Views on 5G-Advanced evolution towards 6G

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3GPP Rel-19 RAN Workshop
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Source: Kyocera Corporation

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Overview

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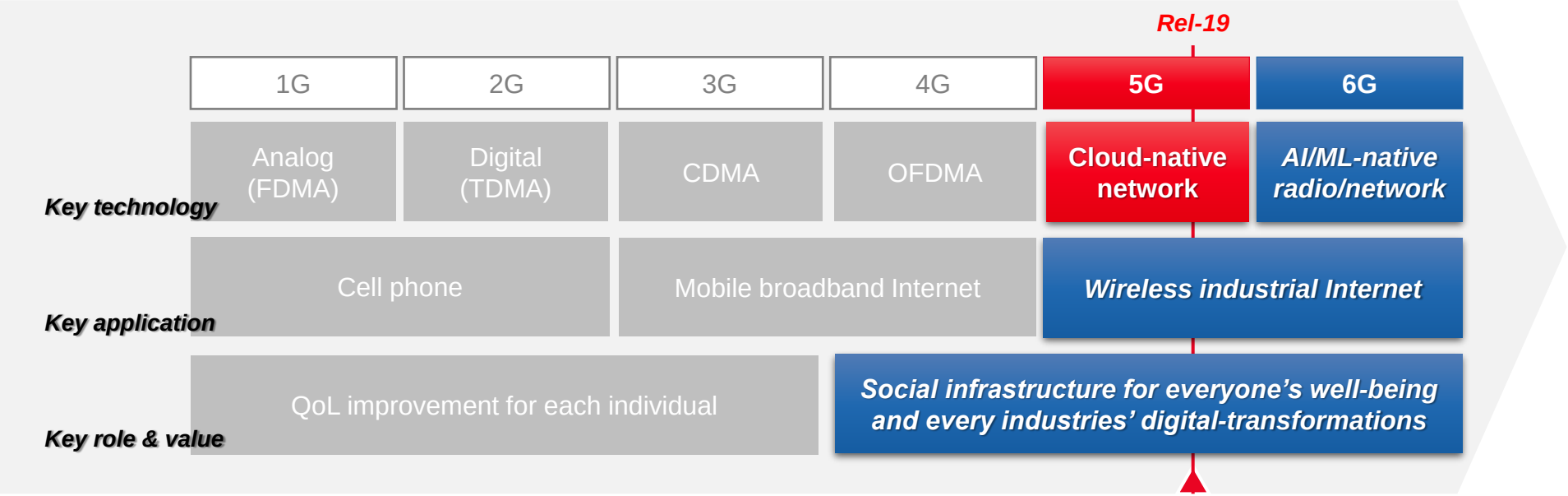
Evolution of mobile network

- Mobile network is expected to take more important roles in the next generation of society, e.g., Society5.0.
- Innovations happened in Technology per 10 years, in Application per 20 years and in Role & Value per 30 years.



Rel-19 is the important stepping-stone towards 6G for sustainable & human-centric society

