

5^G Vision and Enabling Technologies: ETRI Perspective



September 2015

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5G Key Services

Enhanced Mobile Broadband

High data rate

- 4K/8K UHD
- Hologram



- VR/AR(Virtual/Augmented Reality)



Demanding conditions

Broadband Access in Dense Areas



Massive hot spots /Smart office

High-speed Mobility



Moving hot spots/ High-speed train

Low Latency Services

Ultra-high reliability/low latency

- Tactile Internet



- Remote-control robot/machines



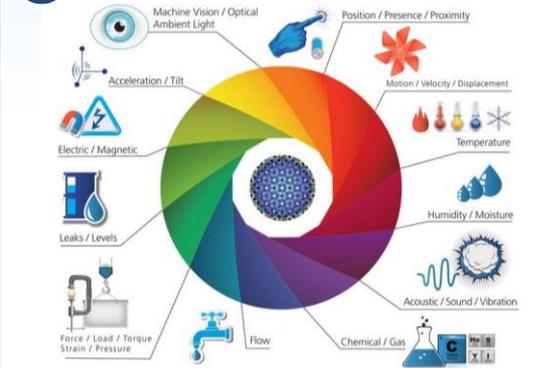
- Connected cars (V2X)



Massive Internet of Things

Massive connectivity

- Remote sensors/actuators



- Smart city-home



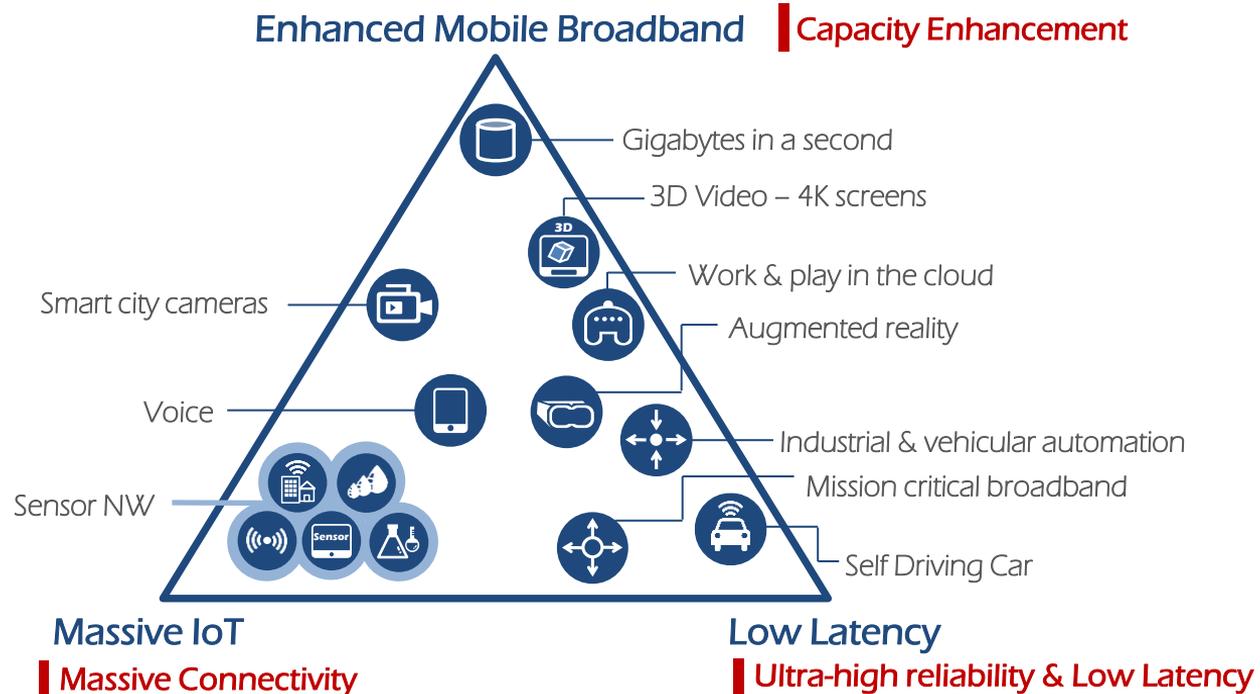
- 5G IoT



5^G Vision & KPIs



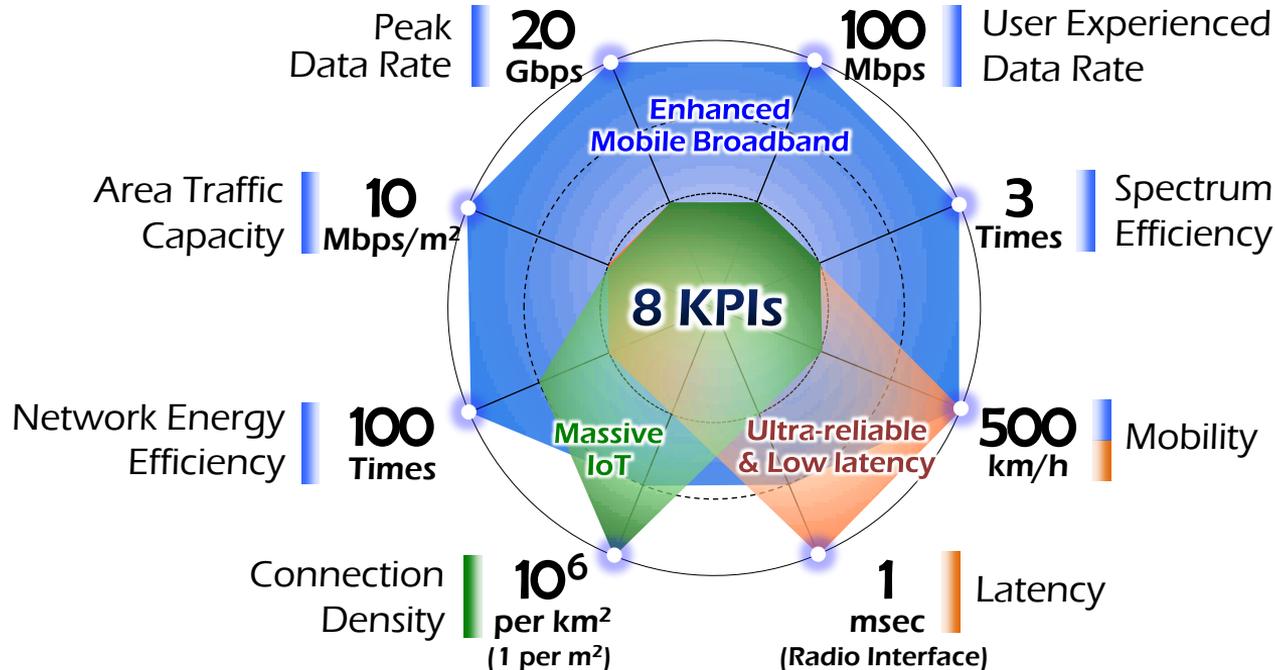
➤ Usage scenarios for IMT-2020



5^G Vision & KPIs



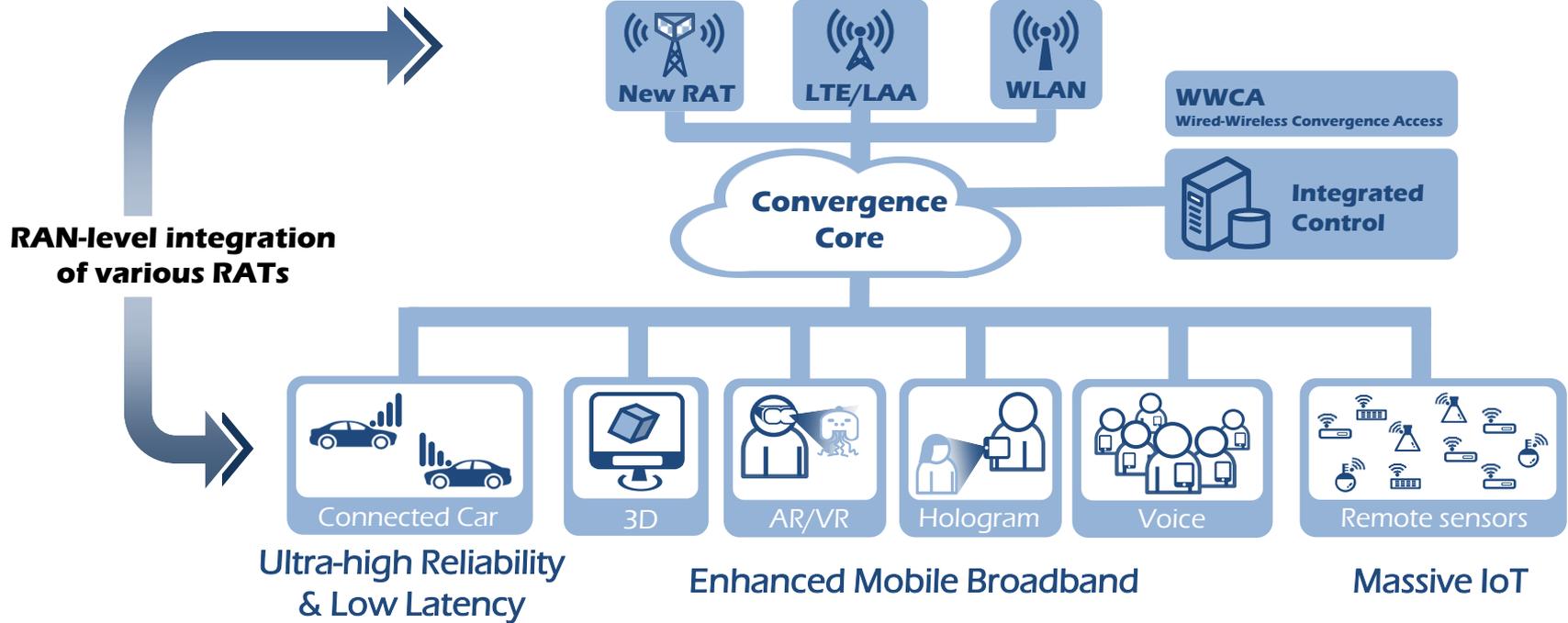
- Capabilities of IMT-2020
 - Inter-relation between the three usage scenarios & KPIs



