

3GPP TSG RAN Rel-18 workshop  
Electronic Meeting, June 28 - July 2, 2021  
Agenda: 4  
RWS-210141



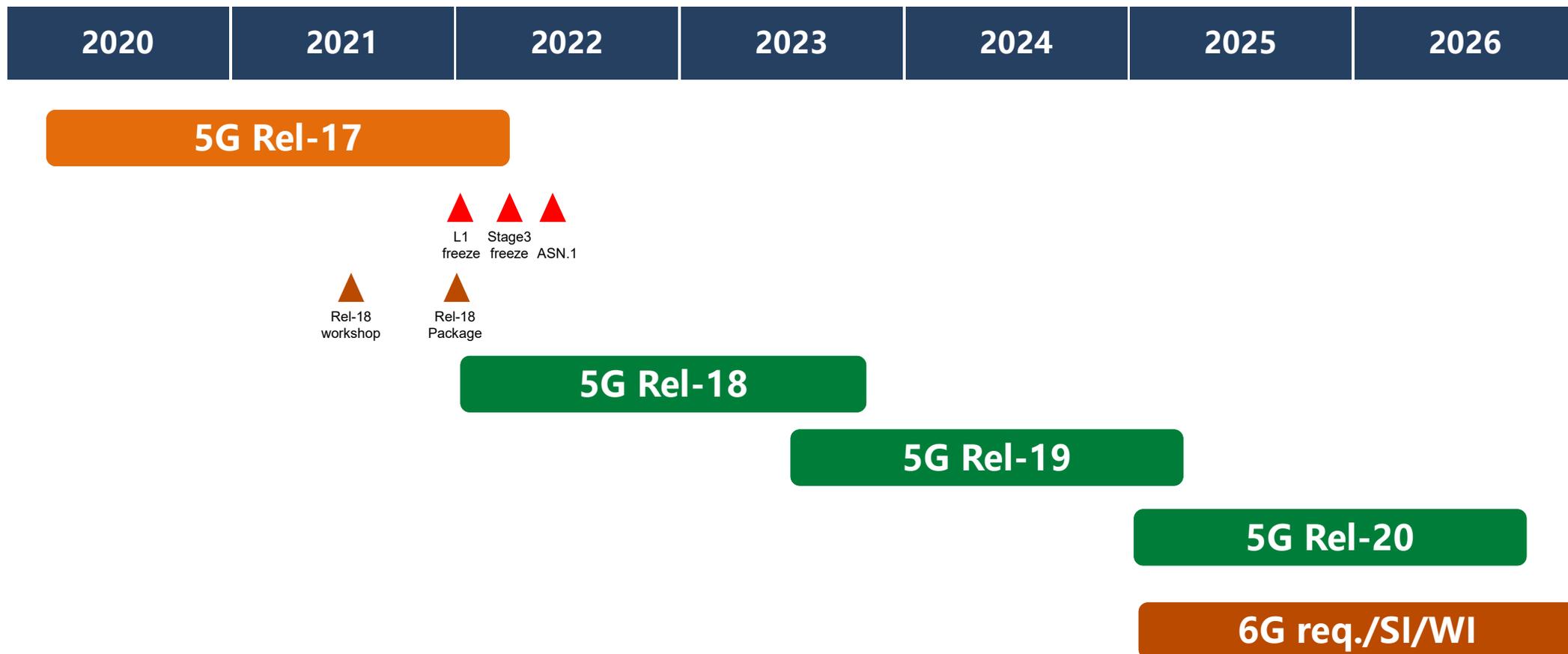
# Views on NR Rel-18

---

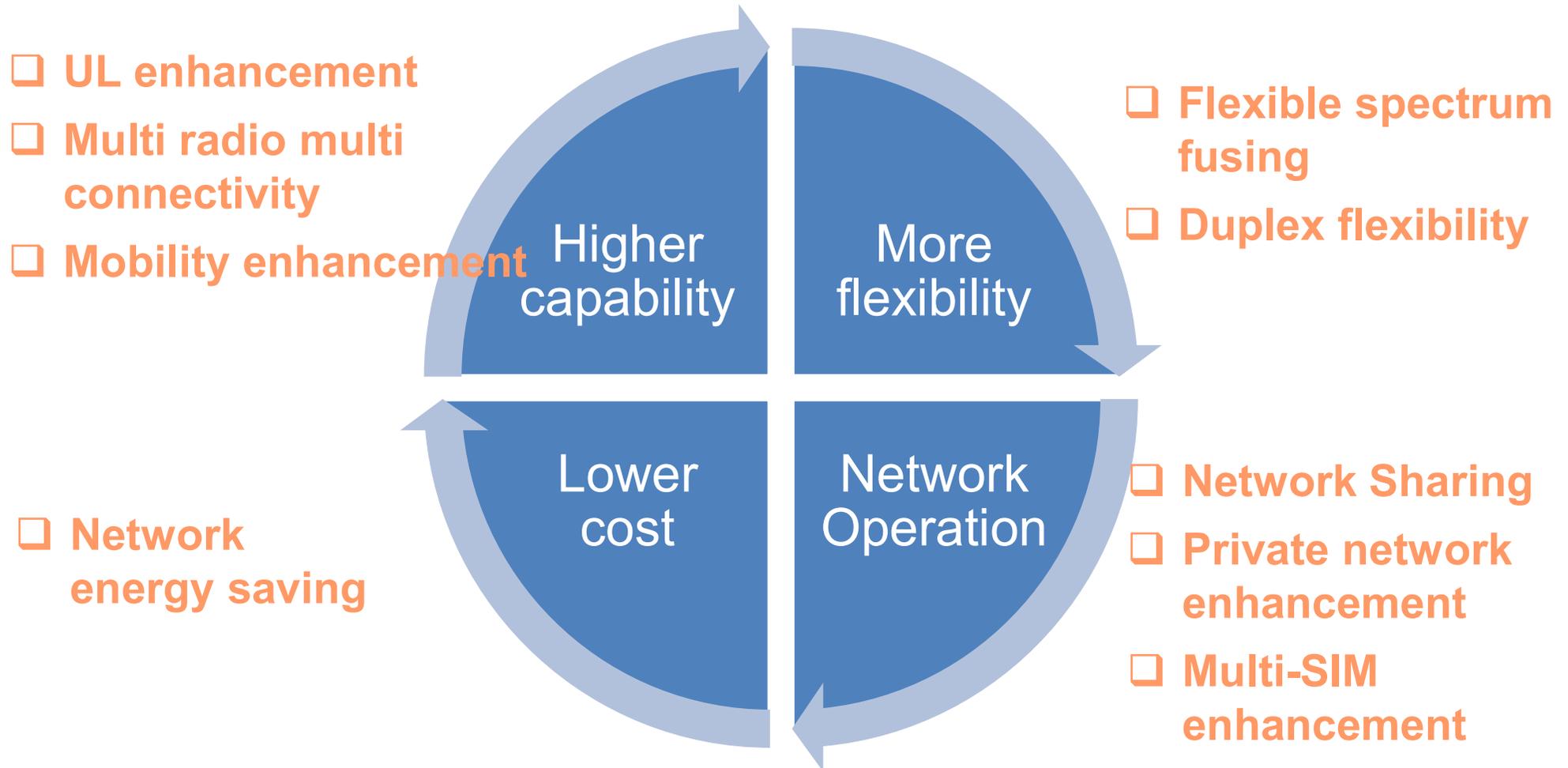
China Telecom

2021-6

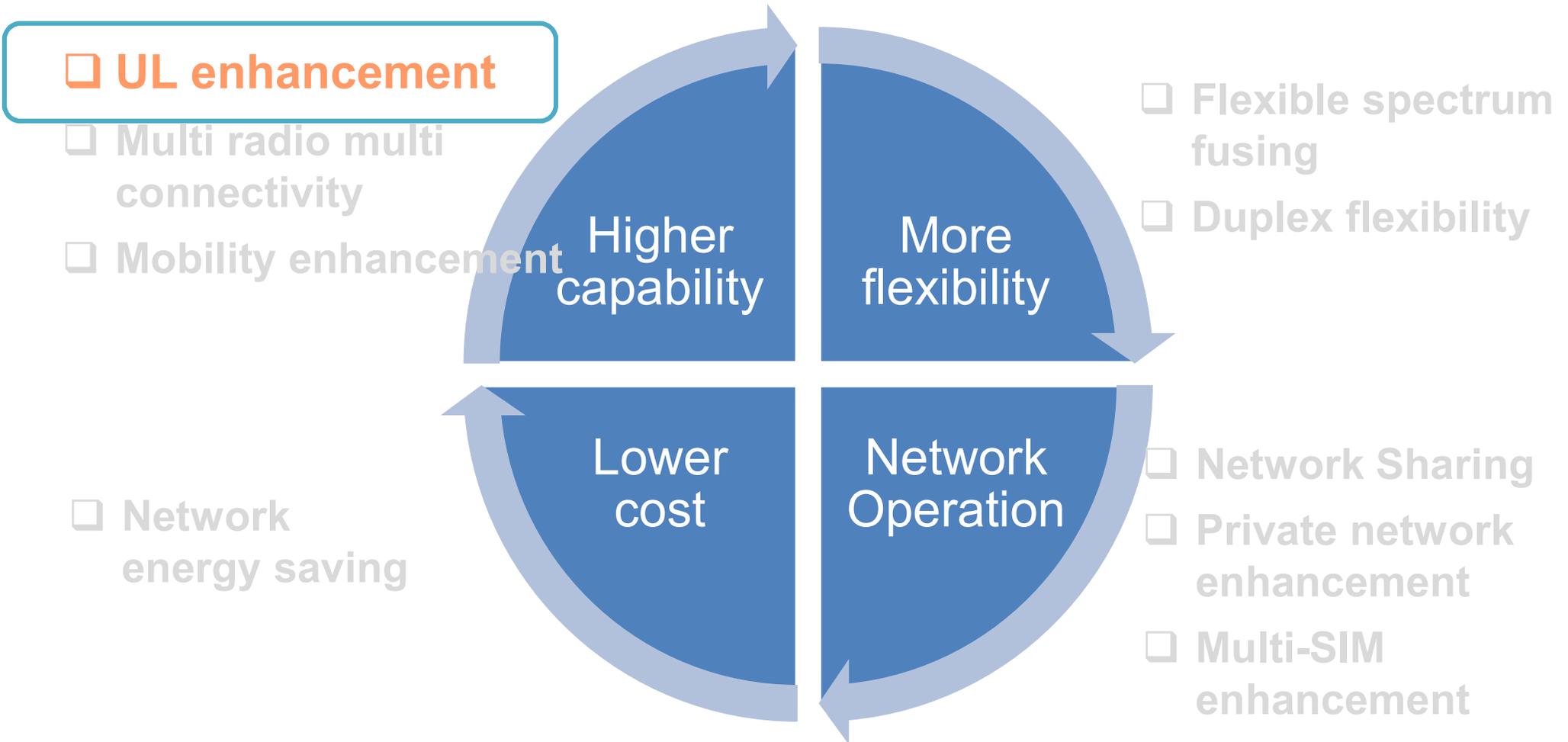
# Possible Timeline



# Requirement for Rel-18: from a wireless perspective



# Requirement for Rel-18: from a wireless perspective



# UL enhancement: Motivations

## ■ Motivations

- » Both coverage & capacity are key factors that an operator considers when commercializing cellular communication networks.
- » For coverage, better coverage capability brings more flexibility in NR network deployment as well as better service quality and less CAPEX and OPEX, which is beneficial to operators.

