

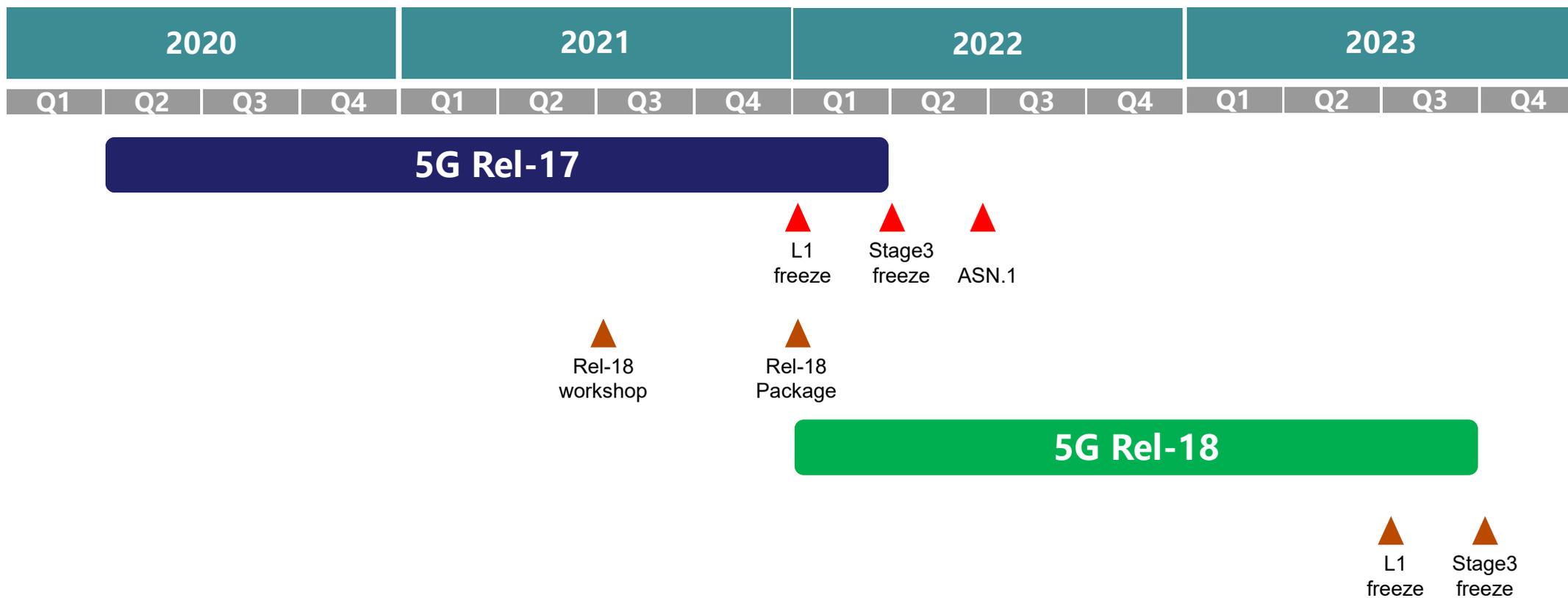
**3GPP TSG RAN Meeting #91-e
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RP-210528**



Views on NR Rel-18

China Telecom
Mar-21

Rel-18 Timeline



Requirement for Rel-18: from our perspective



- Higher capability
 - » UL enhancement
 - » Mobility enhancement
 - » Duplex enhancement
 - » Private network enhancement
 - » Others, e.g., MIMO, IoT, NTN, positioning, AI, ...
- More flexibility
 - » Flexible spectrum fusing
 - » Multi radio multi connectivity
- Lower cost
 - » Network energy saving

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UL enhancement: Motivations (1/2)

■ Motivations

» Both coverage & capacity are important factors for an operator. Enhancement on both of them has practical significance for current & future services.

■ From coverage aspect,

» Cov_Enh SI in Rel-17 has identified UL channels as bottleneck channels. Considering the remaining performance gap, it is beneficial to **continue enhancing UL coverage in Rel-18** to ensure a better network coverage capability. Solutions with companies' interest but not included in Rel-17' Cov_Enh WI scope can be a start point. Meantime, the progress of Rel-17 Cov_Enh WI will also be taken into consideration.

