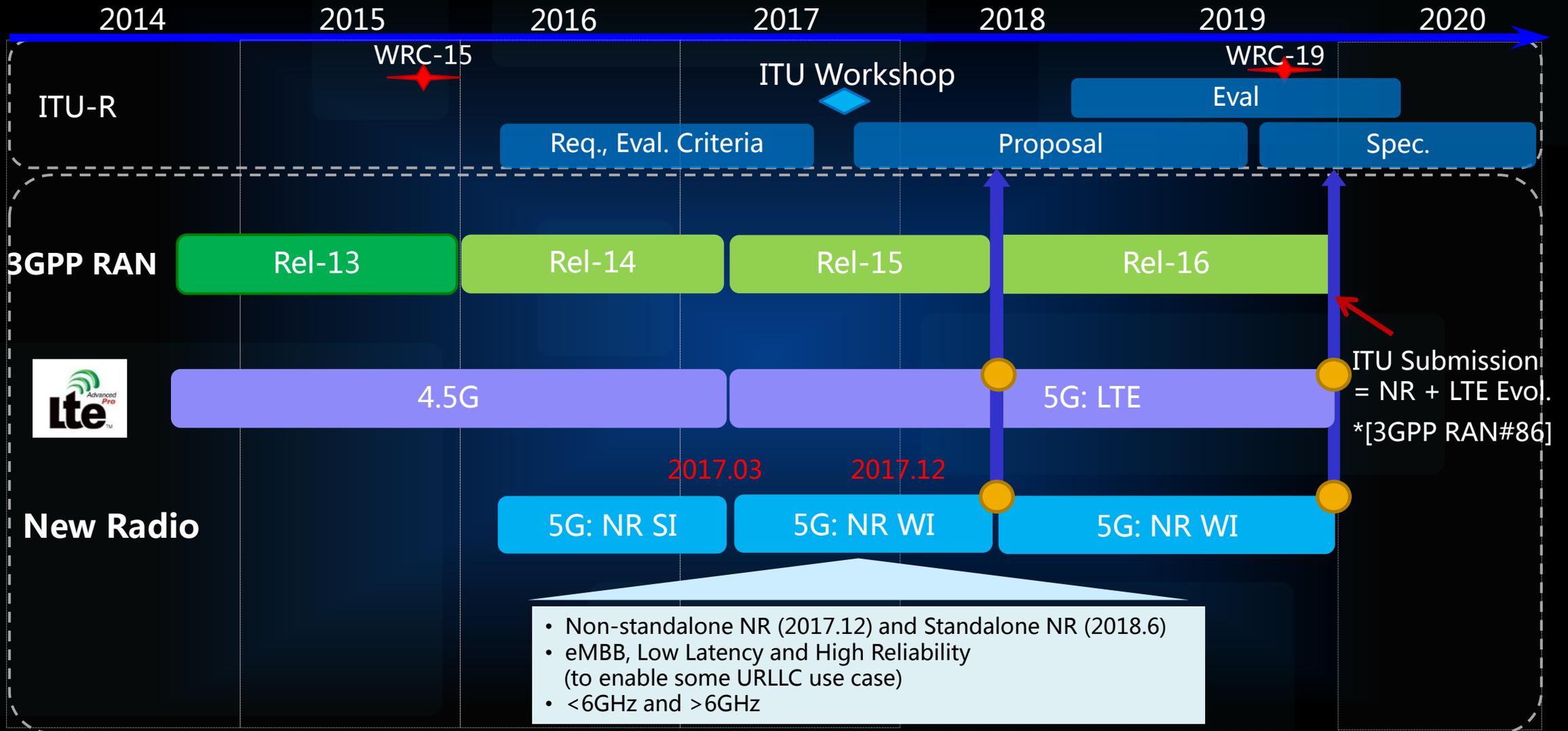




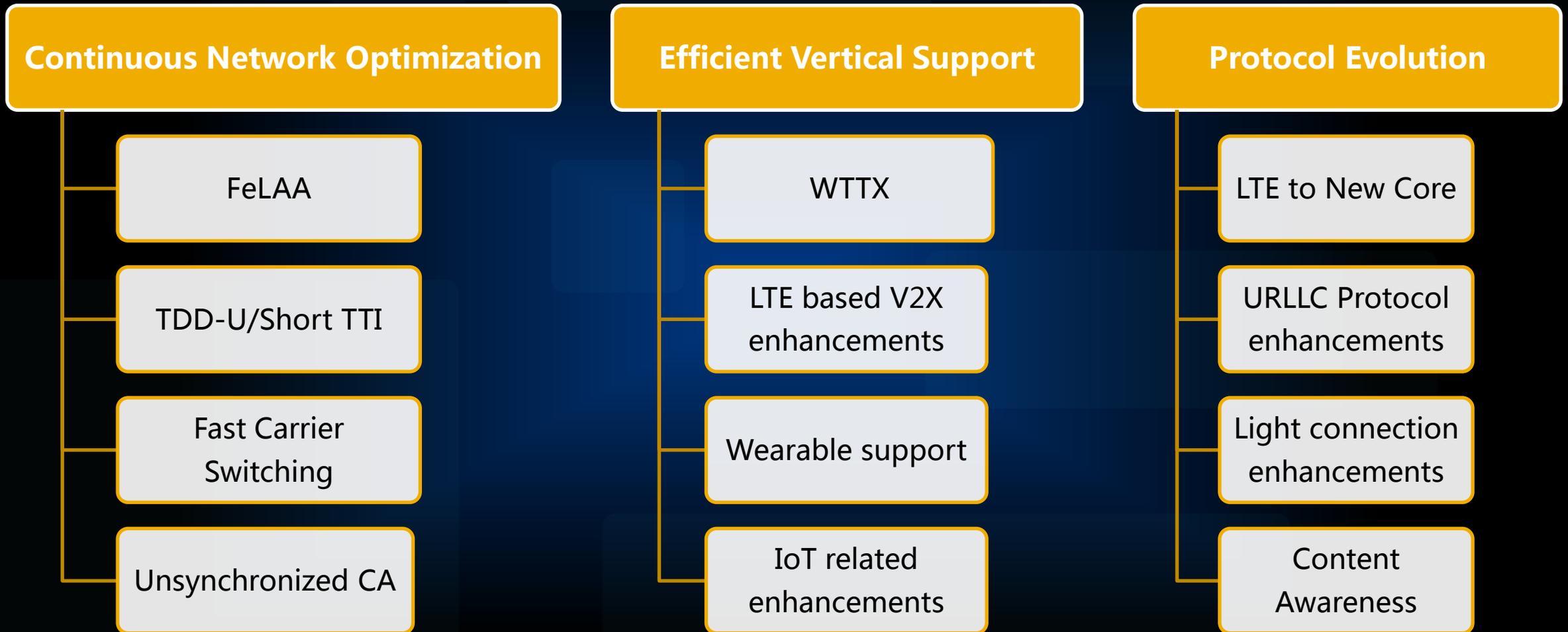
# LTE Continues Evolution in 5G Era!

- LTE Rel-15/16 will meet key IMT-2020 requirements while providing backward compatibility
  - To efficiently address the continuous increasing capacity need for enhanced Mobile Broad Band
  - To support Ultra Reliable Low Latency Communications
  - To further accommodate the well identified valuable vertical service over cellular network
- Some Rel-15 topics will be continuations of Rel-14