| 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   | Several dBs   |
| PUSCH (VoIP)      | Rural 4GHz TDD NLOS O2I (ISD = 1732m) | ~(-1.8) dB | DMRS bundling: ~1dB gain  | -             |
|                   | Rural 4GHz TDD NLOS O2I (ISD = 3000m) | ~(-11) dB  | TB processing: 1~2dB gain | Large         |
| PUCCH (F3 11bits) | Rural 4GHz TDD NLOS O2I (ISD = 1732m) | ~(-2.5) dB | DMRS bundling: ~1dB gain  | ~ 1.5 dB      |

- » For capacity, the emergence of uplink centric services (e.g. real-time HD video, AR/VR/MR) brings challenge to UL capacity.

- For 2K/4K video streaming, UL data rates per 1 HD camera:  
 $\{(2560 \times 1440) \text{ or } (4096 \times 2160)\} \text{Pixel} \times (8) \text{bit/Pixel} \times (25) \text{fps} / (102) \approx 7 \text{ or } 17 \text{Mbps (H.264)}$



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

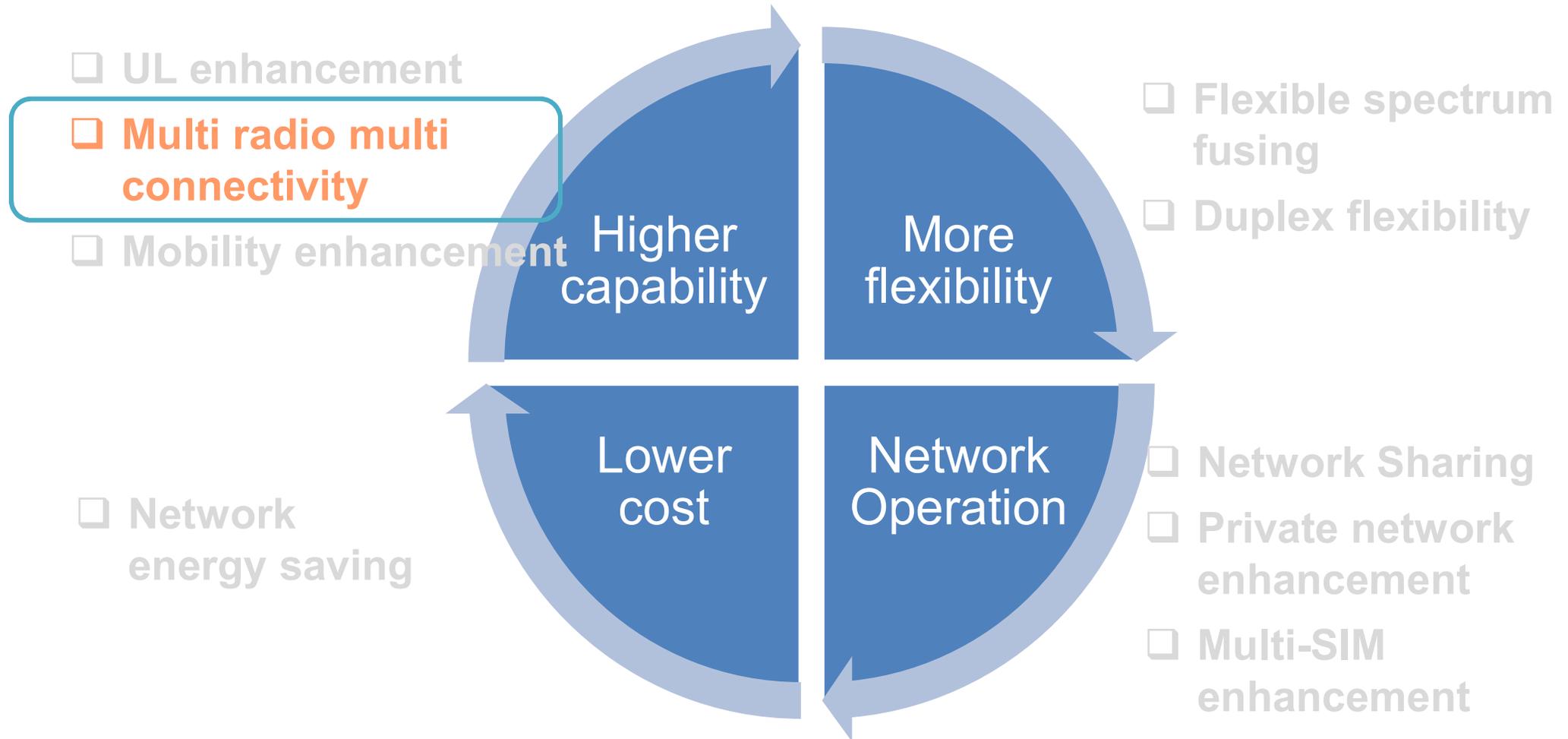
## Coverage enhancement

- Potential PUSCH coverage enhancement
  - » PUSCH repetition type B enhancement
  - » Sub-PRB transmission with multi-slot aggregation
  - » Higher layer compression
    - E.g. Packet aggregation
- Potential PUCCH coverage enhancement
  - » DMRS-less PUCCH with UCI payload up to 11 bits
- PRACH enhancement for FR2
  - » Multiple PRACH transmission
- UE transmit waveform design to reduce MPR

## Capacity enhancement

- Higher order modulation and Higher order MIMO
  - » More UL layers, e.g. 8.
  - » Higher order modulation, e.g. 1024QAM
- DMRS enhancement
  - » DMRS overhead reduction
  - » More DMRS ports, e.g. 24.
- Flexible spectrum allocation
  - » More UL carriers than DL carriers
  - » Flexible association of DL and UL carriers
- UE virtualization and cooperation

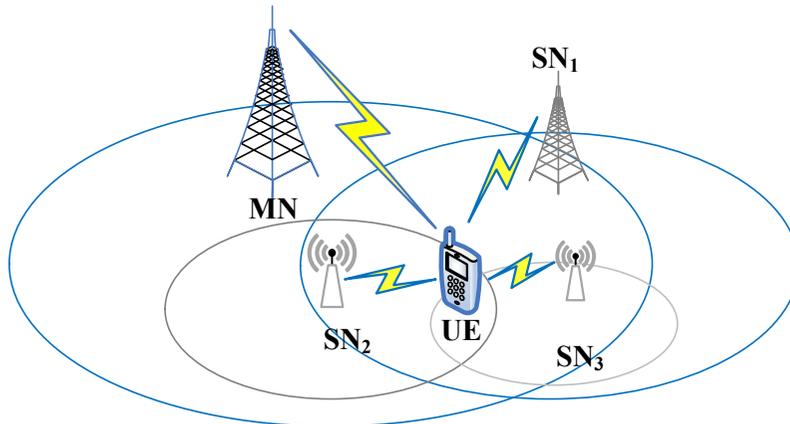
# Requirement for Rel-18: from a wireless perspective



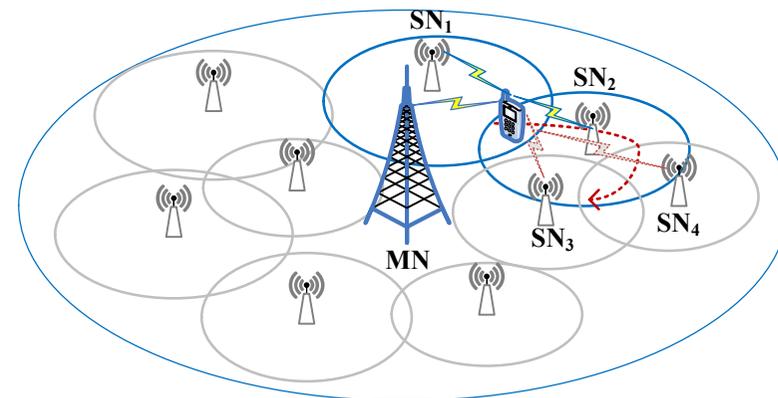
# Multi Radio Multi Connectivity: Motivation(1/2)

## ■ 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 behaviour for future network.
- » The emergence of new applications and services, such as AR/XR, HD live video, requires not only **higher bandwidth and capacity**, but also **service continuity and lower latency** in mobility scenarios.
- » To improve network capacity, **Multi Radio Multi Connectivity(MR-MC)** can be considered as an approach to provide operator with more flexible, effective and uniform network control and radio resource management.



