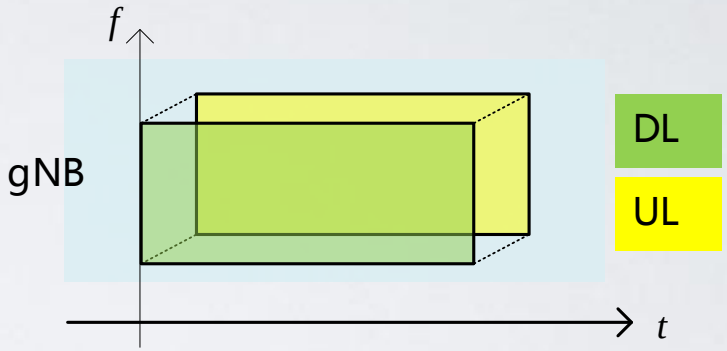
Example 2
(Reduced inter-operator interference)



Example 3

Type-1 FD (Sub-band wise full duplex)

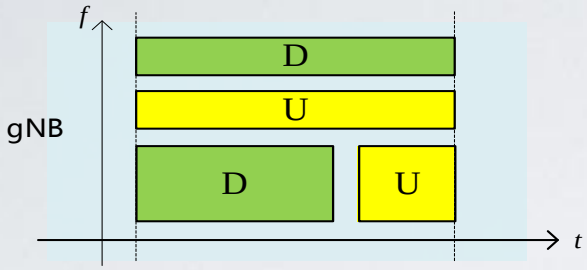
- gNB: Simultaneous Tx and Rx in difference sub-bands
- UE: may not support simultaneous Tx and Rx
- UL-only/DL-only/TDD sub-bands can be configured in the TDD carrier

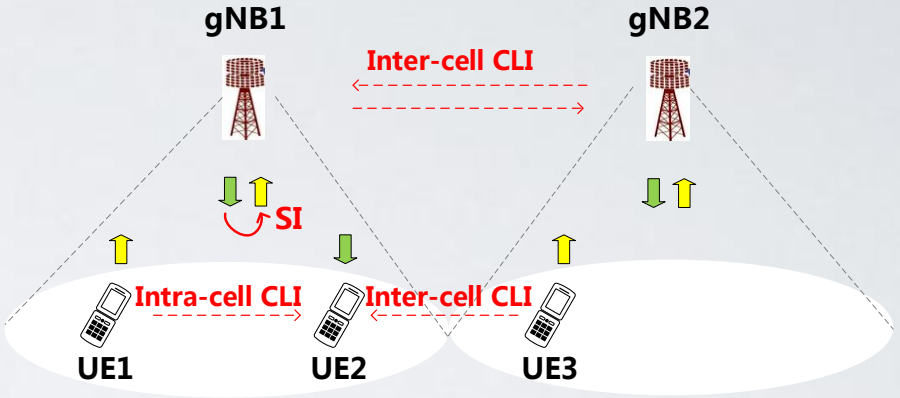


Type-2 FD (Frequency fully overlapped full duplex)

- gNB: Simultaneous Tx and Rx in the same frequency resources
- UE: may not support simultaneous Tx and Rx