# Standard Roadmap: (Rel-15 and onwards)

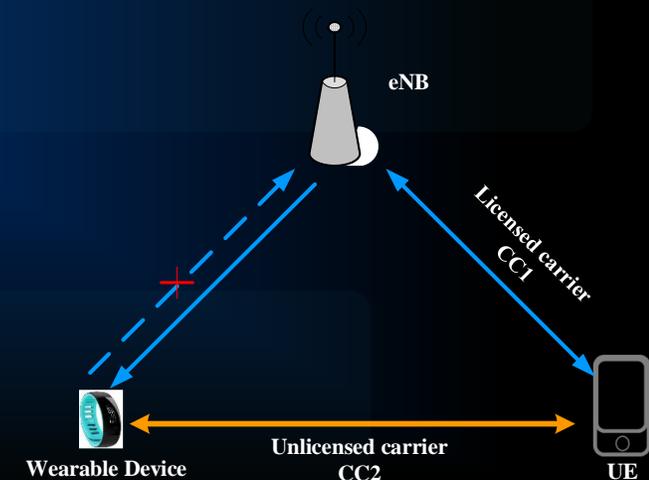
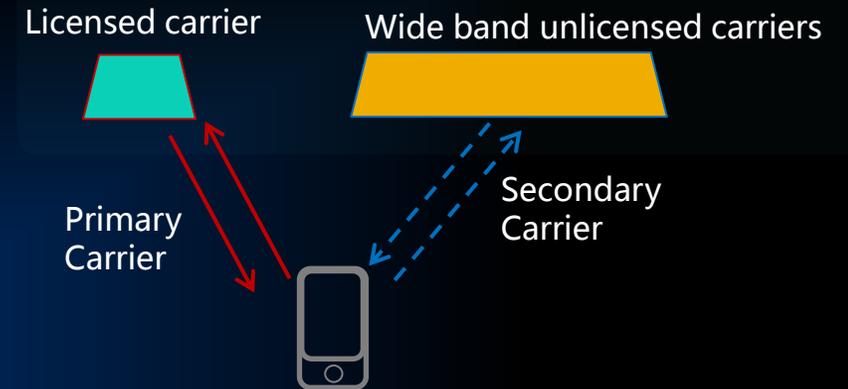


# Overview of LTE Rel-15 Key Features

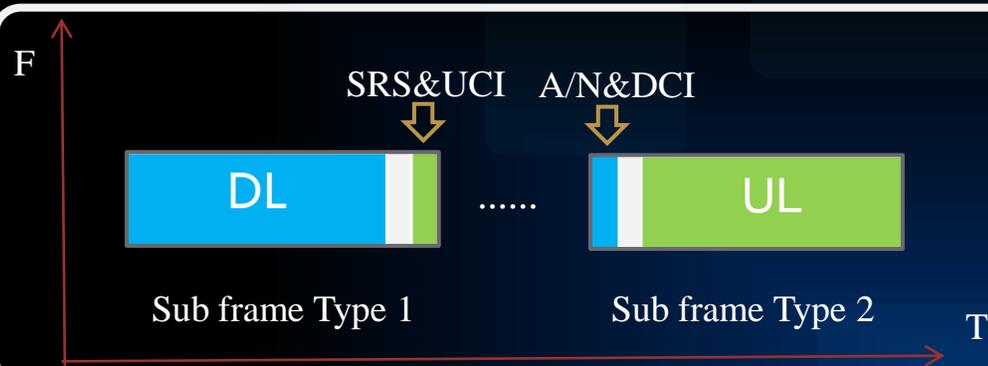


# Further enhancements of LAA

- Start the work now and finish in Rel-15
- Symbol level scheduling for FS3 to improve system performance and resource utilization efficiency
  - Increase the starting position candidates within 1ms-TTI
  - Reduce the time delay between UL transmission and UL grant, to improve the UL performance
  - Faster release of the resource for better coexistence
- Wider bandwidth (40MHz, 80MHz) per carrier, increased sub-carrier spacing, and shorter TTI
  - Improve channel utilization efficiency and reduce implementation complexity
  - Better PAPR (3 dB and more)
  - Enable scalable bandwidth and reduce power consumption
- Sidelink between wearable and UE over unlicensed band, assisted by licensed Uu link
  - Save licensed spectrum from operators for better use and is beneficial to existing UEs.
  - The Uu link from the licensed spectrum can also be used for management of and backup to unlicensed sidelink for better QoS, coverage, and low power consumption.