MR-MC for higher bandwidth and capacity

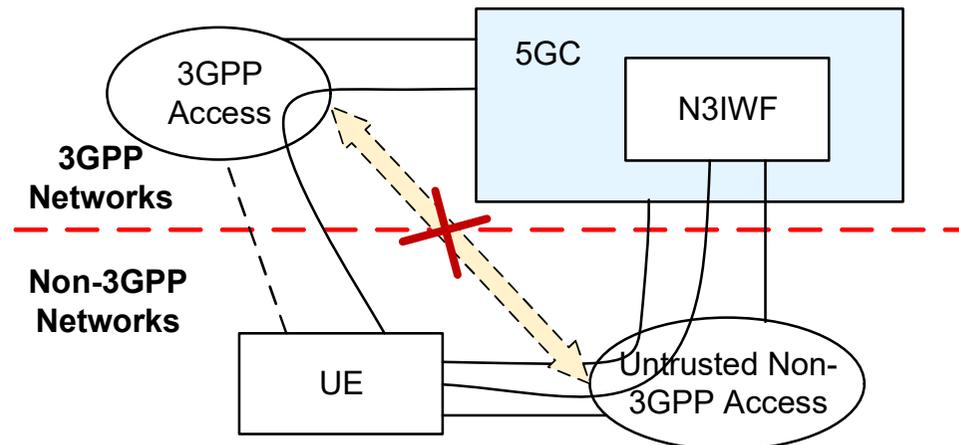


MR-MC for service continuity and lower latency

# Multi Radio Multi Connectivity: Motivation(2/2)

## ■ Motivation

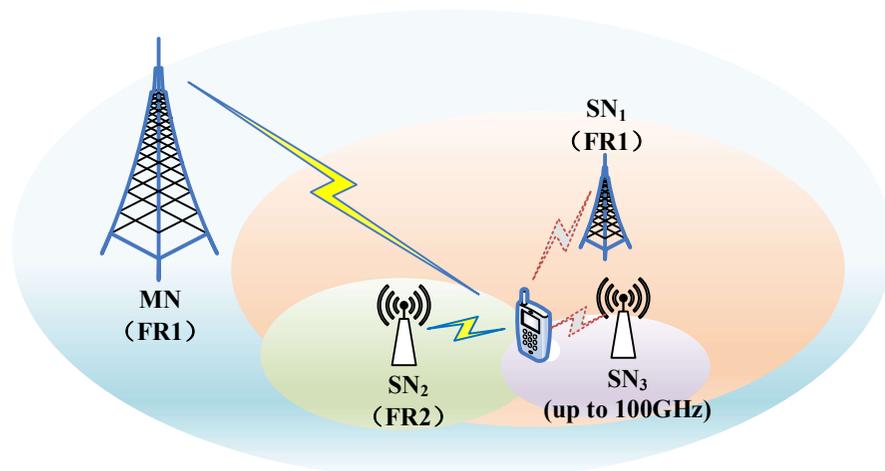
- » Multi-RAT integration can provide Ubiquitous Connection for network users:
  - With the development of Wi-Fi 6 (i.e. IEEE 802.11.ax), WLAN is still expected to be widely deployed by operators/vertical industry enterprise for increasing hotspot throughput and providing supplementary coverage for weak coverage areas, especially for indoor scenarios in the future.
  - Besides that non-3GPP access to 5GC (N3IWF) is already enabled in NR at the core network level, NR-WLAN aggregation at RAN level can achieve common radio resource control and management, and can be further considered and studied.



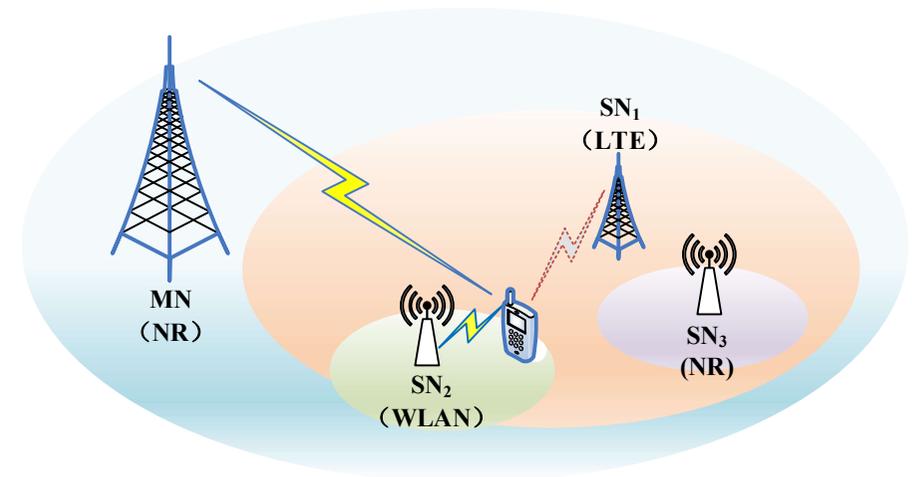
# Multi Radio Multi Connectivity: Potential scope

## ■ Potential scope

- » Specify the architecture, interface, user plane and control plane protocols for MR-MC;
- » Specify mechanism for the traffic steering, switching, aggregation, splitting, retransmission and duplication aspects for MR-MC;
- » Specify mechanisms and signalling to reduce the complexity of MR-MC, including
  - Multi-layers/cell groups management, such as fast and dynamic SCell/SCG activation and deactivation with selective (UL) activation

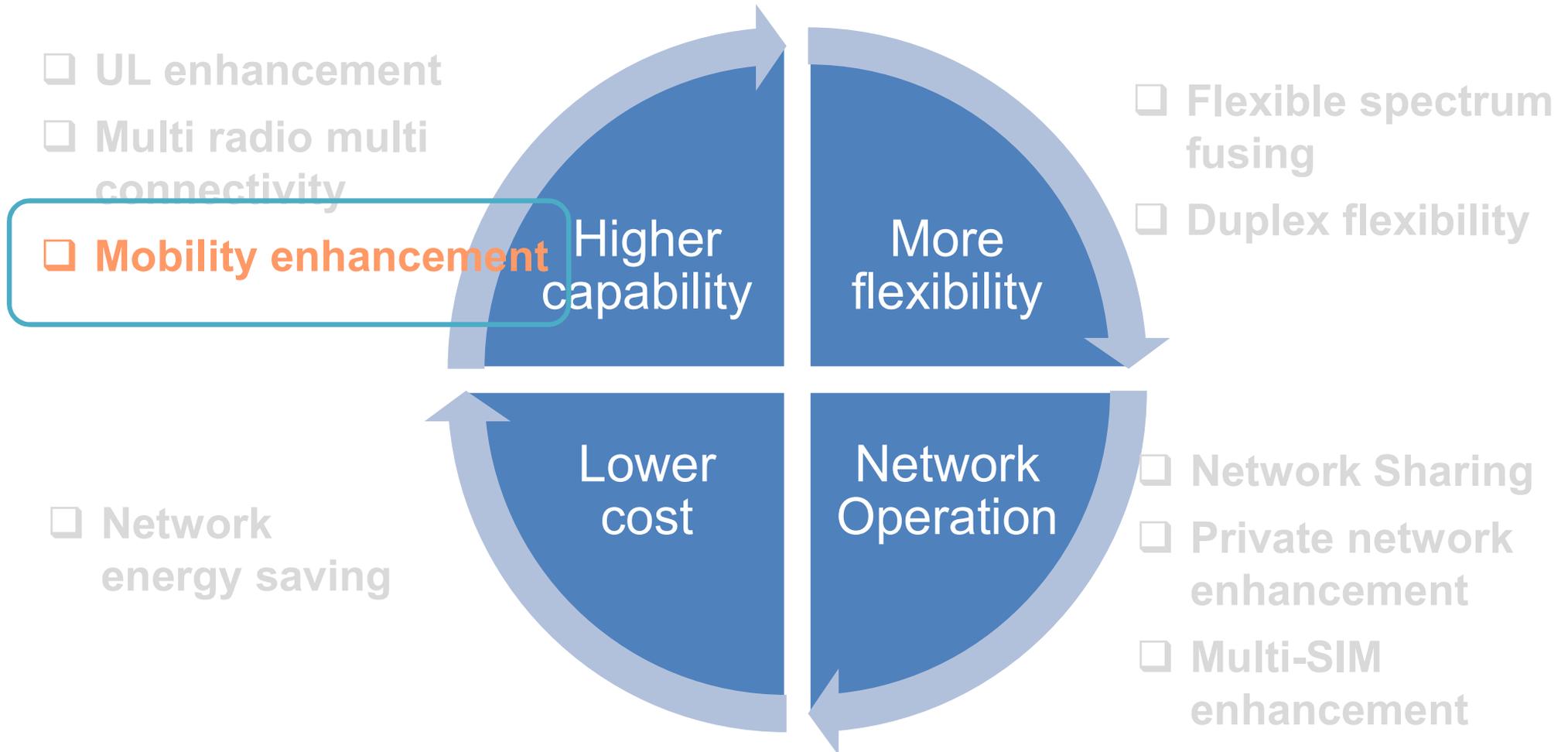


Multi-layer deployment



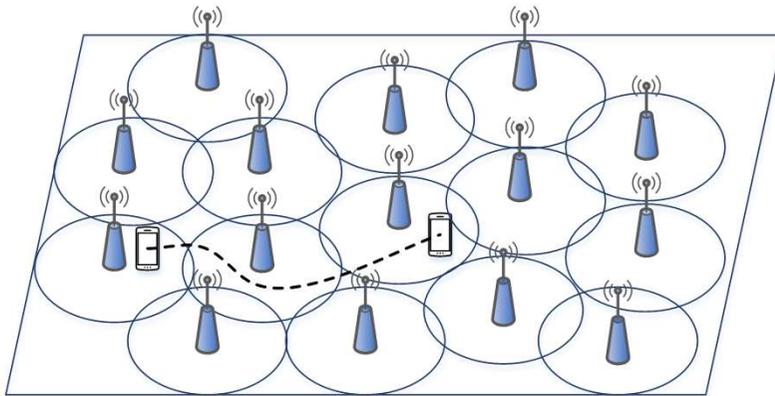
Multi-RAT integration

# Requirement for Rel-18: from a wireless perspective

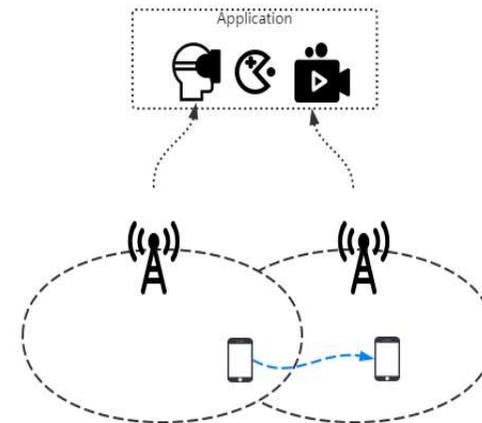


## ■ Motivation

- With increased frequency carrier in 5G evolution, UE will experience more frequent cell selection/re-selection, handover and PScell Change in such scenarios (i.e. UDN, Ultra Dense Network). Moreover, the requirement of packet delay and data rate for new emerging applications (such as XR, 4K/8K video, cloud gaming, etc...) is much stringent, the network needs to provide high quality and consistent services for users especially when user is moving.