[Note] Each of the three usage scenarios does not need to meet all the KPIs

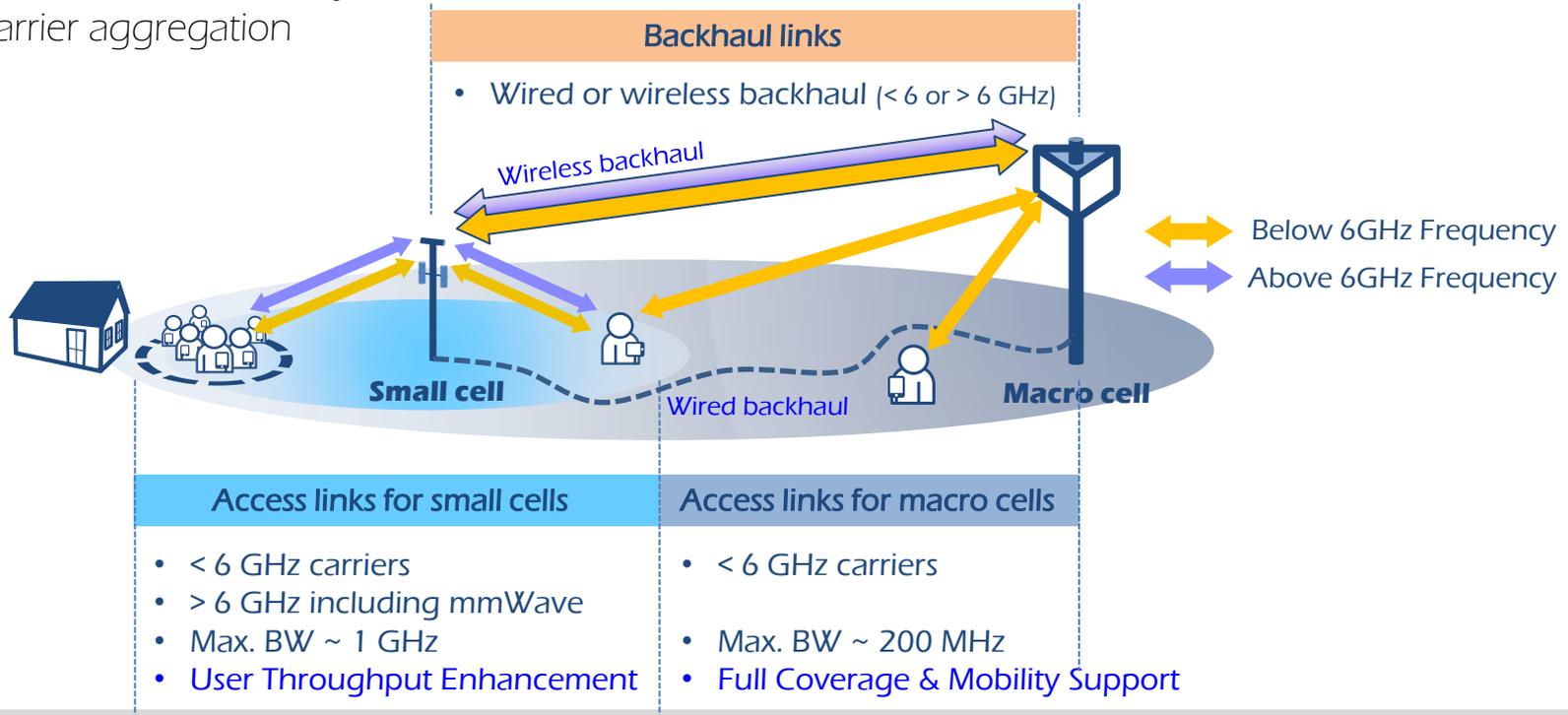
Overview of 5G Radio Access

- 5G Radio Access Technology as a set of tightly coupled existing and new radio access technologies, *i.e.*, evolved LTE, WLAN, and potential new RATs.