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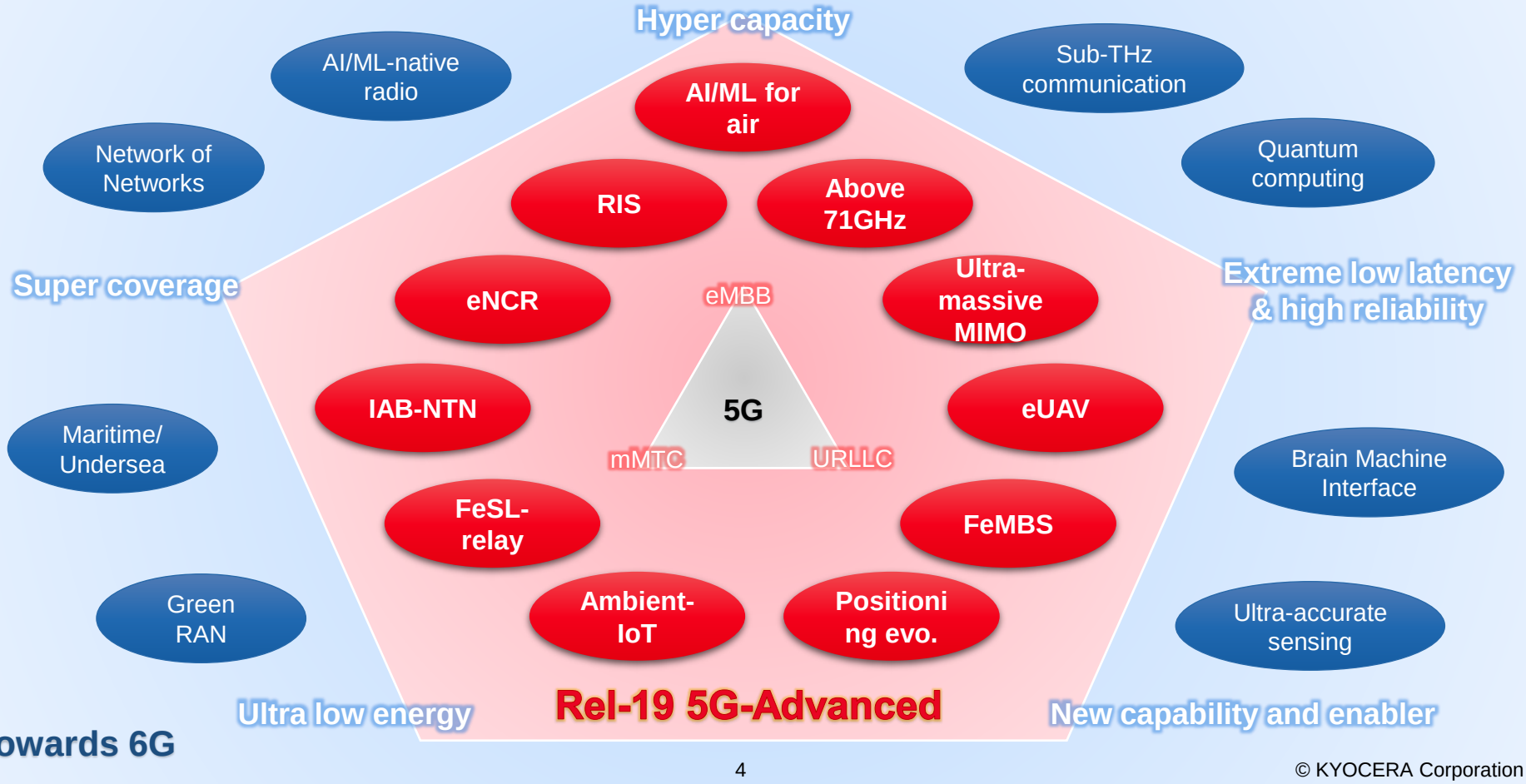
Rel-19 evolution of 5G-Advanced towards 6G



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Highlighted items of interest

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Study on frequencies above 71GHz

Backgrounds

- Rel-17 Extended NR operational support to 52.6-71GHz, which includes the support for the global 60 GHz unlicensed band.
- ITU identified the frequency bands in the range 100GHz to 450GHz for the operation of fixed and land mobile service applications (Ref: WRC-2000 and WRC-19 decisions).
- On-going Rel-19 SA study items work activity reflect 5G-Advanced communication requirements to support Industrial service applications.

Observations

- The availability of Sub-THz frequency bands in the range (100-300GHz), for communication over multiple GHz-wide channel bandwidths, has the potential to address the beyond-5G-Advanced/6G services in a variety of vertical markets.
  - For example, further high-speed and high-capacity of communication infrastructure will be required to realize CPS (Cyber Physical Systems)/Digital Twin and the use of Sub-THz frequencies (100-300GHz) for communications seems to be promising.
- The use of Sub-THz frequencies is often considered unsuitable for long range communication because of their high attenuation. However, their short wavelengths enable large arrays which have the potential to enable longer range communication. (Fig.1 & Fig.2)
- The challenge is the precise adjustment of a pencil beam and narrow coverage, but they also have the advantages of security, less interference and reduced total system power consumption.
- The sub-THz system air interface will not operate in a standalone mode, rather it will use lower frequency (e.g., sub 6 GHz) nodes as anchors to provide sub-THz services (Fig.3)

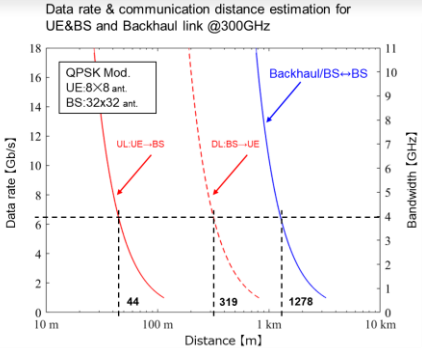

Fig. 1 Link budget curves

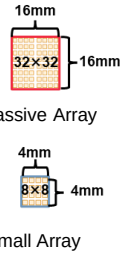

Fig. 2 # of Ant. elements (300GHz)