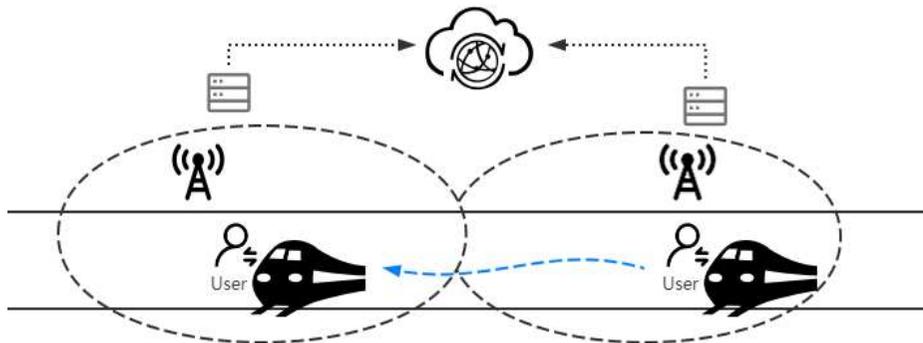
UE Handover more frequent duo to the high frequency deployment



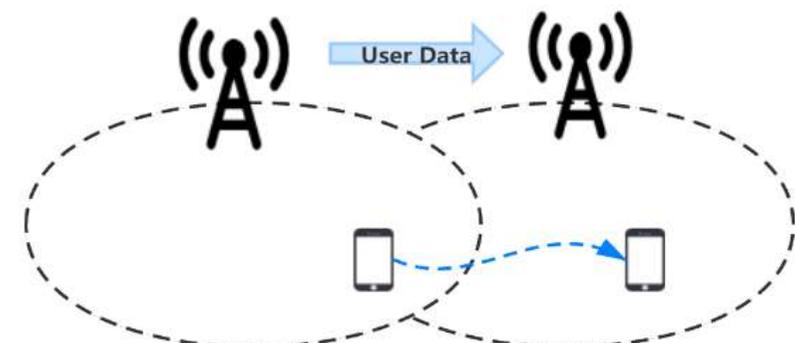
Consistent service guarantee during mobility procedure

# Mobility enhancement : Motivation(2/2)

- In R16 and R17, 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 were not supported for some use cases, such as DAPS HO from FR2 to FR2, NG based CHO. Further extensions should be introduced to enhance the user performance and reduce data interruption.
- The data forwarding mechanism in current mobility procedures can be optimized such as updating early data forwarding status in time.
- Other aspects: such as reduction of UE power consumption and network signaling, as well as fast failure detection and recovery, especially for FR2 scenario.



UE experience NG-based handover in high speed train scenario

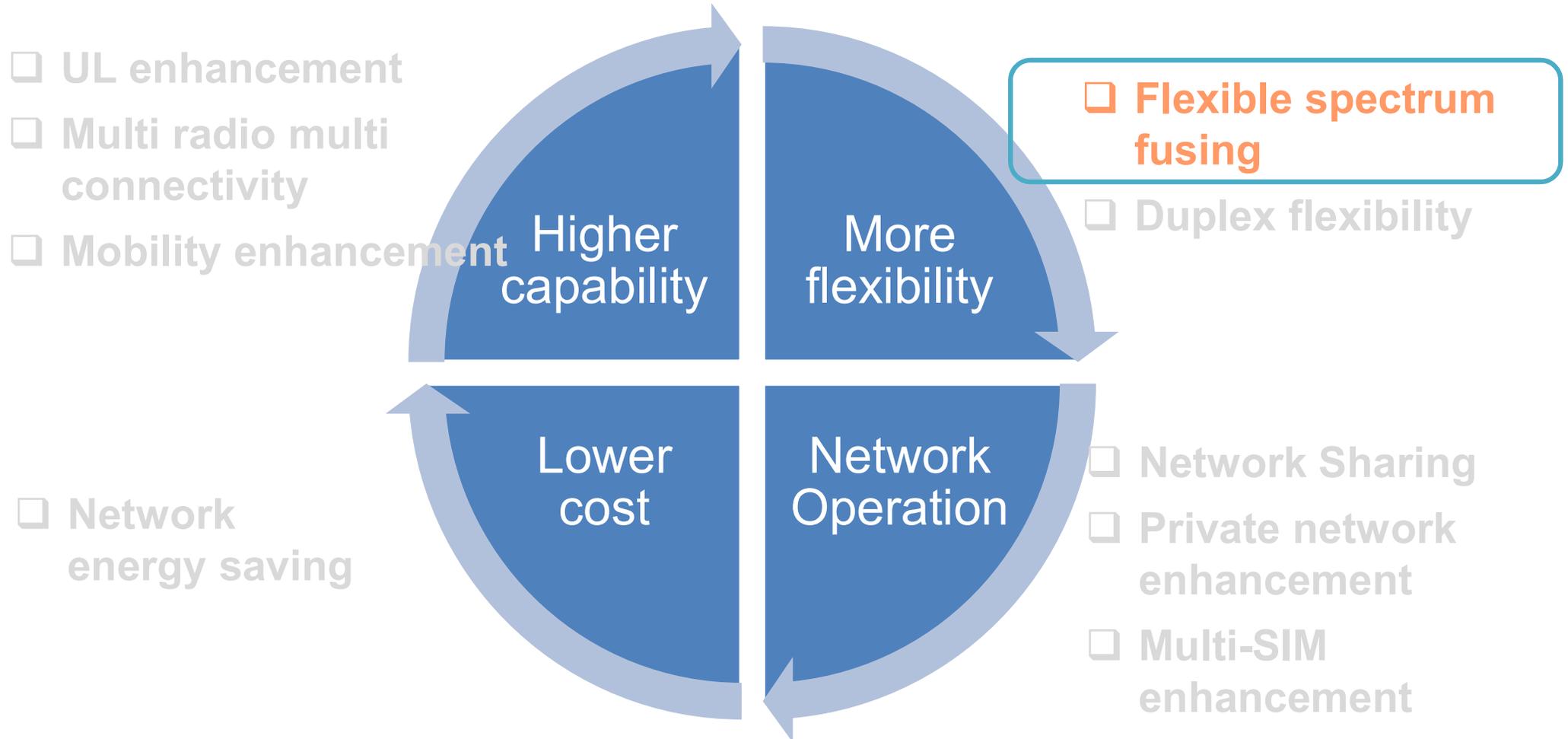


Data forwarding occurs during mobility procedure

## ■ Scope

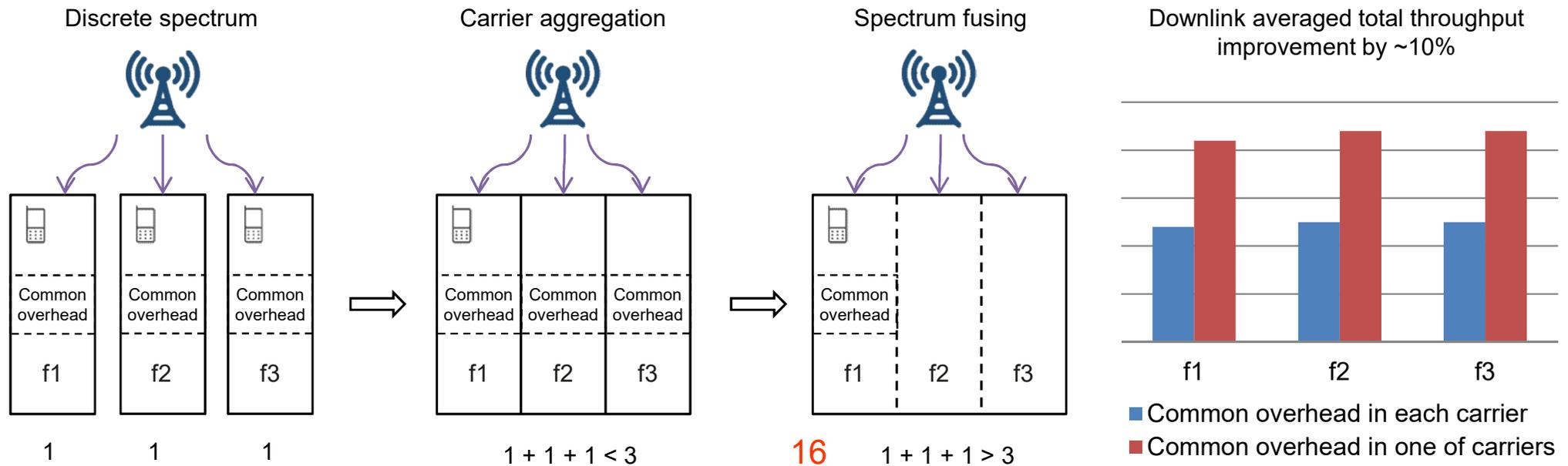
- Ensure higher mobility performance in current handover procedures, such as:
  - Reduce data interruption in FR2, such as RACH less HO;
  - Ensure high reliability and 0ms interruption during HO procedure;
  - Enhance robustness of NG-based handover.
- Reduce data interruption in MR-DC scenario, such as:
  - Reduce data interruption for only MN change procedure;
  - Ensure 0ms interruption for PScell change procedure;
  - Support inter-RAT PScell Change.
- Optimize data forwarding procedure to enhance data continuity and reduce BS load;
- Other aspects related to mobility enhancement, such as reduce UE power consumption or network signaling, fast failure detection and recovery, etc...