Tab. Baseline coverage performance & solutions' gain in TR 38.830

Scenario	Channels	MPL Gap	Solutions in Rel-17 WI	Remaining gap
PUSCH (eMBB)	Urban 4GHz TDD (ISD = 400m)	~(-7) dB	Rep. Type A: 2~3dB gain DMRS bundling: ~1dB gain TB processing: 1~2dB gain	Several dBs
	Rural 4GHz TDD NLOS O2I (ISD = 1732m)	~(-5.4) dB		Several dBs
PUSCH (VoIP)	Rural 4GHz TDD NLOS O2I (ISD = 1732m)	~(-1.8) dB		-
	Rural 4GHz TDD NLOS O2I (ISD = 3000m)	~(-11) dB		Large
PUCCH (F3 11bits)	Rural 4GHz TDD NLOS O2I (ISD = 1732m)	~(-2.5) dB	DMRS bundling: ~1dB gain	~ 1.5 dB

UL enhancement: Motivations (2/2)

■ From capacity aspect,

» Emergence of uplink centric services brings challenge to UL capacity.

- For outdoor scenarios, e.g., Real-time HD video transmission services (e.g. HD video surveillance, HD video transmission by UAV, HD live broadcast) may be critical applications for 5G system to ensure human safety and property safety as well provide various entertainment.

- For 2K/4K video streaming, UL data rates per 1 HD camera:

- $\{(2560 \times 1440) \text{ or } (4096 \times 2160)\} \text{Pixel} \times (8) \text{bit/Pixel} \times (25) \text{fps} / (1024) \approx 7 \text{ or } 17 \text{Mbps (H.264)}$

- Tens of HD cameras may be needed in one cell, which will occupy non-neglectable UL resources. Thus, UL capacity enhancement is needed.

- For Indoor scenarios, e.g., XR services, machine vision (several hundreds Mbps ~ Gbps) also put forward higher requirements on UL capacity.

» Considering operator's practical network deployment:

- For TDD spectrum, DL-heavy frame structure are generally adopted.
- For both TDD and FDD spectrum, UL carrier cannot be separately configured. Additionally, the modulation and MIMO order of UL is lower.

UL enhancement: Potential solutions

■ Potential solutions for UL enhancement

Coverage enhancement for PUSCH	<ul style="list-style-type: none">• Enhancements on PUSCH repetition type B. (~1dB gain, focus S slot)• Sub-PRB transmission with multi-slot aggregation. (~0.8dB)• UE transmit waveform design to reduce MPR. (~1dB gain)• Higher layer compression, e.g., UDC, SIP signal compression and Packet aggregation.
Coverage enhancement for PUCCH	<ul style="list-style-type: none">• Sequence based PUCCH. (~2dB gain)
Capacity enhancement	<ul style="list-style-type: none">• Higher order modulation and Higher order MIMO.• DMRS enhancement.• Flexible spectrum allocation, e.g. dynamic FDD, more UL carriers than DL carriers, flexible association of DL and UL carriers.

■ Motivation

- With increased frequency carrier in 5G evolution, the deployment of base stations will be more intensive and the cell coverage radius will be smaller. UE will experience more frequent cell selection/re-selection, handover or PScell change procedures in such scenarios (i.e. UDN, Ultra Dense Network). This will undoubtedly increase energy consumption, and reduce mobility performance. Furthermore, with the development of various emerging application, higher mobility performance guarantee is needed.
- In previous release, 3GPP has introduced CHO/CPAC to increase the robustness and DAPS HO to achieve 0ms user plane interruption during mobility procedures, however the above technologies can only be used in limited use cases. Further extensions should be introduced to enhance the mobility performance and reduce data interruption in MRDC scenarios.
- Besides, the data forwarding mechanism in current mobility procedures can be optimized, and the solutions which can reduce UE power consumption and network signaling can also be studied. Meanwhile, other aspects related to mobility enhancement can also be considered, such as fast failure detection and recovery.