Type-1 FD operation



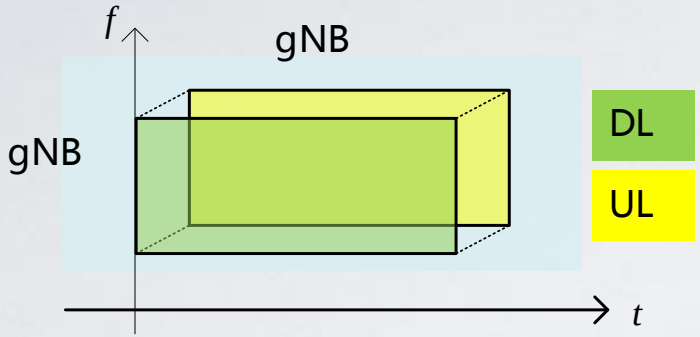


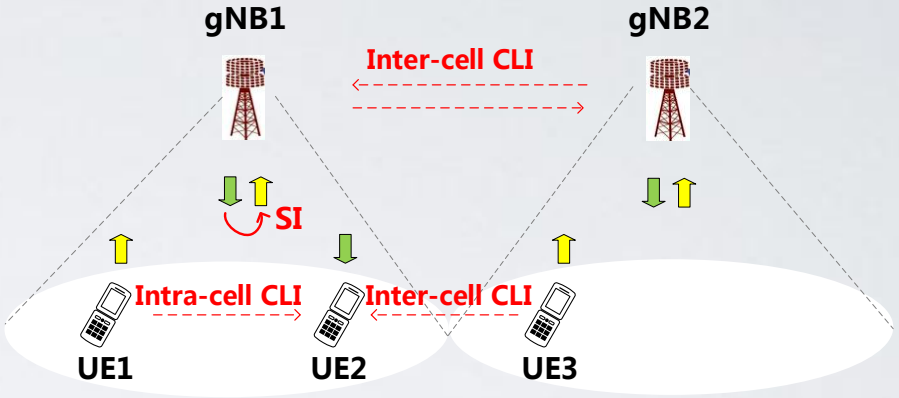
Type-1 FD	UL/DL time-frequency resource partitioning among multiple cells	Interference at gNB	Interference at UE
Case 1	Same	• Self-interference: moderate • Inter-cell CLI: moderate	• Self-interference: No • Intra & Inter-cell CLI: manageable (e.g., with scheduling restriction)
Case 2	Independent	• Self-interference: moderate • Inter-cell CLI: may be challengeable especially considering the DL/UL symbol boundary misalignment	• Self-interference: No • Intra & Inter-cell CLI: may be manageable (e.g., with scheduling restriction)

Note: Type-1 FD at gNB side and half-duplex at UE side are assumed

- **Observation**: At least for case 1 with type-1 FD operation, SI and CLI are moderate and manageable at both gNB and UE.
- **Benefits**:
  - Latency can be reduced for both UL and DL since both UL and DL resource can be available in more time slots
  - UL coverage can be improved since longer uplink transmission/repetition can be exploited
  - UL capacity can be improved based on configuration if more time-frequency resources are configured for UL

Type-2 FD operation





Type-2 FD	Interference at gNB	Interference at UE
Isolated scenario	• Self-interference: possible to manage for gNB with limited level of Tx power and limited number of antennas	• Self-interference: No • Intra-cell CLI: possible to manage based on careful scheduling restriction and interference measurement/report
Multi-cell scenario	• Self-interference: same as for isolated scenario • Inter-cell CLI: may be challengeable especially considering the DL/UL symbol boundary misalignment	• Self-interference: No • Intra & Inter-cell CLI: may be challengeable to mitigate both even with scheduling restriction

Note: Type-2 FD at gNB side and half-duplex at UE side are assumed

- **Observation**: For type-2 FD, at least we can first focus on isolated scenario and small cells with limited Tx power and limited number of antennas, which is possible for some indoor deployments.
- **Benefits**: Type-2 FD operation may provide additional UL and DL performance gain in isolated scenario

Potential objectives for full duplex in NR

- General study on different variants of full duplex operation [RAN1/RAN4]
  - Deployment scenarios (e.g., Isolated, Indoor, Urban, Rural) [RAN1]
  - Frequency range and regulation (e.g., FR1, FR2) [RAN1/RAN4]
  - Duplex mode (e.g., Sub-band wise/Frequency fully overlapped FD at gNB, Full-/Half- duplex at UE) [RAN1]
  - Antenna configuration (e.g., Single-/multi-panel, Co-located/distributed antennas, antenna scale) [RAN1]
- Study on the feasibility of self-interference cancellation to enable full duplex [RAN1/RAN4]
  - Techniques of self-interference cancellation [RAN1]
  - Requirement of self-interference cancellation capabilities for different deployments [RAN1/RAN4]
  - Evaluate the performance of full duplex [RAN1]
    - Evaluation methodology and performance metrics (e.g., spectrum efficiency, user perceived throughput, latency, coverage, etc.)
- Coexistence study among different operators in adjacent channels [RAN4]
- Identify the potential standardization impact to support full duplex operation [RAN1, RAN2, RAN4]