# Requirement for Rel-18: from a wireless perspective



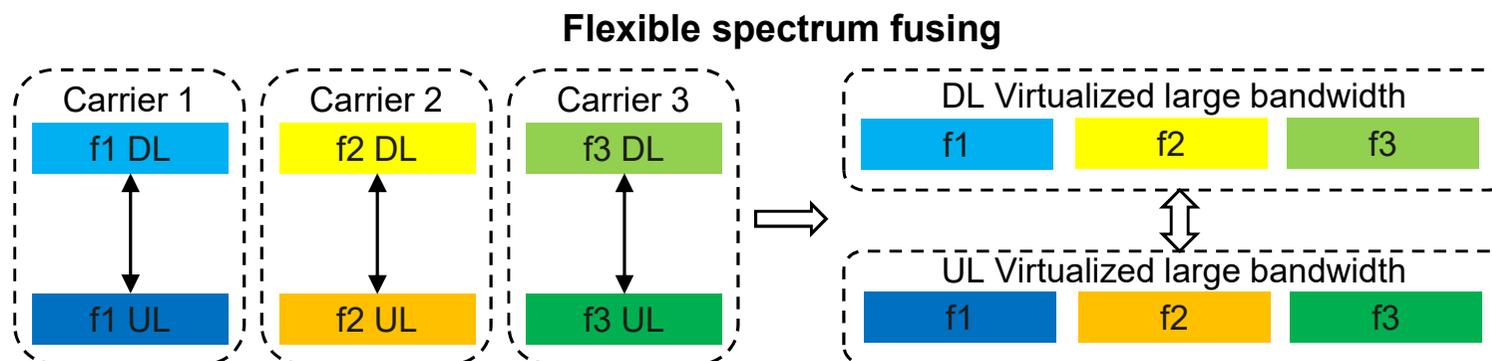
# Flexible spectrum fusing - motivation

- As growth of data traffic and explosion of services, up to 5 down link carriers CA are proposed in RAN4. The Carrier Aggregation has been identified as a direct technology to achieve larger bandwidth and high data rate for NR and LTE. However, from operator point two key aspects need to considerate when deploying CA. The first is cost, addition of carrier will increase the network multiple cells management cost; the second is spectrum efficiency of CA, more control channels and signalings will cause CA spectrum efficiency lower than single carrier with the same total bandwidth.
- The flexible spectrum fusion changing the discrete spectrum utilization from simple aggregation to fusion, and will achieve  $1+1+1 > 3$  by reducing common overhead. The composite spectrum efficiency improvement is expected to be larger than 10% by comparing to traditional CA.



# Flexible spectrum fusing - motivation

- 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. In future, possibly more sub-1GHz spectrum bands such as 700/800/900 MHz can be operated under the co-construction and sharing business mode. How to integrate these fragment spectrums 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 make scheduling more flexible and improve the spectrum efficiency extremely. Below figure gives an example for fusing 700/800/900MHz to one virtualized large bandwidth, flexible scheduling could happen in the virtualized bandwidth.



# Flexible spectrum fusing - scope

## ■ Scenarios

- » Focus on the spectrum frequency of which the bands are neighboring, e.g. 700MHz/800MHz/900MHz or 1.8GHz/2.1GHz, etc.

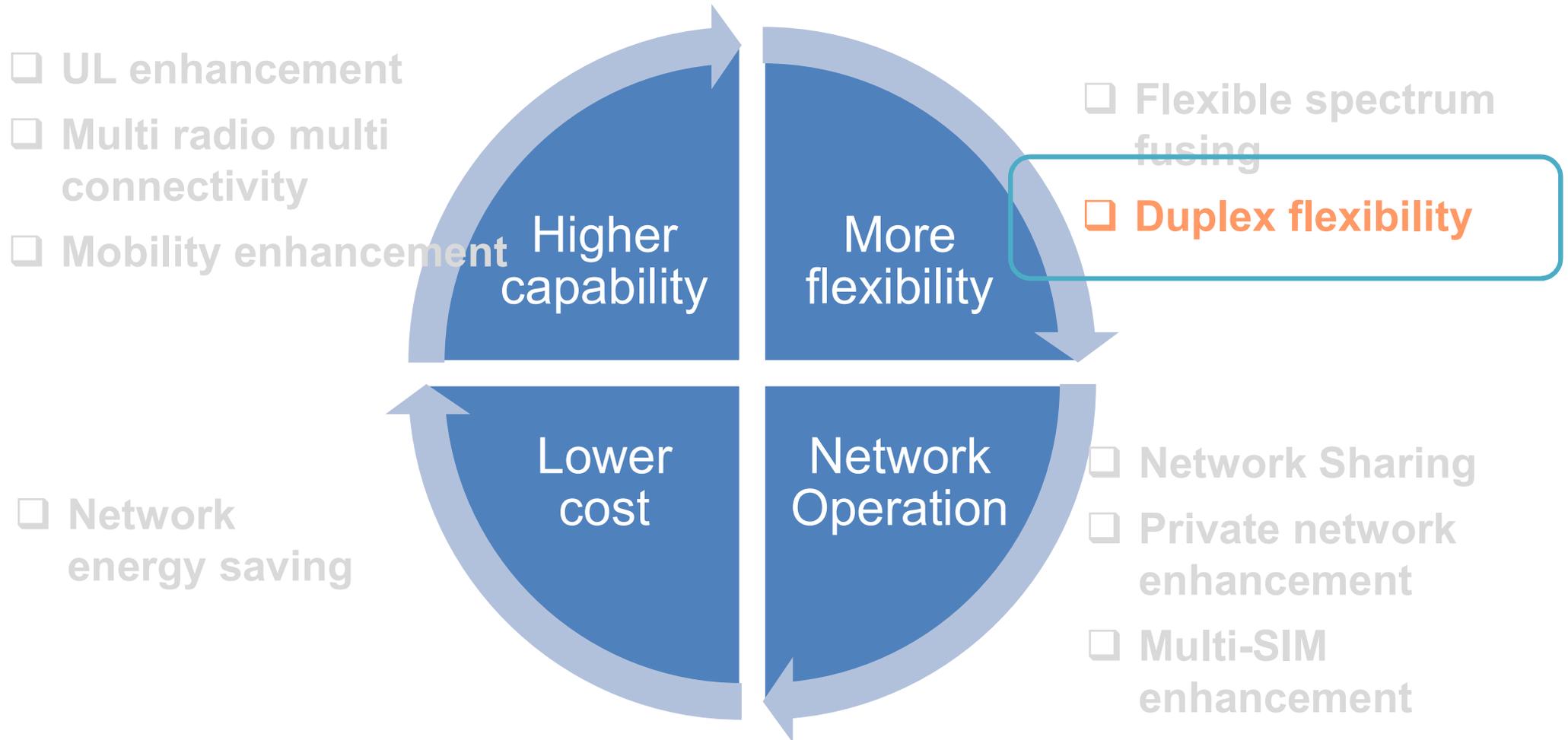
## ■ Frameworks

- » The frameworks to achieve flexible spectrum fusing include multiple cells of CA and single cell;
- » Whether to down-select the framework is FFS;

## ■ Objectives

- » For multiple cells of CA, enable flexible configuration of downlink and uplink physical carrier frequency for one or multiple frequency bands:
  - Flexible uplink and downlink carrier linkage (FDD and TDD);
  - One downlink physical carrier can be shared by multiple cells;
- » For single cell with multiple downlink and multiple uplink carriers, specify single cell mapped into non-contiguous bandwidth of one or multiple frequency bands, subject to aggregated cell bandwidth no more than Rel-17 maximum carrier bandwidth per cell.
  - A band combination of multiple bandwidths of the same duplex mode can be mapped into single cell;
- » Combine PDCCHs from multi-carriers and allocate in one of carriers
- » Simplify SSB designation to allocate in one of carriers

# Requirement for Rel-18: from a wireless perspective

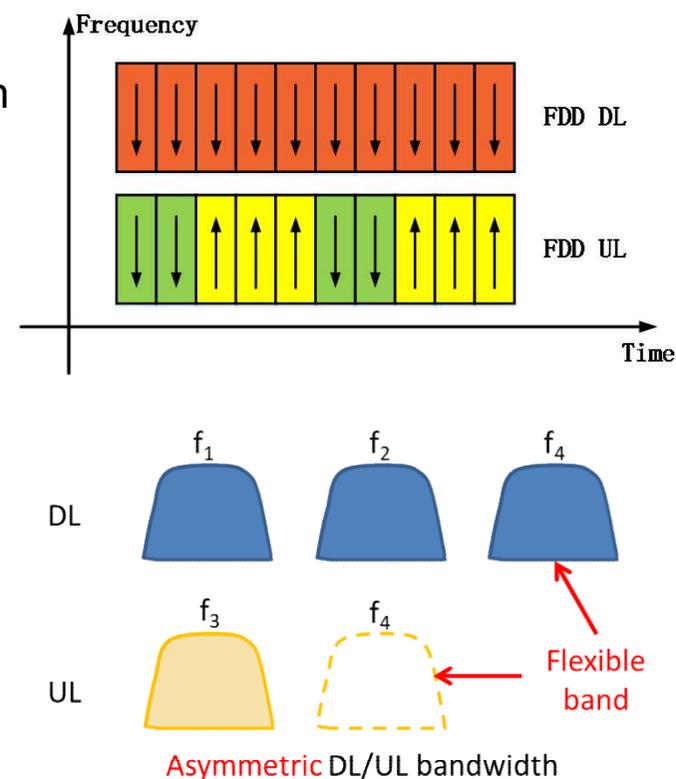


# Enhancement for duplex mode: Motivation



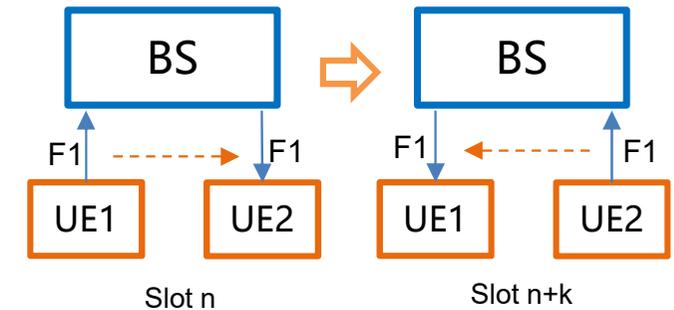
- In Rel-14 NR SI, the benefits of flexible duplex were observed in TR38.802:
  - » Evaluations show that duplexing flexibility with cross-link interference mitigation schemes provides better UPT compared to static UL/DL resource partition and duplexing flexibility without cross-link interference mitigation 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).
- For flexible duplex transmission:
  - NR already supports dynamic change of the UL/DL transmission in TDD mode.
    - To support flexible resource adaptation for unpaired NR cells, UE CLI-RSSI and SRS-RSRP measurements/reporting and exchange of intended DL/UL configuration between gNBs have been specified in Rel-16 CLI handling WI.
    - 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;
- For full duplex transmission:
  - UL/DL Simultaneous transmission doubles the spectrum efficiency in theory;