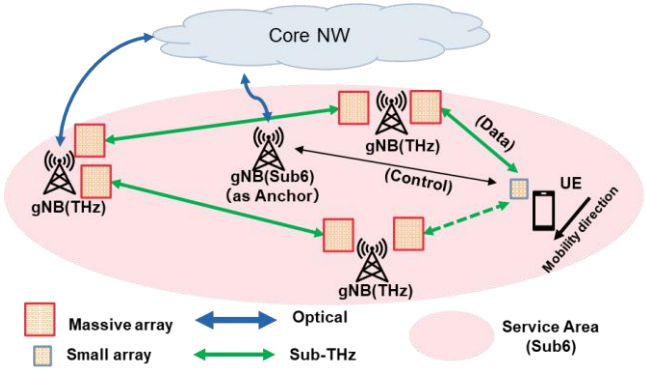

Fig. 3 Sub-THz frequencies deployment configuration example

Begin an early-stage study of Sub-THz use cases, deployment scenarios and requirements in Rel-19 and later.

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Study on Reconfigurable Intelligent Surface (RIS)

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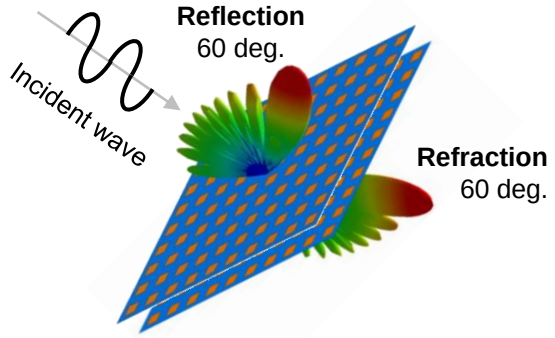
Motivations

- Coverage and capacity enhancements are essential and most important point in cellular systems, especially for FR2 deployments:
  - Rel-16 introduced Integrated Access and Backhaul (IAB), comprised of IAB-DU and IAB-MT.
  - Rel-17 introduced NR Repeaters, which is just amplify-and-forward (AF) repeater.
  - Rel-18 introduced Network-controlled repeaters (NCR), comprised of NCR-Fwd and NCR-MT.
- Reflector is one of traditional methods in wireless systems to make the signal path to be seen as “quasi” line-of-sight.
- Metamaterial is widely used in products such as antenna, reflector and refractor (i.e., meta-surface).
- Stand-alone meta-surface with beamforming is close to mass-production, and RIS is in PoC phase.

	RIS	IAB	Repeater	NCR
Coverage extension	Short	**Long**	**Long**	**Long**
Repeating signal SNR	**Ideal**	**Ideal**	Worse	Worse
Complexity	**Low**	Very high	Medium	Mid. to high
Power consumption	**Low**	Very high	Medium	Mid. to high
NW-controlled BF	**Yes**	**Yes**	No	**Yes**
BF variable angle	**240 deg.** **Reflect & Refract*	e.g., 120 deg. **Panel ANT*	e.g., 120 deg. **Panel ANT*	e.g., 120 deg. **Panel ANT*
Full duplex support	**Yes**	**Yes**	[No]	[No]
Deployment	**Window/Wall**	Rooftop	Rooftop/Pole	Rooftop/Pole

One surface with 240 deg. reconfigurability



Study on RIS should start in Rel-19, in order to encourage & accelerate mmWave deployment/usage

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Study on Ambient IoT

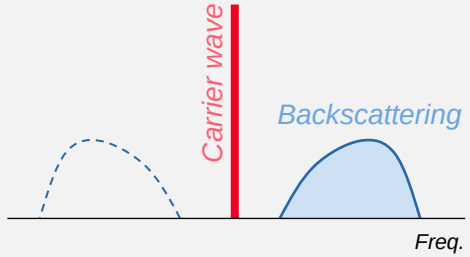
Rel-18 RAN-level study outcomes

- RAN-level study on Ambient IoT is planned to be completed in RAN#100 [RP-223396].
- TR 38.848 captured various considerations on scenarios, use cases, topologies, design targets, etc.
- In addition, three device categories for Ambient IoT device were captured, i.e., Devices A, B and C:
  - At least for Devices A & B, backscattering transmission is assumed to be applied.