■ Scope

- Ensure higher mobility performance in current handover procedures, such as:
 - Ensure high reliability and 0ms interruption during HO procedure;
 - Enhance robustness of NG-based handover...
- Reduce data interruption for mobility procedures in MRDC scenario, such as:
 - Reduce data interruption for inter-MN handover without SN change procedure;
 - Ensure 0ms interruption for PScell change procedure...
- Optimize data forwarding procedure to enhance data continuity and reduce BS load.
- Reduce UE power consumption or network signaling during mobility procedure.
- Other aspects related to mobility enhancement, such as fast failure detection and recovery.

Enhancement for duplex mode: Motivation



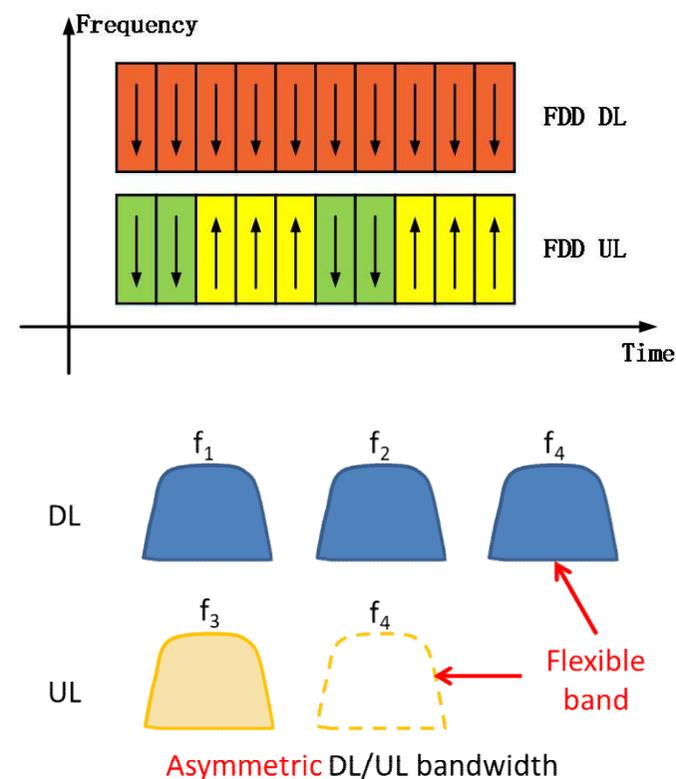
- With the increasing of asymmetric DL/UL services and the changing ratio between DL/UL, the static partition of the DL/UL resource is not spectral efficient.
- In Rel-14 NR SI, the benefits of flexible duplex were observed as in TR38.802:
 - » Evaluations show that duplexing flexibility with cross-link interference mitigation schemes provides better UPT compared to static UL/DL resource partition and duplexing flexibility without cross-link interference mitigation schemes for indoor hotspot (4GHz and 30GHz), urban macro (4GHz unpaired spectrum and 2GHz paired spectrum) and dense urban scenarios(4GHz and 30GHz unpaired spectrum).
 - » Evaluations show that duplexing flexibility without cross-link interference mitigation schemes provides better UPT compared to static UL/DL resource partition at least for some cases.
 - » The cross-link interference mitigation schemes include sensing based methods, advanced receivers, coordinated scheduling/beamforming, power control, link adaptation, hybrid dynamic/static UL/DL resource assignment.
- NR already supports TDD operation where the transmission direction of most time resources can be dynamically changed.
 - » The Rel-16 WI for CLI handling (NR_CLI_RIM) specified exchange of intended DL/UL configuration between gNBs and two types of CLI measurements/reporting to support flexible resource adaptation for unpaired NR cells. Coexistence among different operators in adjacent channels was also investigated in TR38.828 with dynamic TDD operated.
- Further enhancement for duplex mode needs to consider dynamic DL/UL resource split for FDD as well or spectral efficiency improvement.