- Dynamic FDD enables the adaption to traffic imbalance in DL and UL paired spectrum, 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
- Potential study objectives to support dynamic duplex resource utilization of FDD
  - » Identify the regulatory and potential scenarios/bands under which the reverse transmission in FDD spectrum can be considered;
  - » Study signaling to enable flexible duplex transmission in FDD spectrum;
  - » Interference management for cross-link interference;
  - » Identify and define design targets for coexistence among cells in the same and adjacent frequency;

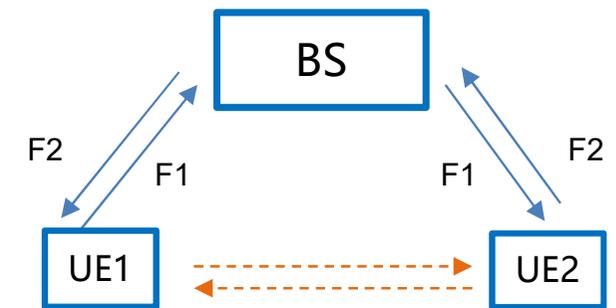


# Enhancement for duplex mode: potential scope(2/2)

- Full duplex of gNB with normal UE could be the first phase to support full duplex
- Potential study objectives to support full duplex at gNB side
  - Study the feasibility and identify the potential scenarios
    - Identify prior scenarios in terms of deployment scenario, frequency range, etc
    - Evaluation of potential performance improvement, interference cancellation requirement, coexistence among different operators in adjacent channels
  - Investigation of possible standardization impacts
    - Study the signalling, frame structure design to enable full duplex
    - Study the self-interference and cross-link interference handling techniques

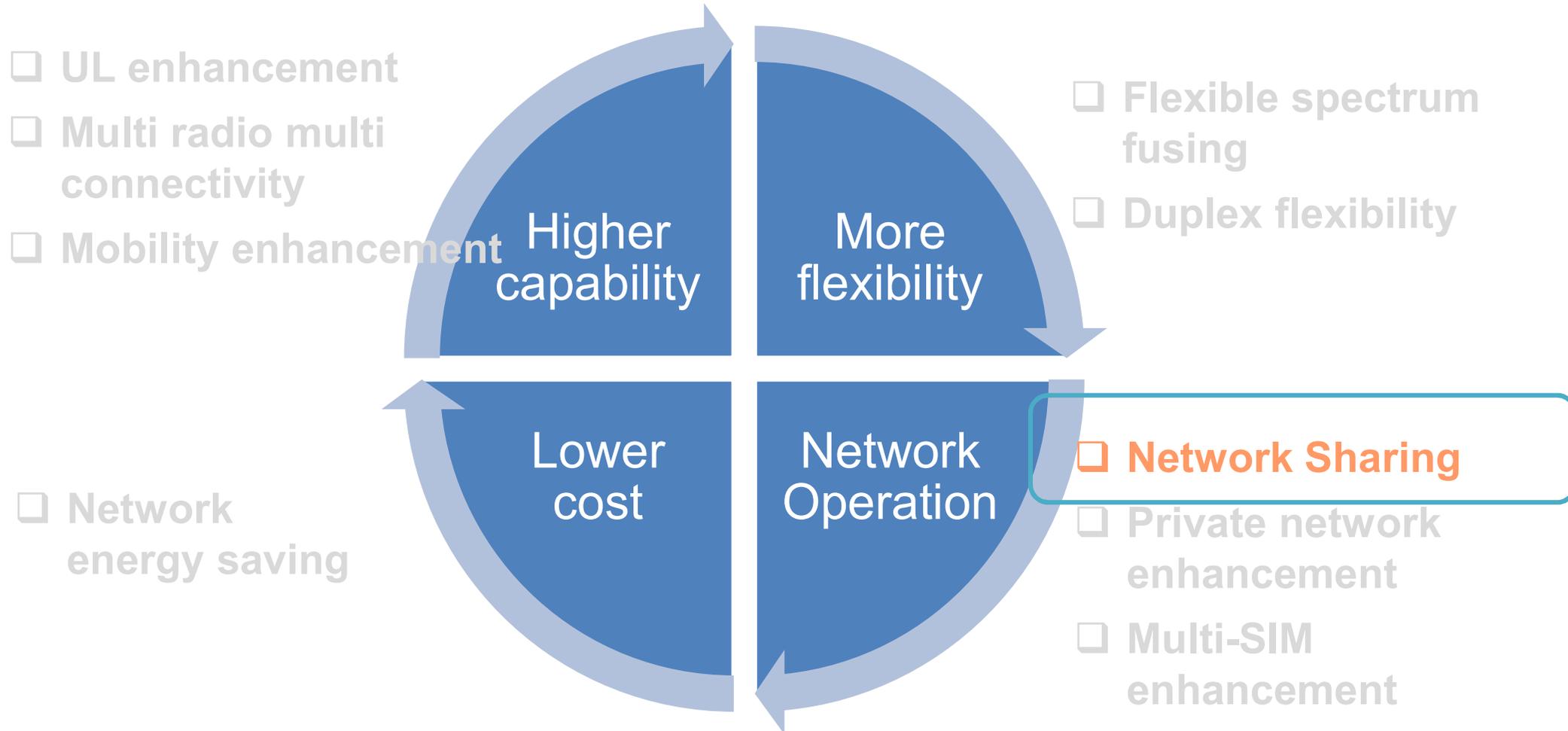


(a) TDD at UE



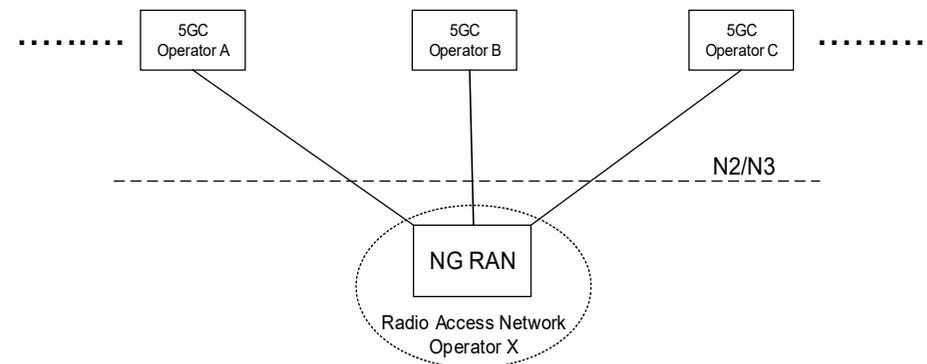
(b) FDD at UE

# Requirement for Rel-18: from a wireless perspective



# Customizable Network Sharing: Motivation

- By the cooperative deployment, operators can launch 5G network quickly with the CAPEX and OPEX reduction.
- Up to now, China Telecom and China Unicom have deployed the largest sharing 5G network in the world. There are more than three hundred thousands of sharing 5G base stations covering all of major cities in China.
- Meanwhile, the cooperative operators may have their respective operation strategies. The existing functions of network sharing need to be enhanced to meet the requirement of operator customizable configuration.



## ■ Customizable Sidelink Configuration

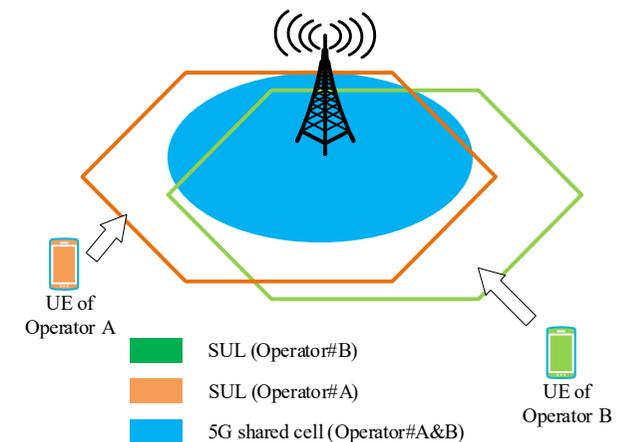
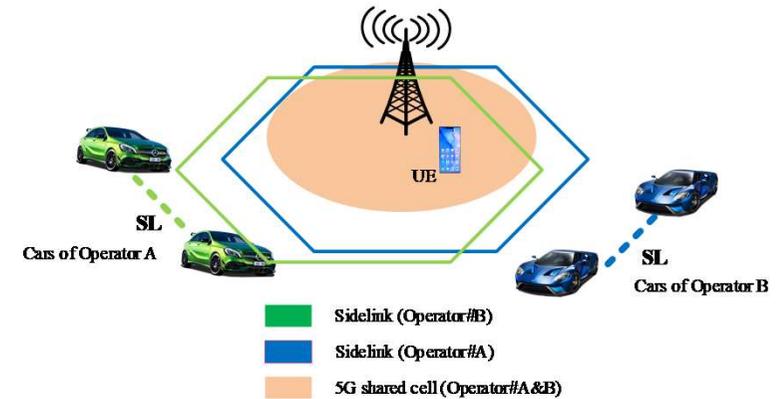
» However, the existing V2X/Sidelink functions cannot support the different configuration for operators.

## ■ Customizable SUL Configuration

» The existing SUL mechanism cannot support the different SUL configuration by operators.