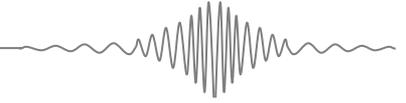


5G Radio Access Structure

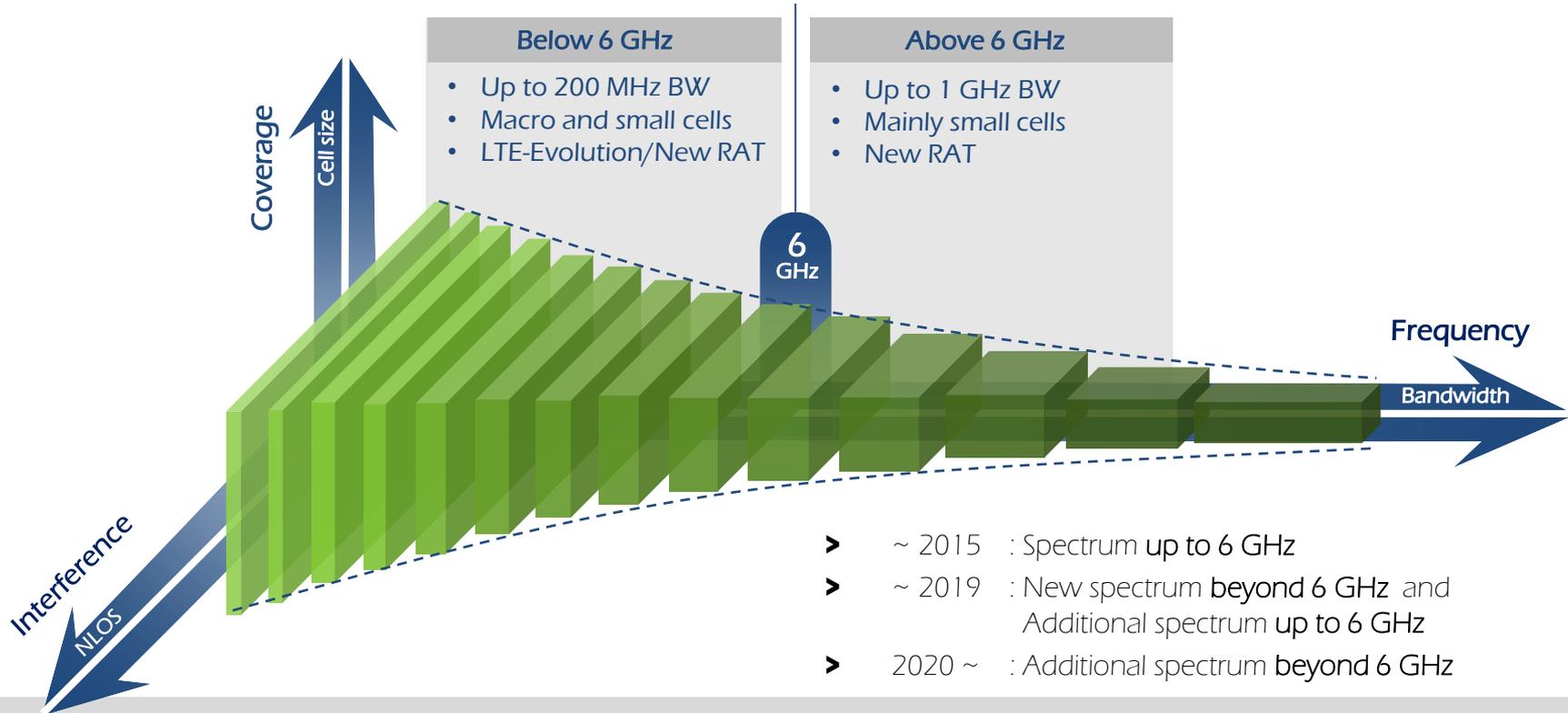
- High density small cells controlled by the macro cell
 - Multi-node connectivity
 - Carrier aggregation