# TDD Universal Frame Structure

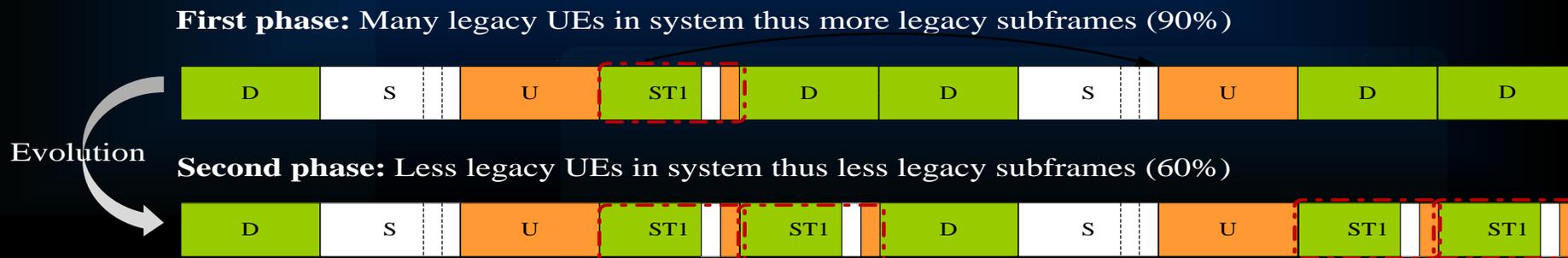


## • TDD Universal Frame Structure

- DL/UL control channels in one SF as FDD
- Uniform HARQ Timing as FDD
- LTE numerologies and backward compatible

## • Benefits

- Fast SRS/CQI for Massive MIMO
  - More beam-forming gains
  - More gains for small packets and high speed users
- Short HARQ RTT
- Control channel alignment across cells
- Dedicated A/N to reduce bundling



# Fast Carrier Switching

- Motivations

- Allow UE with limited CA capability/complexity/energy to quickly access more carriers in UL & DL
- Improve network interference coordination / load balancing and utilization ratio of CA
- Take full advantage of multi-carrier LBT for LAA
- Can naturally incorporate and enhance R14 SRS switching, which further improves DL beamforming for TDD CCs
  - Conclusion on switching time from R14 SRS switching confirms that subframe level switching is feasible
- 2x ~ >5x edge UPT gains than slow carrier switch for licensed/unlicensed carriers

- Objectives

- To support efficient carrier selection operation for load balancing/shifting, interference coordination and avoidance, based on fast carrier switching for DL and UL at the UE [RAN1]
  - Enhancements to enable fast switching: L1 indication and signal, L2 MAC signaling
  - Measurements, feedback, and procedures
  - Cross-carrier HARQ retransmissions, including asynchronous HARQ for UL
- Corresponding higher-layer procedures and signalling [RAN2]
- Corresponding UE and eNB core requirements and enhancements [RAN4]
  - Switching times
  - Measurement enhancements

# Unsynchronized CA

Scenarios	Synchronized Network Ideal backhaul	Unsynchronized network Non Ideal or Ideal backhaul
UE capable of two UL carriers	Carrier aggregation	Dual connectivity
UE capable of single UL carrier	Carrier aggregation	Not supported so far

- UE capable of only one UL CC cannot support Dual Connectivity in case of unsynchronized network
- Supporting user plane aggregation with single uplink for inter-sites in the unsynchronized network , for example
  - Remove the SFN alignment requirement between serving cells for CA
  - PCC acquires SFN offset between cells of two sites
  - PCC configures the HARQ mapping, DRX and measurement GAP to UE based on the SFN offset

# WTTx Enhancements

- A wireless connection from a LTE eNB to a “super UE”
  - E.g., from LTE eNB to above-rooftop CPE then to indoor users
  - E.g., from LTE eNB to faraway super UE then to scattered rural users
  - Note link between the super UE and the end-user is not within the scope of this proposal and can be non-3GPP link.
- Distinctive characteristics of WTTx include channel conditions, very low mobility UEs, very high capability and high demand UEs.
- The access link Requires new features and enhancements to be customized, standardized, and developed for very high efficiency.  
E.g. Peak data rate > 1 Gbps per 20 MHz CC, i.e. 50 bps/Hz
- Technical components considered:
  - Higher-order modulations (e.g. 1024QAM)
  - CA enhancements with reduced GP, DL/UL CA for high capability UE
  - Enhancements for long-distance communications (control channel)
  - MIMO enhancement (e.g. high order MIMO, LA enh. SRS enh.)
  - Procedural simplification and overhead reduction (RRM, DM-RS reduction)
  - Control channel enhancements and overhead reduction (e.g. Joint DCI for multiple SFs and CCs)
  - Support 16/32 multiple RX antenna (RAN4 impact)