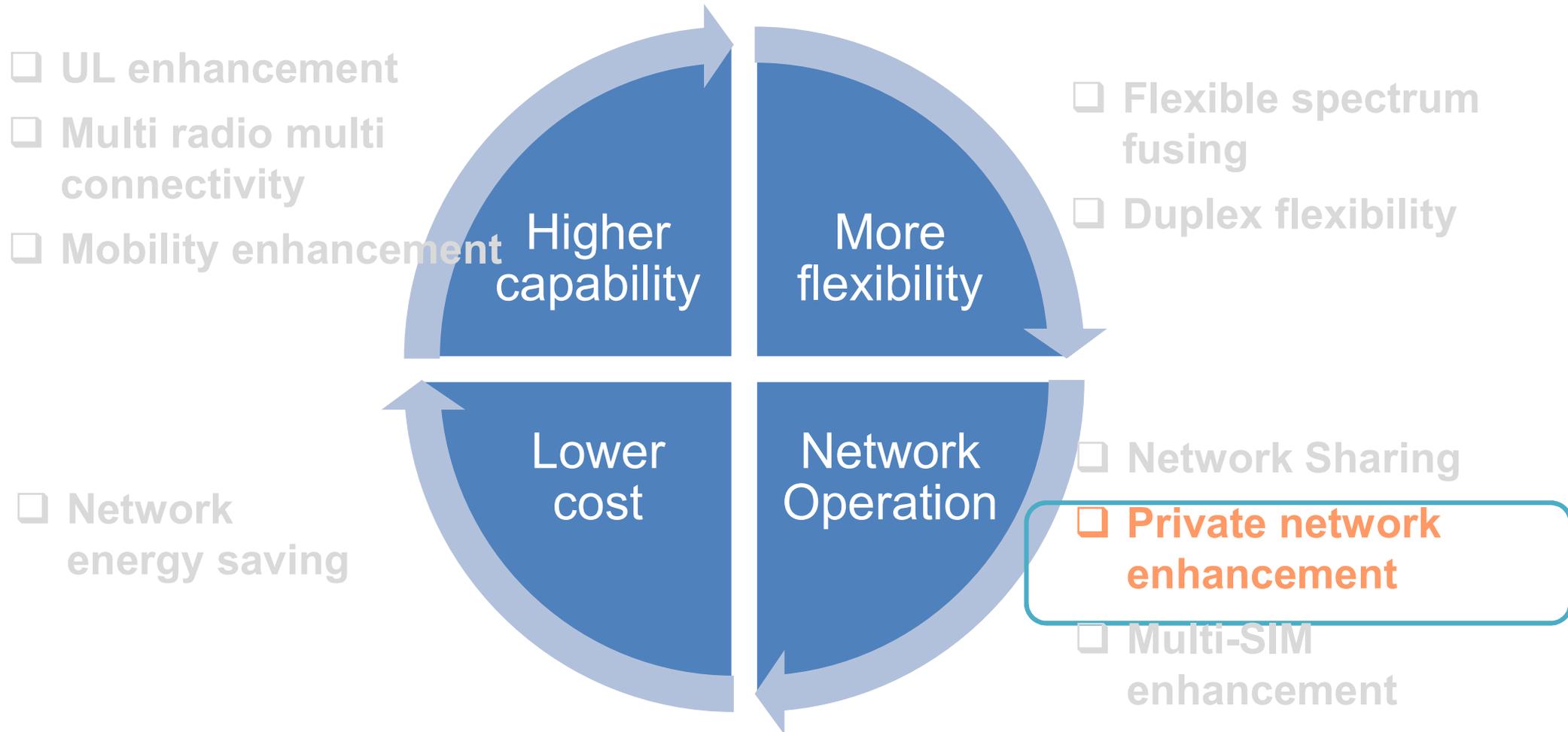
## ■ UE Type Selection for Network Sharing

» With the existing network sharing system, operators cannot select the types of users which should be allowed to access to the sharing cell.



- The objective of this work item is to enhance the network sharing functions to support the operator customizable configuration and meet the differentiated operation requirement.
- Detailed objectives of the work item are:
  1. Specify the items which should be customizable for operators;
  2. Specify mechanisms to enable customizable configuration of SUL for operators;
  3. Specify mechanisms to enable customizable configuration of Sidelink for operators;
  4. Specify mechanisms to differentiate the usage of the sharing EN-DC network between 4G and NSA users;

# Requirement for Rel-18: from a wireless perspective

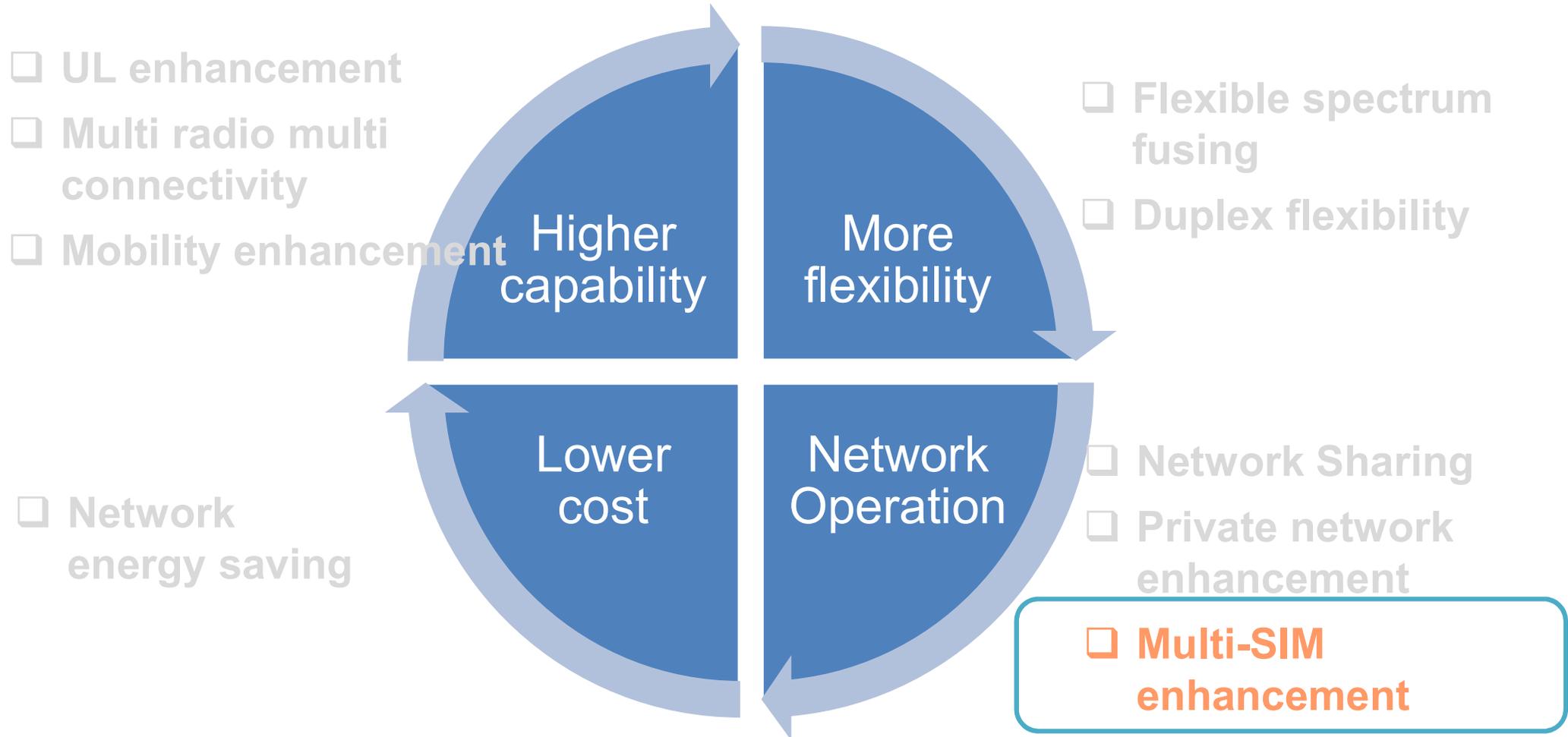


- Non-Public Network was introduced in Rel-16 with basic functions, and further enhancement in Rel-17 to enable wider cooperation between different networks/different entities to support use cases for NPN to provide access for UE that has third party credentials or no subscriptions beforehand, as well as IMS and VIAPA related use cases.
- Rel-17 FS\_eNPN study has concluded in total 4 key issues and progressed to the normative phase. But according to TR 23.700-07, there are yet two key issues not addressed in Rel-17 time frame, namely:
  - Support for equivalent SNPNs
  - Support of non-3GPP access for SNPN services
- Vertical have strong requirement to monitor the service performance:
  - Enable operator/vertical to perform an accurate troubleshooting;
  - Forecast the service performance based on the Service Performance monitoring.

- There are maybe unresolved issues left over in Rel-17 eNPN due to the tight time frame need to be further addressed in Rel-18, such as:
  - A PDU session anchored at the SNPN cannot be maintained during mobility when the UE accesses the SNPN using credentials owned by a Credentials Holder separate from the SNPN, which implies a lack of service continuity.
- From RAN points of view, there are also several aspects which need further work in Rel-18 as follows:
  - As many operators have deployed the NB-IoT networks and China Telecom has operated the largest NB-IoT network in the world, it is envisioned that the NPN for NB-IoT/eMTC can provide operators more comprehensive support of IoT use cases.
  - NG-RAN is not aware of the UE serving (selected) CAG ID in case of initial access and handover.

- Check the RAN impact of SA2 study on further enhanced support of NPN, and specify the corresponding RAN functionality where necessary:
  - Support for enhanced mobility when involving SNPN
  - Support for enhanced onboarding functionality
  - Enable more efficient SNPN support for voice services
  - Address new SA1 requirements (e.g. from PALS work) related to NPN.
- Specify the RAN functionality of the following Further enhanced NPN in NG-RAN:
  - 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;

# Requirement for Rel-18: from a wireless perspective



- 5G UEs supporting 2T/4R become mainstream in market.
- Without adding new RF module, Multi-SIM UE can support dual Tx/ dual Rx by sharing one Tx and multiple Rx chains between two USIMs dynamically, and therefore provide a better user experience.