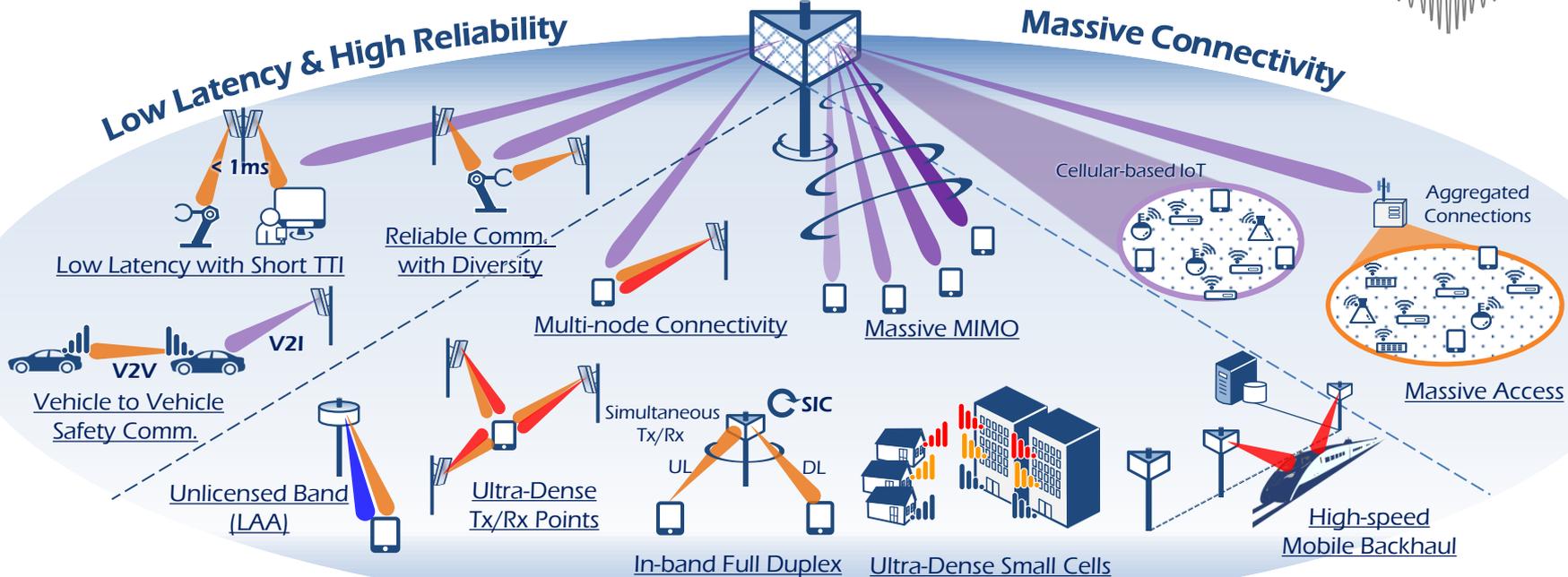
Spectrum use



- Comparison between below 6 GHz and above 6 GHz radio access



Elements of 5G radio access



Enabling Technologies

5^G

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Massive MIMO

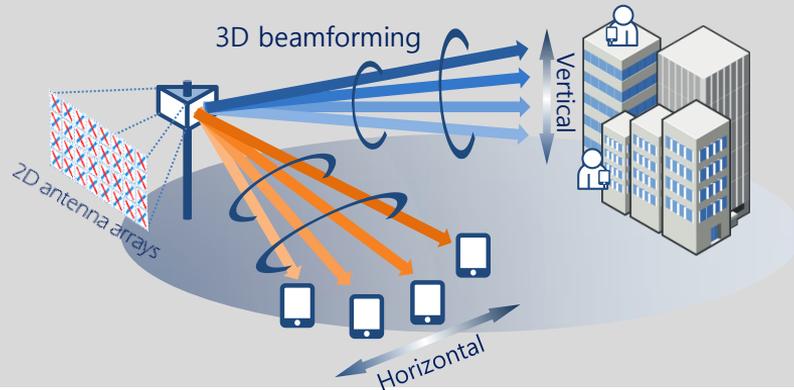


Massive MIMO

Very large scale MIMO

Maximum use of spatial degree of freedom by employing a large number of antennas (~100s)

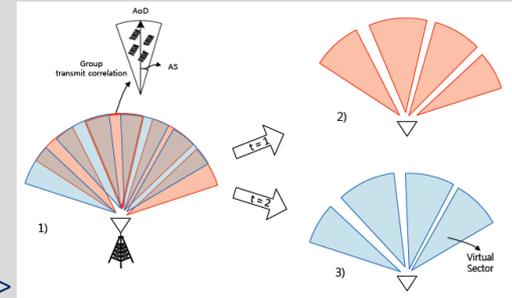
- Mainly for macro-cell layers in 5G multi-node connectivity deployments
 - Separate frequencies for small cell and macro-cell layers
 - 2D antenna arrays to produce 3D beamforming



System capacity ~ 10x

Enhancement of the system capacity up to ~ 10x by fully utilizing MU MIMO gain

- RAN specification issues
 - MU (Multi-User) CSI feedback for efficient MU MIMO operation
 - Reference signals (CSI-RS, DM RS) design for large numbers of antennas without introducing excessive overhead
 - Hybrid beamforming



< Virtual Sectorisation >

Ultra Dense Network



Ultra Dense
Network

Hyper dense network

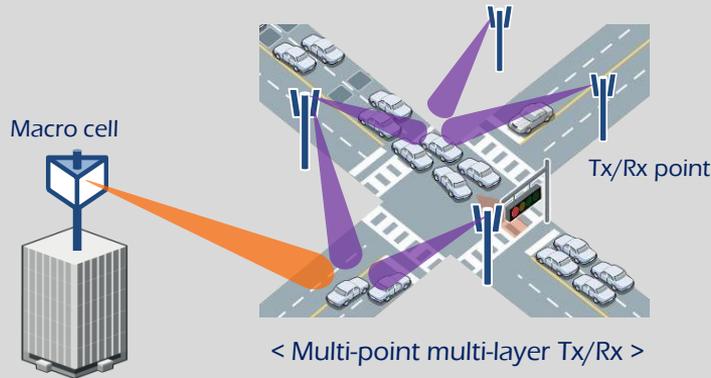
High density Tx/Rx points for areal capacity increase