Outline

- **eMBB**
  - Frequency combination based elastic cell
  - MBS enhancement
  - SON/MDT further enhancement
  - Air-to-ground (ATG)
  - Home base station (HBS)
  - Smart repeater
- **Non-eMBB**
  - URLLC through dual UEs
  - RSU-like network node
  - Inter-UE handover for the same user
  - Further enhancement of RAN slicing
- **Cross-Functionalities**
  - Full duplex
  - UE aggregation
  - Network energy saving
  - AI/ML enabled RANs

UE AGGREGATION (1)

- The motivation of this SI is to investigate how to address the issue of the shortage of UL UE transmission power in 5G via UE aggregation mechanism:
  - In compare to LTE, various type services required the wide UL bandwidth requirement is increasing and becomes pervasive in 5G network
    - e.g. AR/VR devices, live video from UAV, etc.
  - In this case, the bottleneck of supporting the applications with wide UL bandwidth on 5G terminals is the limited UL UE transmission power, e.g. 23dBm or 26dBm.
  - Although some enhancement to eliminate the bottleneck has been adopted, e.g. SUL, super Uplink, it seems not sufficient to satisfy the demand.
  - Therefore, the mechanism of UE aggregation which can be one way to ensure a high UL bandwidth target value is desired to be investigated
  - This is in particular useful in the case of the terminal with less size limitation
    - e.g. terminal equipped in the UAV, vehicle and assessment line for motion controller in the factory

AR/VR

Video for Remote Monitoring

Drone with live video

UE AGGREGATION (2)

- **Issue**
  - How to avoid the data disorder and data duplication during the data splitting between the aggregated UEs

- **Intention of the SI is to study the potential UE aggregation mechanism**
  - Which kind of L2 architecture can be utilized to aggregate more than one terminal to improve the UL throughput
  - How to support the data lossless or minimized data loss during the session/packet switching amongst the aggregated terminals