- **Offer better user experience in voice service and data service**

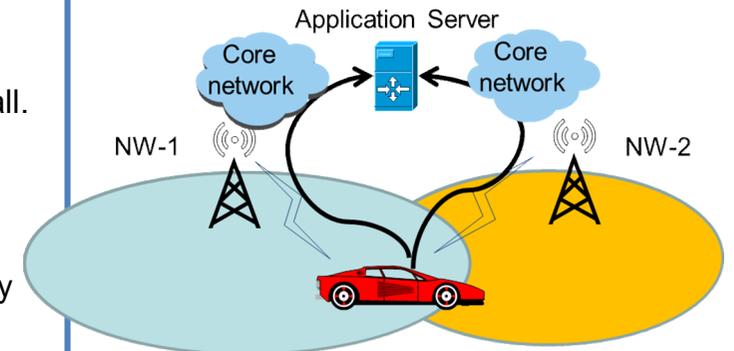
- ✓ support data service in one USIM while voice call ongoing on another USIM
- ✓ notify user of an incoming call of another USIM without impact the ongoing voice call.

- **Offer more reliable connections for vehicle communication.**

- ✓ Set up connections with both NW-1 and NW-2 and application can route data packets through either or both network according to the network service quality. The server finally aggregates the packets from NW-1 and NW-2 in application layer.

- **Activate 5G message services in both USIMs.**

- ✓ Traditional short message will finally evolve to 5G message which enable the users to exchange multimedia contents such as picture, video, audio and file via operators' IMS core network. The UE has to keep alive for 5G message services every three to five minutes. In addition, if 5G message service in USIM-1 and USIM-2 are frequently activated like wechat and whatsapp the Multi-SIM UE has to keep connection with both NW-1 and NW-2

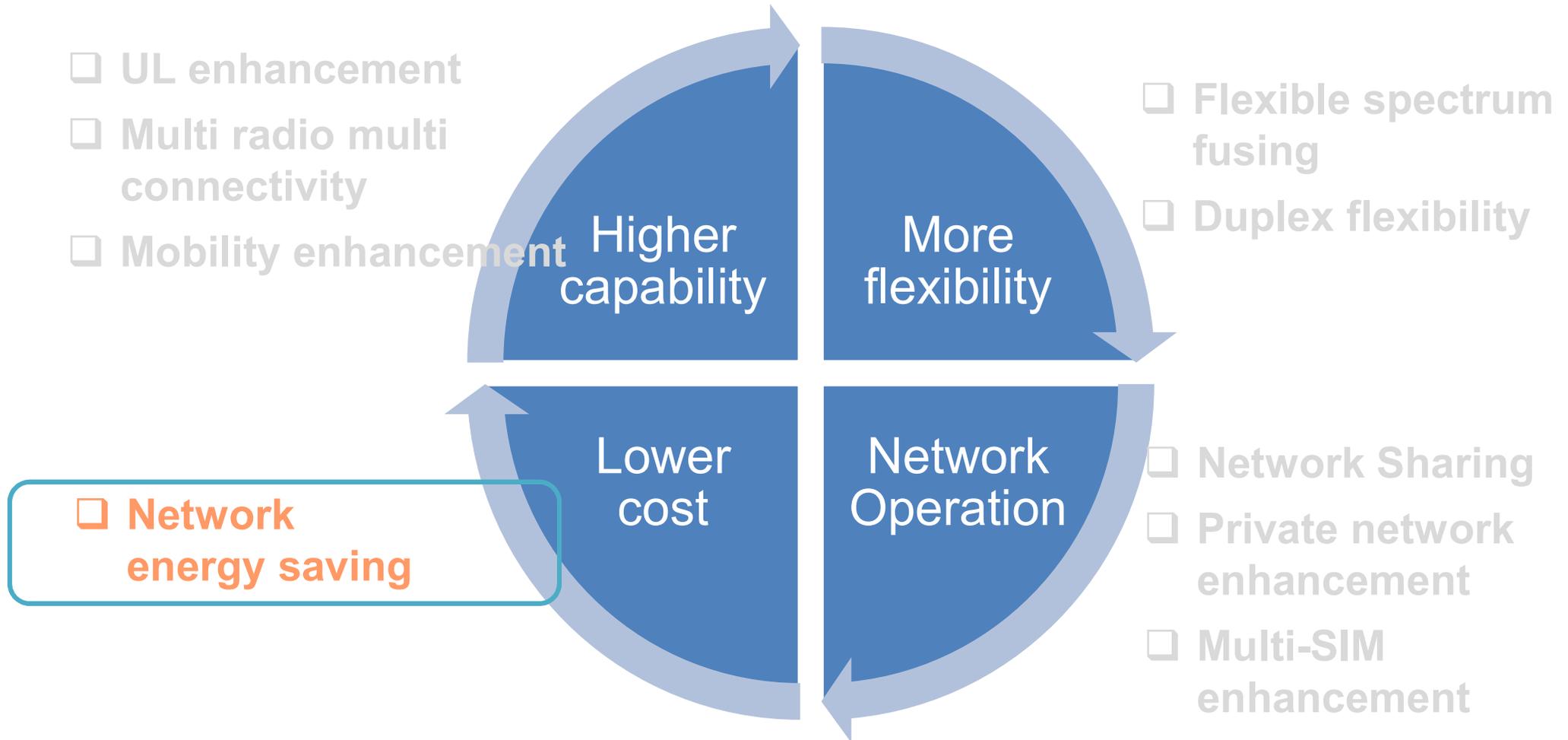


Multi-SIM vehicle module with dual Tx/ dual Rx capabilities can set up connections with both NW-1 and NW-2

- In 3GPP rel 17, WID of support for Multi-SIM devices is still ongoing. The scope of the WI only covers the use cases for Multi-SIM devices with single Tx/ dual Rx and single Tx/ single Rx capability. Dual Rx/ dual Tx is excluded from the WI for lack of time budget. However, plenty of companies thought dual Tx/ dual Rx Multi-SIM devices deserve further study in future release. At least the key issues below should be considered.
- **Key issue1: UE capabilities are impacted when it tunes away partial of Tx or Rx chains from NW-1 for connected mode activates in USIM-2.**
  - » Maximum number of Uplink/ downlink MIMO layers, CA/DC band combination and capabilities related to SRS may be impacted when both USIM enters RRC CONNECTED states. UE will encounter RLF and RRC configuration failure if UE and network are out of sync in capabilities.
- **Key issue2: UE transmitting power may be impacted for UL power sharing between two USIMs.**
  - » When dual Tx/ dual Rx UE are in RRC connected status in both USIMs and transmitting simultaneously with two networks, the total uplink transmitting power is shared by two USIMs. As restrained by SAR, the UE may not be able to support simultaneous transmission with maximum output power when both USIMs are active. Therefore, UE should reduce output power to guarantee SAR requirements and the strategy of output power reduction maybe diverse for different type of devices.
- **Key issue3: Interference maybe exist between different USIMs.**
  - » For UE supporting dual Tx/dual Rx, kinds of interference signals (Harmonics Interference, Intermodulation Interference, Crossmodulation Interference, Blocking Interference,etc) between different RF transmission chains may exist. To solve complex problems of interference when UE activates two USIMs, interference control scheme needs to be considered for both chip design and device design.

- Proposal: Enhancement on Multi-SIM devices supporting dual TX/ dual Rx are considered in a Rel-18 WI.
- Specify mechanism for UE to notify Network A of its update in capabilities when it tune away partial of Tx or Rx chains from Network A.
- Specify mechanism for UE to request Network A to release/deactivate SCG/Scell for Multi-SIM purpose.
- Evaluate the impact of UL power sharing between two USIMs and specify power transmitting requirement if needed.
- Evaluate the impact of interferences between different USIMs and specify an interference control scheme if needed.

# Requirement for Rel-18: from a wireless perspective



- Power consumption of a single NR base station is 3+ times higher than LTE currently.
- Implementation based base station energy saving solutions have been considered
  - Channel shutdown, carrier shutdown, deep sleep and device shutdown, etc
  - Based on relative semi-static and statistical criteria, e.g., cell load over/under a certain threshold
- Network energy saving solution specified in LTE and NR
  - The cell switch-off/re-activation of capacity booster cell via X2/Xn/S1 interface
  - The inter-system network energy saving is being discussed as one issue of NR R17 WI “enhancement of data collection for SON/MDT in NR”
  - AI based network energy saving is one of the use cases in NR R17 SI “Study on further enhancement for data collection”

## ■ Extension to more scenarios

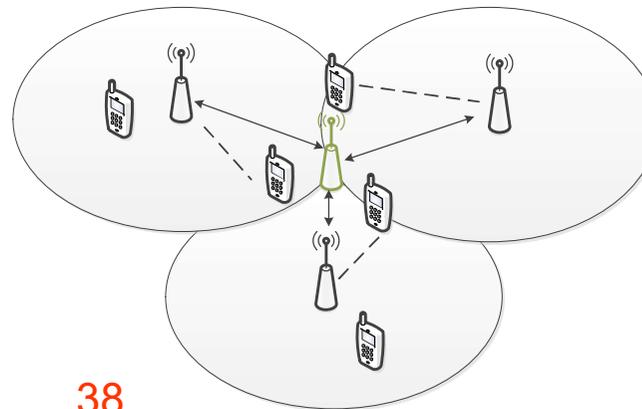
- Only single hop network is considered so far, and multi-hop network scenario, e.g., IAB, needs further study
- Only capacity booster cell scenario is considered, and compensation cell scenario needs further study

## ■ More flexible and dynamic energy saving management

- Currently, the cell/module switch off/on decision
  - is based on coarse statistical cell load information, e.g., number of connected UEs
  - is controlled by preconfigured sleep period manually, and can only be applied to the tidal case
  - is with the assumption of uniform traffic distribution, and NOT the actual traffic distribution in time domain/geographic area

# Network energy saving: Potential enhancements

- More flexible and dynamic energy saving management
  - To enable more accurate and flexible gNB/module level energy saving strategy decision, especially for non-tidal case and non-uniform traffic/UE distribution
  - To enable timely gNB wake-up mechanism as response to the upcoming traffic/connected UEs or the idle/inactive UEs of which the traffic is about to arrive
- Potential enhancements
  - Potential UE assistance information report, e.g., traffic prediction
  - gNB information exchange to support beam level operation coordination and transmission power adjustment coordination
  - UL/DL measurement enhancement



# Thanks!

---