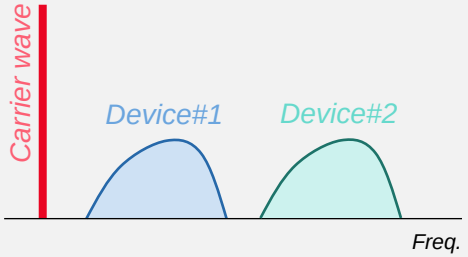
Proposed requirements for Rel-19 WG-level study and normative work

- Waveform should be common for all device categories, i.e., backscattering transmission is baseline.
- Single-sideband (SSB) backscattering transmission should be considered, in terms of spectral efficiency and for providing a higher average effective power across the transmitted band.
- Multiplexing of backscattering transmissions from multiple devices (due to one carrier wave) should be considered.
- Co-existence with NR deployment should be ensured, i.e., shared radio resource is baseline.

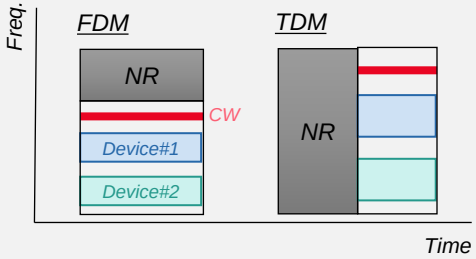
SSB backscattering transmission



Multiplexing of devices



Co-existence with NR



Follow-up WG-level study is expected to start in Rel-18, for corresponding normative work in Rel-19

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Enhanced network-controlled repeaters (eNCR)

Rel-18 NCR supported a set of basic functions:

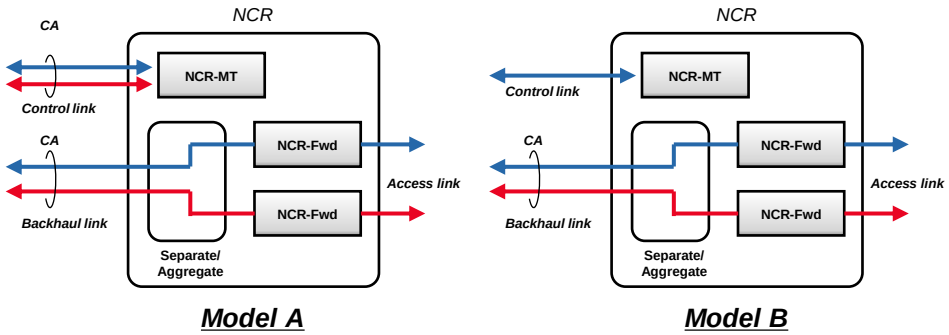
- Introduction of NCR comprised of an NCR-Fwd and an NCR-MT.
- Single-beam operation by Side Control Information and Configuration.
- Manual configuration of NCR-Fwd characteristics by OAM.
- Limited support of CA/DC deployments, e.g., forwarding contiguous CA signal by NCR implementation.

However, Rel-18 NCR was just workable but still less efficient for practical deployments.
On the other hand, demands of NCR are increasing due to e.g., mmWave deployments and for future Sub-THz usage.

Rel-19 should support practical enhancements

- *For better coverage and capacity:*
  - Multi-beam operations.
  - Full support of CA/DC deployments.
- *For CAPEX and OPEX reductions:*
  - Non-OAM dependent NCR-Fwd configuration,
    - e.g., Beam characteristic identification via NCR-Fwd Capability, instead of OAM.
  - Interoperability for multi-vender deployments.
- *For wide-range and early implementation:*
  - Active reflector/refractor (or RIS) as NCR-Fwd

CA setup model options



Enhancement of NCR is essential for wide-use in practical networks and better user experiences on FR2

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Further enhanced sidelink relay (FeSL-relay)

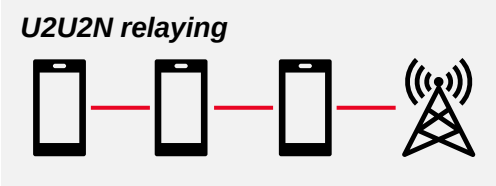
Sidelink relay status:

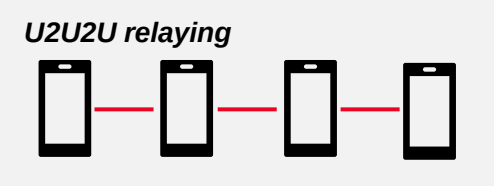
- Rel-17 introduced UE-to-Network relay (U2N), with L2 and L3 relaying architectures.
- Rel-18 supported UE-to-UE relay (U2U) and multipath relaying (with direct path and indirect path).