Enhancement for duplex mode: potential scope

- **Dynamic FDD** could enable the adaption to traffic imbalance in DL and UL, which includes:
 - » Dynamic in **time domain**: allow DL transmission in part of the slots in UL spectrum, or UL transmission in part of the slots in DL spectrum
 - » Dynamic in **frequency domain**: flexible bands for asymmetric DL/UL bandwidth allocation for FDD

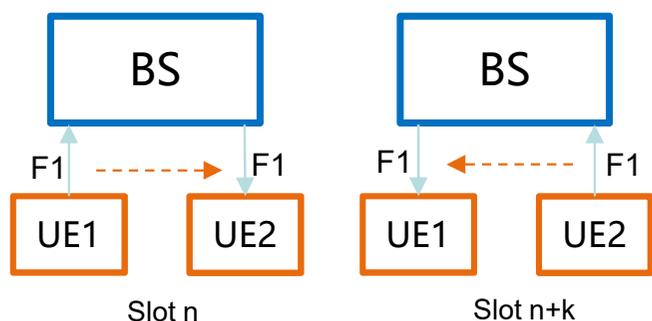
- Potential enhancements to support dynamic UL/DL resource utilization of FDD spectrum

- » Identify the regulatory and potential scenarios/bands under which DL/UL transmission in FDD UL/DL spectrum can be considered
- » Specify signaling to enable DL/UL transmission in FDD UL/DL spectrum
- » Interference management for DL/UL cross-link interference
- » Co-existence issues including inter-band and inter-operator

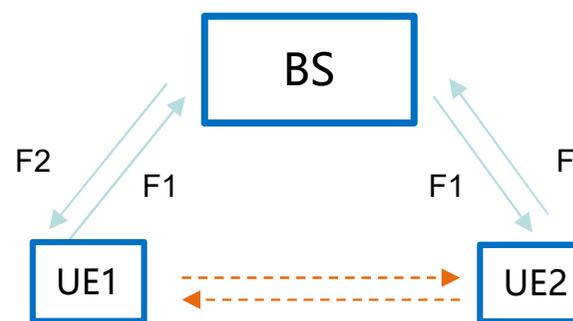


Enhancement for duplex mode: potential scope

- Full duplex is an attractive technic capable of providing DL/UL resource at any time and doubling the spectrum efficiency in theory
- **Full duplex at gNB, and half duplex at UE** could be the first phase to support full duplex



(a) TDD at UE



(b) FDD at UE

■ Potential enhancements to support full duplex

- » Identify the prior scenarios for full duplex operation, e.g. pico, relay, D2D, frequency range, etc.
- » Specify signaling to enable full duplex
- » Frame structure design for full duplex
- » Interference management for self/cross link interference
- » Co-existence issues including inter-band and inter-operator

Further Enhancement of Private Network (1/2)



■ Background

- » The fundamental functions of Non-Public Network were studied and specified in SA and RAN in Rel-16 and its enhancement functions were studied and specified in Rel-17. However due to the high work load and limited time, some functions were still missing.

■ Motivation

- » In Rel-17, the **NG-RAN node is not aware of the UE serving (selected) CAG ID** in case of initial access and handover. Therefore operators can not get the cell level usage of CAG users, and can not show the efficiency of PNI-NPN to their vertical and/or enterprise customers who are willing to pay for the private network. So the operators need to have full knowledge of CAG cell usage condition and this can help them to optimize and promote their NPN networks.
- » In Rel-16, the NB-IoT/eMTC connected to 5GC has been supported. However, the **NPN support for NB-IoT/eMTC** is not. As many operators have deployed the NB-IoT networks, it is envisioned that the NPN for NB-IoT/eMTC can provide operators more comprehensive support of IoT use cases.
- » In Rel-17, a SNPN UE or PLMN UE could access to a visited SNPN through authentication of their home service provider. When these UEs move from the visited SNPN into their home SNPN/PLMN networks, or move from the home SNPN/PLMN into a visited SNPN, the service continuity for interworking between PLMN and SNPN should be supported.
 - **Mobility scenarios, including service continuity**, for:
 - (1) UE moving from SNPN#1 with separate entity#1 to SNPN#2 with separate entity#1 available; and
 - (2) UE moving between SNPN#1 (where separate entity=PLMN) and PLMN.

Further Enhancement of Private Network (2/2)



■ Scope

The objective of this work item is to support Further enhanced non-public network (FeNPN) for NG-RAN with the following functionality:

- » The service continuity for interworking between PLMN/SNPN and SNPN should be supported.
- » The support of SNPN and PNI-NPN for eMTC/NB-IoT connected to 5GC
- » For PNI-NPN, support reporting of serving (selected) CAG ID usage including initial access and handover, if justified
- » Remaining issues if any, e.g. CAG ID level unified access control, left over manual CAG selection etc.