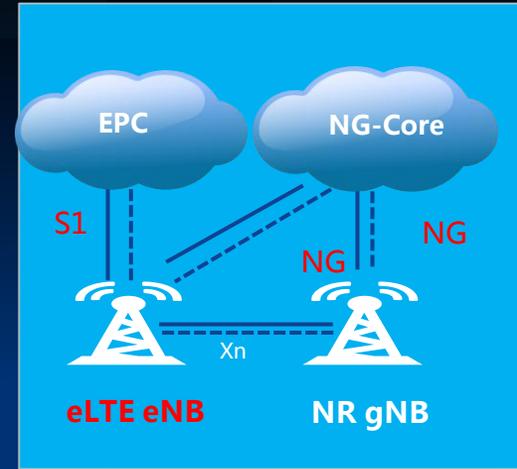
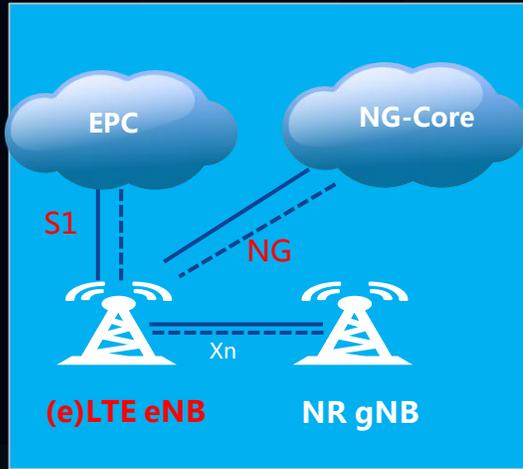
# LTE Based V2X Enhancement

- New study at SA1: “SID Proposal for Study on Enhancement of 3GPP support for V2X services” covering both evolved LTE RAT and new 3GPP RAT (i.e. NR)
  - There would be two phases for CoSdG (Cooperative Short Distance Grouping, similar to platooning)
  - In Phase I, the typical required transmission frequency among the vehicles is up to 40Hz, translating into 25ms radio latency
  - In Phase II, the transmission frequency is 100Hz to coordinate the driving maneuver. The radio latency is 1ms
- eV2X for Rel-15 to support platooning
  - Further latency reduction if Rel-14 does not meet CoSdG requirements
  - Enhancements for sidelink unicast for reliability and efficiency improvement
  - Tight coordination between Uu and PC-5
  - Filter design for reduced In-Band Emission (RAN4)

# IoT Enhancement

- NB-IoT further enhancement at Rel-15, e.g.
  - TDD NB-IoT
  - Enhancement to support wearable devices
- Procedure optimization for contention based transmission
  - RAR without control channel
  - Scheduling grant based on the pre-configured resource
  - Simplified RACH procedure
  - HARQ optimization (e.g. group feedback)
- Uplink non-orthogonal multiple access
  - Time domain spreading for UEs with repetition transmission
  - Frequency domain variable spreading transmission with/without bit arrangement to add transmission reliability

# Supporting NSA NR and Connecting to NG Core



- Support Non-standalone NR
  - New interface between (e)LTE eNB (evolving to Rel-15) and NR gNB
  - Common PDCP
- eLTE eNB connecting to NG Core
  - New interface between eLTE eNB (evolving to Rel-15) and NG Core
  - Enhancements on RRC/PDCP/etc. layers to support the new NG Core functions.

# URLLC Support



- Reliability > 99.999% & E2E latency ( both UL & DL <= 8ms in most cases )
- Mainly medium to small packets < 100B or data rate is ~10Mbps
- Coverage everywhere
- Fast connection setup required
- Requirement for high speed (> 120km/h ) in some cases
- Dense devices for industrial environments

- Multi-link diversity in frequency/spatial domain
- Coding schemes with no error floor and quick decoding
- Ultra-reliable and low latency for DL/UL control channel
- Multi-QoS multiplexing (e.g., URLLC and eMBB) on the same carrier
- Fast RRC state transition
- CP latency reduction via shortened RACH procedure
- Make-before-break based mobility
- Multiple connectivity for reliability improvement

Thank you