Increase of both capacity & spectral efficiency

Areal capacity increase by $\sim 1000x$

Spectral efficiency increase for UE up to ~ 10 bps/Hz

- Distributed UDN (independent or coordinated control)
 - Each Tx/Rx Point as an access node
- Centralized UDN
 - One access node controls a group of Tx/Rx points



- RAN specification issues
 - UE-centric virtual cell formation
 - Discovery of Tx/Rx points near the UE
 - Virtual cell operation using the proximity points
 - Multi-point multi-layer transmission/reception
 - Multi-layer transmission/reception using multi Tx/Rx points
 - Codebook, power control, UE feedback etc
 - Interference mitigation/cancellation
 - Cooperative transmission between UE-centric virtual cells
 - Network assisted interference suppression/cancellation

In-band Full Duplex

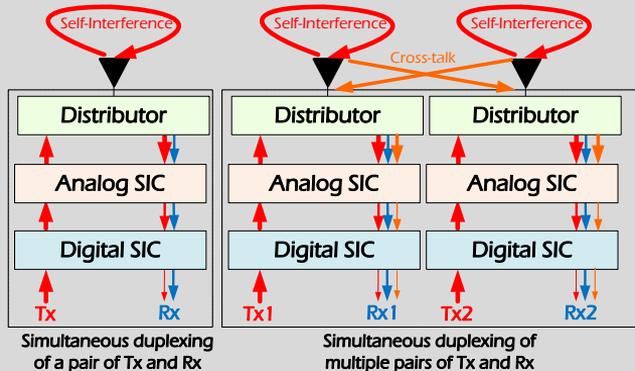


Transmit and receive information simultaneously over the same frequency band

Increase spectral efficiency by up to 2x

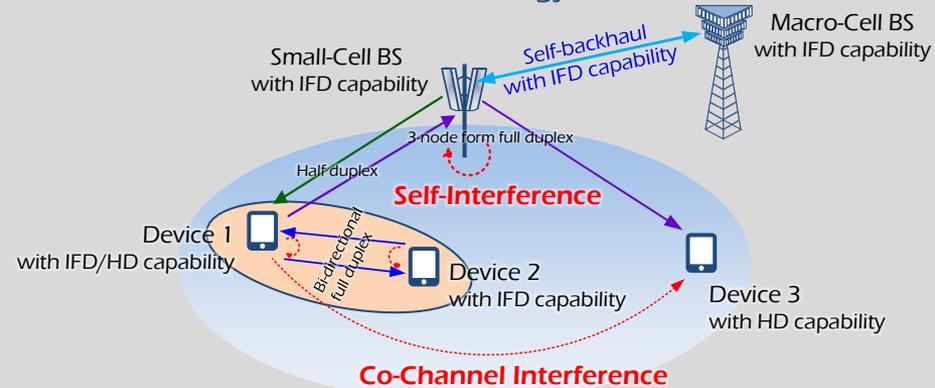
► IFD feasibility issues

- Self-Interference Cancellation (SIC)
- Single-shared antenna based IFD transceiver
- Multi-shared antenna based IFD transceiver



► RAN specification issues

- Radio protocols for maximizing SIC efficiency
- Co-channel interference control
- Dynamic duplex technology
- Wireless self-backhaul technology



Service-aware Scalable TTI for Low Latency



< 1 ms

Low Latency

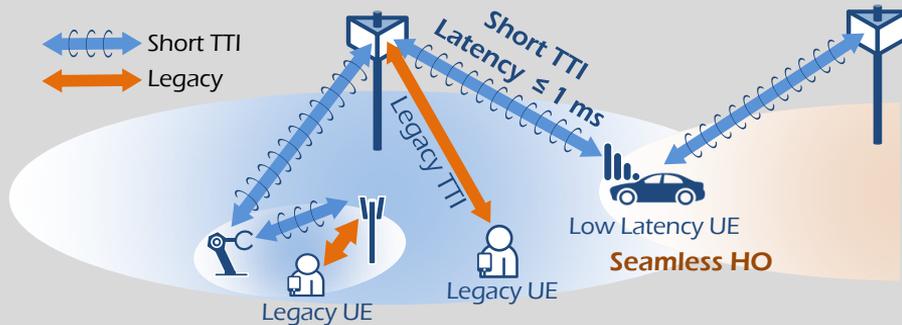
Low-latency Packet delivery

Using small duration of a transmission (~ hundreds of microseconds) on radio link with delivery reliability enhancements

One-way Transmission delay up to 1 ms

Provide an end-to-end delay of ~ 5ms enabling new category of low latency services