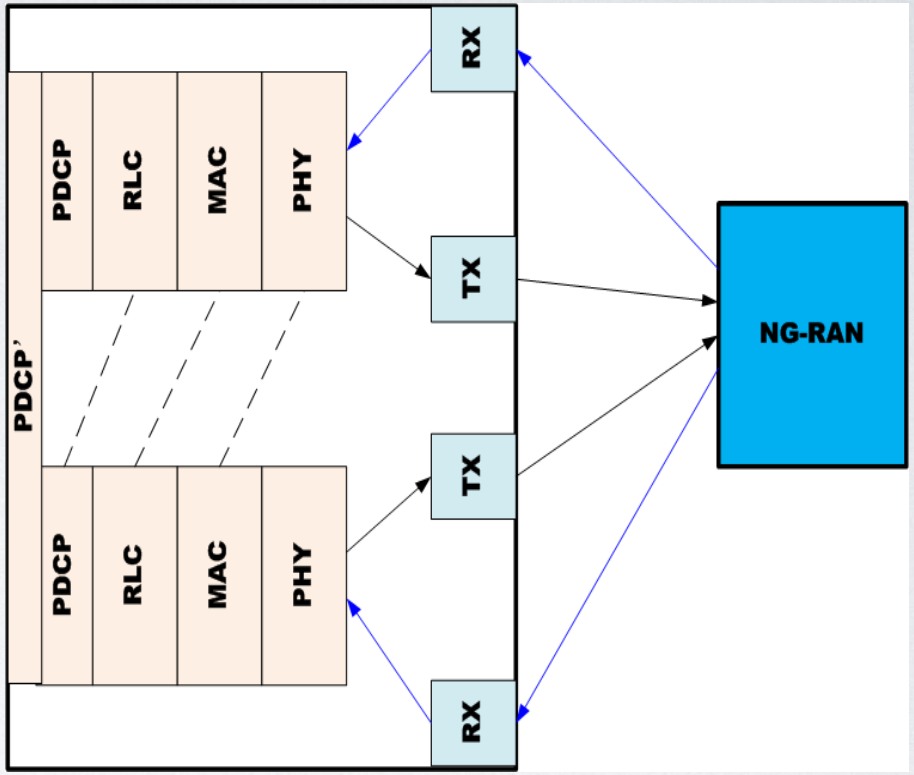


Figure : L2 architecture of UE aggregation for UL TX power boosting

POTENTIAL OBJECTIVES FOR UE AGGREGATION

- Identify and study potential UE aggregation mechanism, including [RAN2, RAN3]
  - RRC management procedure to enable UE aggregation [RAN2]
  - L2 architecture, functionalities and interfaces to allow aggregated UEs to receive control signalling/data in coordination mode, e.g. without data disorder or data duplication during the data splitting between the aggregated UEs [RAN2]
  - Mobility of aggregated UEs with Service continuity [RAN3]

Outline

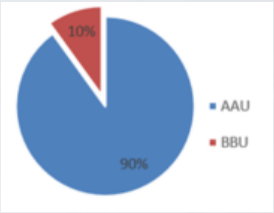
- **eMBB**
  - Frequency combination based elastic cell
  - MBS enhancement
  - SON/MDT further enhancement
  - Air-to-ground (ATG)
  - Home base station (HBS)
  - Smart repeater
- **Non-eMBB**
  - URLLC through dual UEs
  - RSU-like network node
  - Inter-UE handover for the same user
  - Further enhancement of RAN slicing
- **Cross-Functionalities**
  - Full duplex
  - UE aggregation
  - Network energy saving
  - AI/ML enabled RANs

Network energy saving

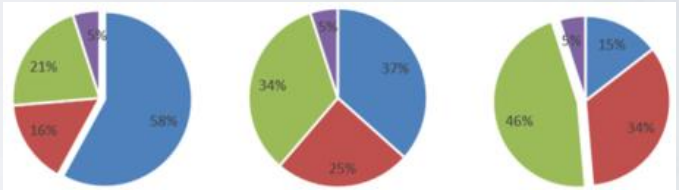
Motivations

- Network energy cost is the primary focus of operators for a sustainable 5G deployment.
- Power consumption of a 5G base station will be 3~4 times higher than LTE, due to 8 times TX/RX channels, 10 times bandwidth and larger transmission powers.
- Standardization efforts have been given to UE power savings in Rel-15/16/17, network power consumption has not been the focus.
- Enhancement of energy saving should be considered in Rel-18

Power consumption Percentage of BS component



Power consumption Percentage of AAU components in difference load status



Fully loaded | 30% loaded | empty load

Potential objectives

- General requirement: solutions for network energy saving should allow early implementation, i.e., not largely rely on terminal assistance.
- Definition of different energy saving modes and network signalling support to enable energy saving.
- Multi-RAT/Multi-carrier synergy energy saving mechanisms
- Traffic/UE behavior/user experience aware energy saving

Outline

- **eMBB**
  - Frequency combination based elastic cell
  - MBS enhancement
  - SON/MDT further enhancement
  - Air-to-ground (ATG)
  - Home base station (HBS)
  - Smart repeater
- **Non-eMBB**
  - URLLC through dual UEs
  - RSU-like network node
  - Inter-UE handover for the same user
  - Further enhancement of RAN slicing
- **Cross-Functionalities**
  - Full duplex
  - UE aggregation
  - Network energy saving
  - AI/ML enabled RANs