■ MIMO

- » Enhancement for CSI measurement and reporting
- » multi-TRP/panel enhancement

■ IoT

- » Potential new market and the enabling technique, e.g.,
 - Further reduced complexity and power consumption
 - Massive connection

■ Positioning

- » Higher accuracy and lower latency for extended use cases

■ NTN

- » Networking and architecture issues

■ AI

- » Normative phase based on Rel-17 study

■ ...

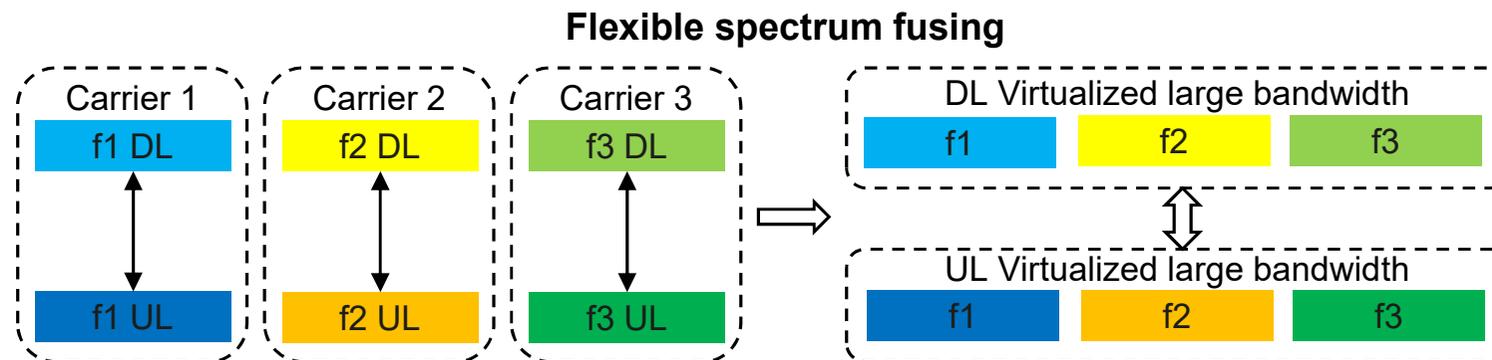
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Flexible spectrum fusing

- Sub-1GHz plays the important role in wireless communication due to outstanding coverage performance, which on contrary made the sub-1GHz spectrum rare and fragmentally allocated in such as 700/800/900 MHz for IMT. How to integrate these fragment spectrum efficiently and schedule the resource more flexibly to meet 2B/2C requests will be the key question.
- The idea of flexible spectrum fusing is to integrate the bandwidths from different carriers to one virtualized bandwidth, will improve the spectrum efficiency extremely and make scheduling more flexible.



- The scope for flexible spectrum fusing includes
 - » Combine PDCCHs from multi-carriers and allocate in one of carriers
 - » Simplify SSB designation for carriers covered by flexible spectrum fusing
 - » Specify related RF requirements for flexible spectrum fusing

■ Motivation

- » Due to the high 5G frequency bands up to 100GHz and with the gradual 4G frequency refarming, multi-layer overlapping deployment will be a normal behavior for future network. To improve network capacity and reduce OPEX, Multi Radio Multi Connectivity can be considered as an approach to provide operator with more flexible, effective and uniform network control and radio resource management, i.e., multi-network integration.
- » Meanwhile, with the development of Wi-Fi 6 (i.e. IEEE 802.11.ax), WLAN is still expected to be widely deployed by operators/vertical industry enterprise for increasing hotspot throughput in the future. Besides that non-3GPP access to 5GC (N3IWF) is already enabled in NR at the core network level, NR-WLAN coordination at RAN level can achieve common radio resource control and management, and can be further considered and studied.
- » Multi radio multi connectivity will be a trend for the future network deployment. The RF capability limitation of UE and the complexity of both the network and the UE for multi radio multi connectivity might be potential challenges. It is also meaningful to study additional solutions to solve these problems.