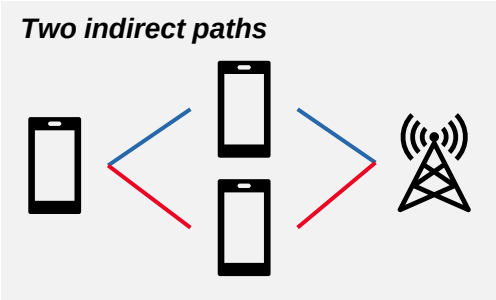
However, multi-hop relaying has not been specified even though it's quite useful e.g., on disaster sites. Additionally, multipath relaying is limited to the set of direct path and indirect path, i.e., working only in-coverage. Lack of topology options would only offer limited QoS, especially for out-of-coverage UEs.

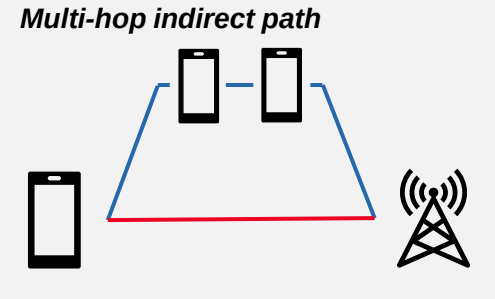
Rel-19 supports additional topologies

- Multi-hop relaying:
  - U2U2N relaying.
  - U2U2U relaying.
- Enhanced U2N multipath relaying:
  - Two indirect paths.
  - Multi-hop indirect path.
  - Inter-gNB multipath relaying.
- U2U multipath relaying:
  - Indirect path + direct path.
  - Two indirect paths.
- Coexistence of U2N and U2U relaying:
  - One relay UE acts as both U2N & U2U









Enhancement of NCR is essential for better coverage

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Study on AI/ML for air-interface Phase 2

Rel-18 study

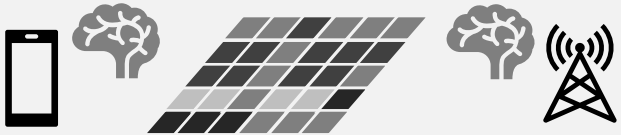
- General framework is being discussed; Life cycle management including model transfer options, collaboration level, etc.
- Three use cases are identified; CSI feedback, Beam management and Positioning.
- However, it might be too early to go forward to the normative work. So, Rel-19 study continuation is preferable.

Rel-19 study should cover new use cases and exact standardization areas

- New use cases:
  - Physical layer domain scenarios:
    - e.g., Sidelink, Unlicensed spectrum, Ranging
  - L2/L3 domain scenarios:
    - e.g., DRX, mobility, UAI,
  - Streamlining use cases to be standardized:
    - Including new use cases and existing use cases
- Framework enhancements:
  - Inter-operability is the key point.
  - LCM enhancements, if any.
  - Data collection enhancements, if any.
- Security/privacy aspects, if any.

AI/ML-based adaptive C-DRX operation

AI/ML-based dynamic resource utilization



We're open to have a normative work in Rel-19!

Follow-up study on AI/ML for air-interface are important towards AI-native radio in 6G

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Other topics

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Rel-19 Multicast Broadcast System (FeMBS)

- Specify leftover functions:
  - Extended cyclic prefix (ECP)
  - Single frequency network (SFN)
- Study other topological enhancements:
  - MBS relaying (e.g., via SL relay).
  - Capacity enhancements (e.g., CA/DC).

Rel-19 Enhanced mobile IAB (emIAB)

- Study possible enhancements, e.g.,
  - Mobile IAB-node as parent (multi-hop)
  - Mobile IAB-node as satellite (IAB-NTN)
  - Topology-wide fairness and latency reduction enhancements.
  - Mesh-networking (especially for FR2).

Rel-19 Enhanced UAV (eUAV)

- Collision avoidance during initial access
  - Height-dependent PRACH partitioning
- Resource coordination b/w on-ground & in-air UAVs
  - UAV-dedicated frequency deployments
  - Height-dependent cell reselection priority.
  - Height-dependent Tracking Area
- UAV-assisted inter-cell interference coordination
  - e.g., for far-away cells, unreachable via Xn

Rel-19 SON/MDT enhancements

- Support of additional features:
  - Mobile IAB (e.g., related to full migration)
  - NCR (e.g., related to forwarding signals)
  - LTM (e.g., new HOF report)
  - XR (e.g., related to PDU set)
  - MBS (e.g., reception quality)
  - Sidelink relay (e.g., target relay (re)selection, path switch latency/failures)

Enhancements for existing functionalities are important for more use cases in various industries

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