- Radio access providing multiple packet-delivery delays
 - Multi heterogeneous TTIs in one radio frame structure to meet multiple latency requirements from various services
 - Support for both macro and small cells



- RAN specification issues

- Design of new radio access features for low latency
 - Backward or non-backward-compatible frame structure
 - Short TTI requiring short processing time
 - Enhancements of PHY and MAC features for low latency
 - Seamless handover with small or zero interruption time
- Enhanced CA and DC for support of multiple TTIs
- High-reliability packet-delivery with delay constraints
 - Retransmission enhancements with fast HARQ and fast ARO
 - Diversity using multi-domain(time, frequency, space) resources

Advanced V2X



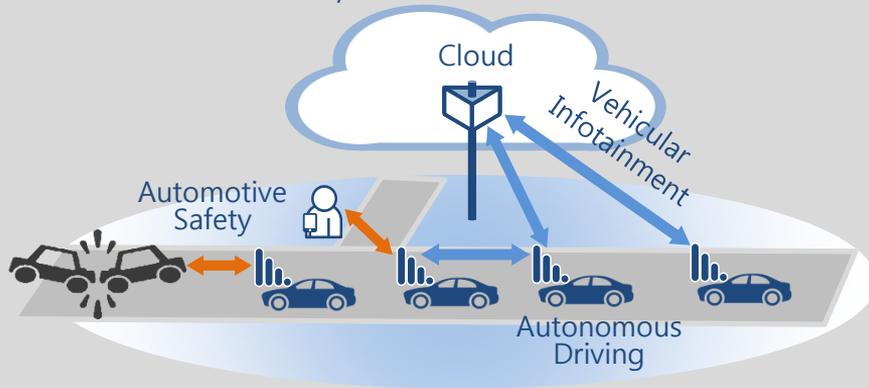
Vehicle-to-Everything

Advanced V2X Communication
for safety and non-safety
services

Potential Requirements for Advanced V2X

Support of low-latency (<5ms), high-reliability (>99.9%), high data rate (~ 100Mbps), high-mobility (> 280km/h absolute speed)

- Fundamental V2X comm. for safety-services (Rel-14)
- Advanced high-performance V2X comm. for upcoming services (e.g. autonomous driving, vehicular internet & infotainment services)



➤ RAN specification issues

- Enhanced V2V Communication
 - Support of Unicast as well as Multicast/Broadcast
 - New frame structure to support low latency and high reliability transmission in high-speed mobility
 - Multi-hop communication among vehicles
- Enhanced V2I Communication
 - Support of high data rate in highly dense area
 - Support of low latency and high reliability transmission in high-speed mobility
 - Efficient interface between vehicle and road infrastructure to support fast and seamless mobility

Massive Connectivity

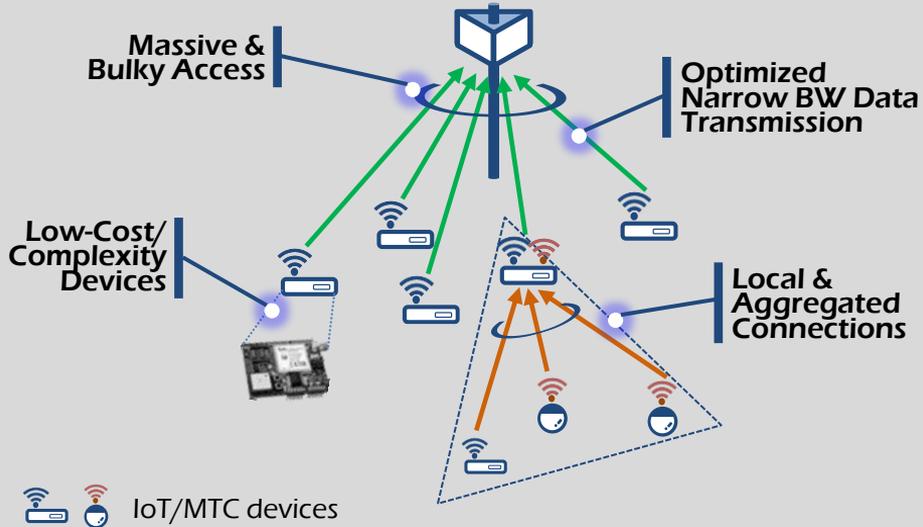


Massive
Connectivity

Massive IoT/MTC devices

Support of massive connections from the IoT/MTC devices characterized by sporadic small data transmissions

Up to 10^6 devices/km²



> RAN specification issues

- Low Cost/Complexity Devices
 - (Ultra) narrow bandwidth transmission with single RF/Antenna, low power, and limited MCS
- Massive and Bulky Access
 - Minimum signaling for scheduled transmission
 - Contention-based direct uplink data transmission over pre-configured resources
- Optimized Radio Transmission for Narrow BW Data Tx
 - Enhanced control/data channel structure for narrow BW Tx
 - Fine-granularity resource management to support large number of devices
- Local and Aggregated Connections
 - Local connections over (multi-hop) D2D links
 - Aggregated connections through GW/relay devices and seamless service continuity