AI/ML enabled RAN-Overall

Motivations and Rel-17 attempts

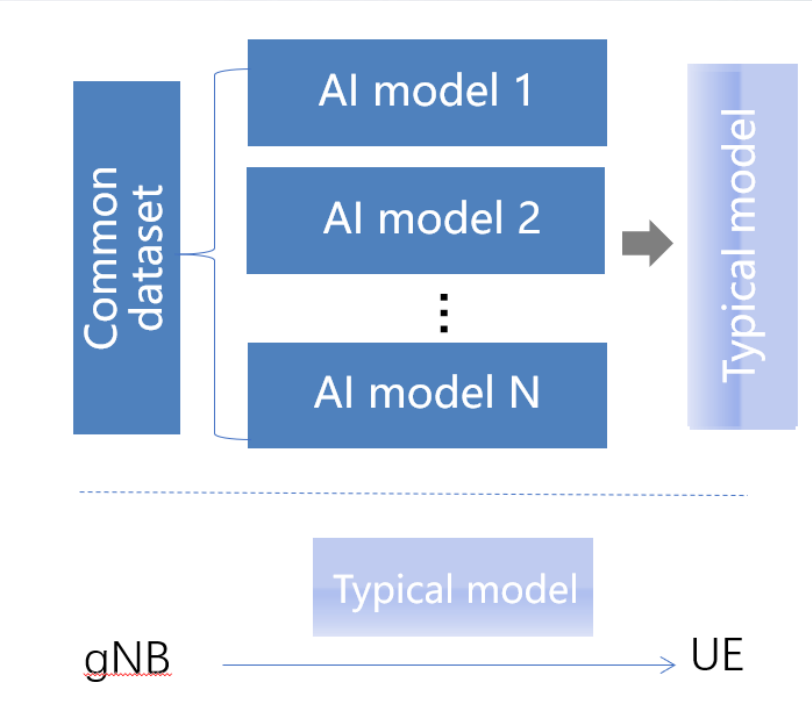
- 5G networks are facing increasing numbers of KPIs and has to address more complex system design and optimization issues introduced by NR.
- Traditional human-machine interaction is slow, error-prone, expensive, and cumbersome
- Rel-17 Data collection enhancement SI, the first attempt of applying AI/ML in RAN, intends to build common AI/ML terminology, high-level framework, and to study the initial use cases and specification impact.
- In Rel-18, applying AI/ML techniques to physical layer is promising and continuing high-layer/system-level work is expected as well

Rel-18 objectives

- A follow up Rel-18 WI of RAN3-leading SI, taking AI framework and recommended use cases in the Rel-17 TR to normative work, e.g.,
  - AI/ML for energy saving.
  - AI/ML for traffic steering
  - AI/ML for load balancing
- A Rel-18 SI to investigate AI/ML enabled physical layer and other promising use cases on high-layer/system-level optimisation.

AI/ML enabled RAN-PHY：Motivation

- AI provides a possibility to solve the problems, which are difficult to model or find the solution, and further improve the spectrum utilization.
- Compared with traditional algorithms, the performance of AI relates to many factors, e.g. data sets, architecture of AI model, training method, hyper parameters. To evaluate different AI algorithms and compare AI with traditional algorithms, the evaluation methodology for AI based PHY enhancement should be studied first.
  - For a potential use case, various AI models may be used, and different AI models may be used by different UEs.
  - For common understanding and evaluation, some basic concepts and terminologies can be introduced to describe AI models.
  - To ensure the basic performance, typical AI models can be introduced, and if needed, the typical model can be sent to UE.



Potential Objectives for AI/ML enabled RAN-PHY

- Identify typical use case(s) for AI based physical layer enhancements [RAN1]
- Study the evaluation methodology of AI based physical layer enhancements [RAN1]
  - Study the common dataset for each use case, including the source, the size and the structure of the dataset.
  - Study the evaluation metrics, e.g., throughput increase, overhead reduction, complexity reduction, etc.
- Study the typical AI models for each use case [RAN1]
  - Study the architecture of typical AI model based on the common parts of different AI models
  - Study the parameterized expression of typical model, including the input/output, architecture, parameters, etc.

中国移动
China Mobile

THANK YOU !