Multi Radio Multi Connectivity (2/2)

Scope

- » Scenarios and use cases for multi radio multi connectivity, including
 - Multi-layer deployment
 - Multi-network integration
- » Reduce the complexity of multi radio multi connectivity
 - Simplify overall architecture, air/network interface, UP and CP protocol aspects
 - Traffic steering, switching, aggregation, splitting, retransmission and duplication
 - Multi layer/CG management
 - Mobility optimizations, measurement and reporting aspects

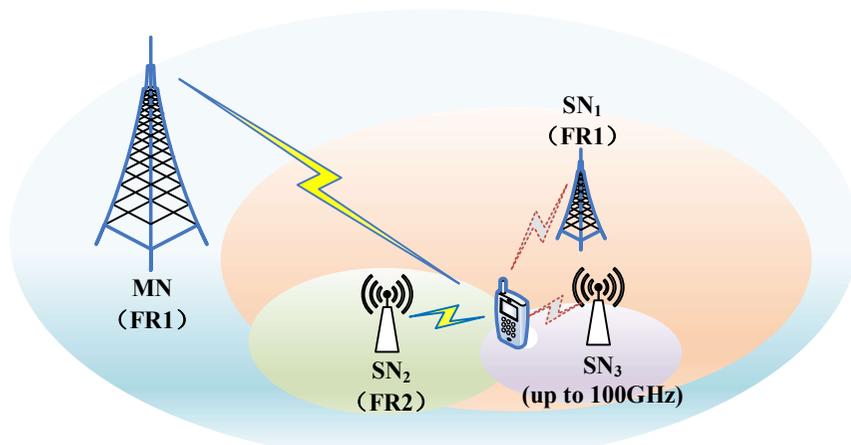


Fig.1 Multi-layer deployment

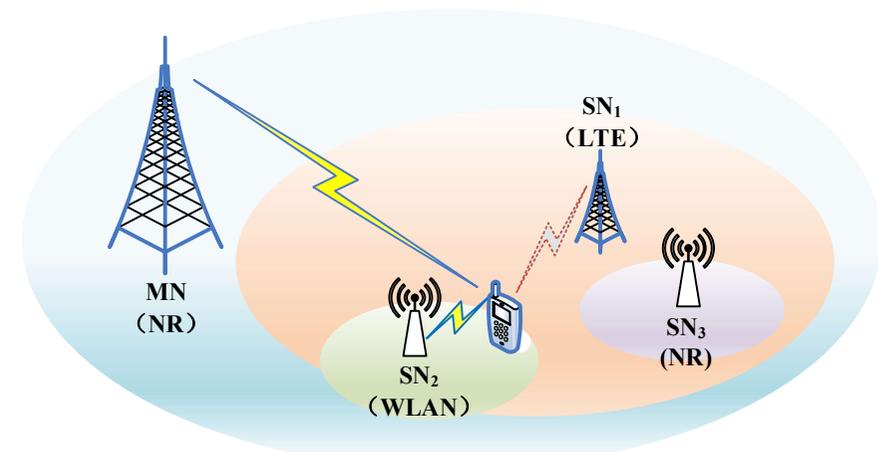


Fig.2 Multi-network integration

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Network energy saving : Motivation



■ Motivation

- The power consumption from base station reaches to 70% of total power consumption. Energy cost in the network has been a continuous high focus among operators.
- Some evaluation and analysis have shown that NR network power consumption of a single base station will be 3~4 times higher than LTE currently.
- Thus, further enhancement on NR network energy saving would be necessary in Rel-18.

Estimation of power consumption and cost: LTE vs. NR

Parameter	LTE value		NR value		Note
	3 RRU	1 BBU	3 AAU	1 BBU	
1 BS					
Peak power (W)	840	170	3450	310	280W/RRU 1150W/AAU
Total power(W)	1010		3760		
Total cost (CNY)/year	7.5k		28.5k		0.85CNY/kWh

Network energy saving : potential scope

- Energy efficient time/frequency/space domain transmission; (RAN1)
- Compensating RATs deployment scenario; (RAN3, RAN2)
- Service experience-aware energy saving; (RAN3, RAN2)
 - » Based on NWDAF analytic, such as analytic on RFSP (SA2 impact)
 - » Based on MDAS recommendation for energy saving (SA5 impact)
- Supporting potential update on the definition of energy efficiency KPI (RAN3)



Thanks!