Millimeter-Wave (mmWave)



New frontier bands (30~300GHz)

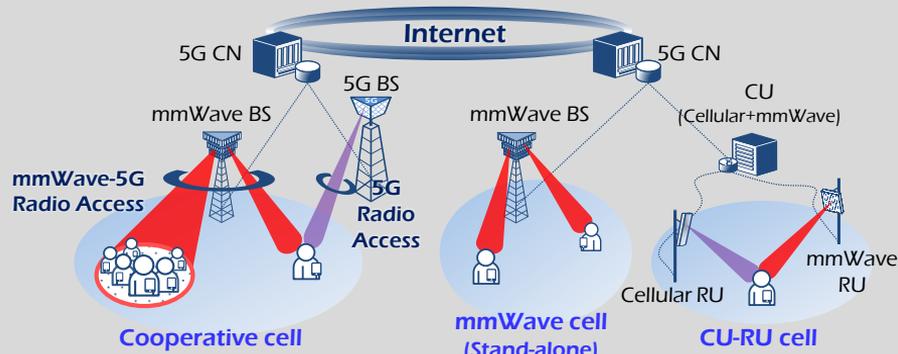
Offer very high traffic volume with an order of magnitude greater bandwidths

Average multi Gbps User Experience

Min. 1 Gbps anytime, anywhere

> Various mmWave cell deployment

- Stand-alone cell: full coverage of target area with mmWave BS
- Cooperative cell: mmWave cell controlled by Macro cell
- Cloud RAN: overall cell control with Macro RU & mmWave RU



> RAN specification issues

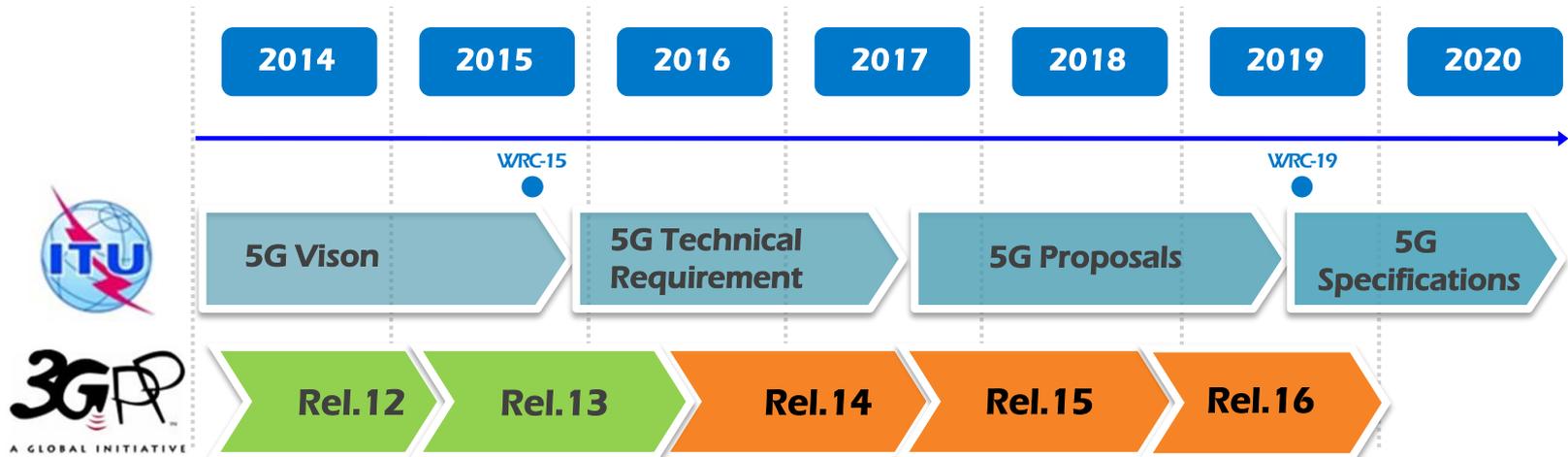
- mmWave channel modeling
- Design of new radio interface for mmWave
 - Pathloss compensation/Blockage avoidance solution
 - Beamforming, NLOS transmission, relaying, multi-point diversity etc.
 - Integration with the existing RATs and the new RAT for < 6 GHz



3GPP 5G Standardization Timeline

➤ Proposal for 5G release plan

- Each release to take 15 month duration
- Rel-14 (2016. 3 – 2017. 6): Study Item on 5G
- Rel-15 (2017. 6 – 2018. 9): Work Item on 5G
- Rel-16 (2018. 9 – 2019. 12): 5G evolution



Thank You !!!

5G