

5G RAN Technology Trends and Commercialization

Qucell Networks Oct. 26, 2021

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1. 5G Services : 3 Use Cases

eMBB : enhanced Mobile Broadband

eMBB is evolution of mobile networks (MBB is an initial use case for LTE). 5G should push further network throughput and enhance user experience. (target DL throughput is up to 20 Gbps)

- More bandwidth and new frequency bands (mmWave)
- More antenna and beamforming

URLLC : Ultra-Reliable and Low-Latency Communication

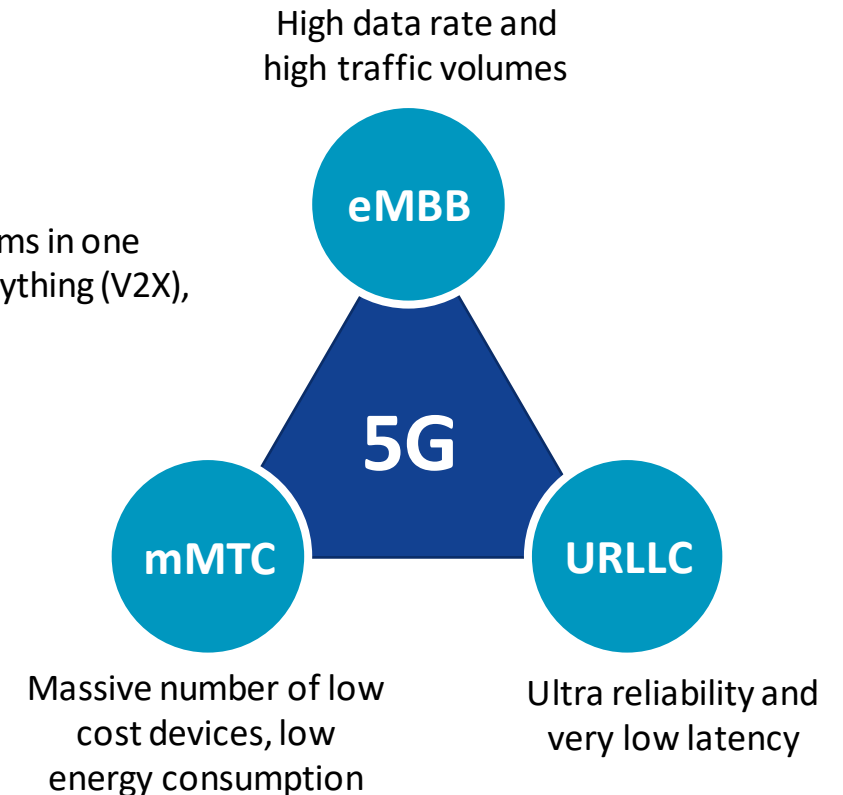
Partially (or mostly) about machine-to-machine communication and also about ultra low latency (<1 ms in one direction) and extremely high reliability. Use cases: Factory automation, Traffic safety, Vehical to Everything (V2X), Robots control and remote medicine, etc.

- Mini-slot that allows to transmit data within a part of slot (TTI in LTE)
- Allowed time to process data is much shorter (comparing to LTE)

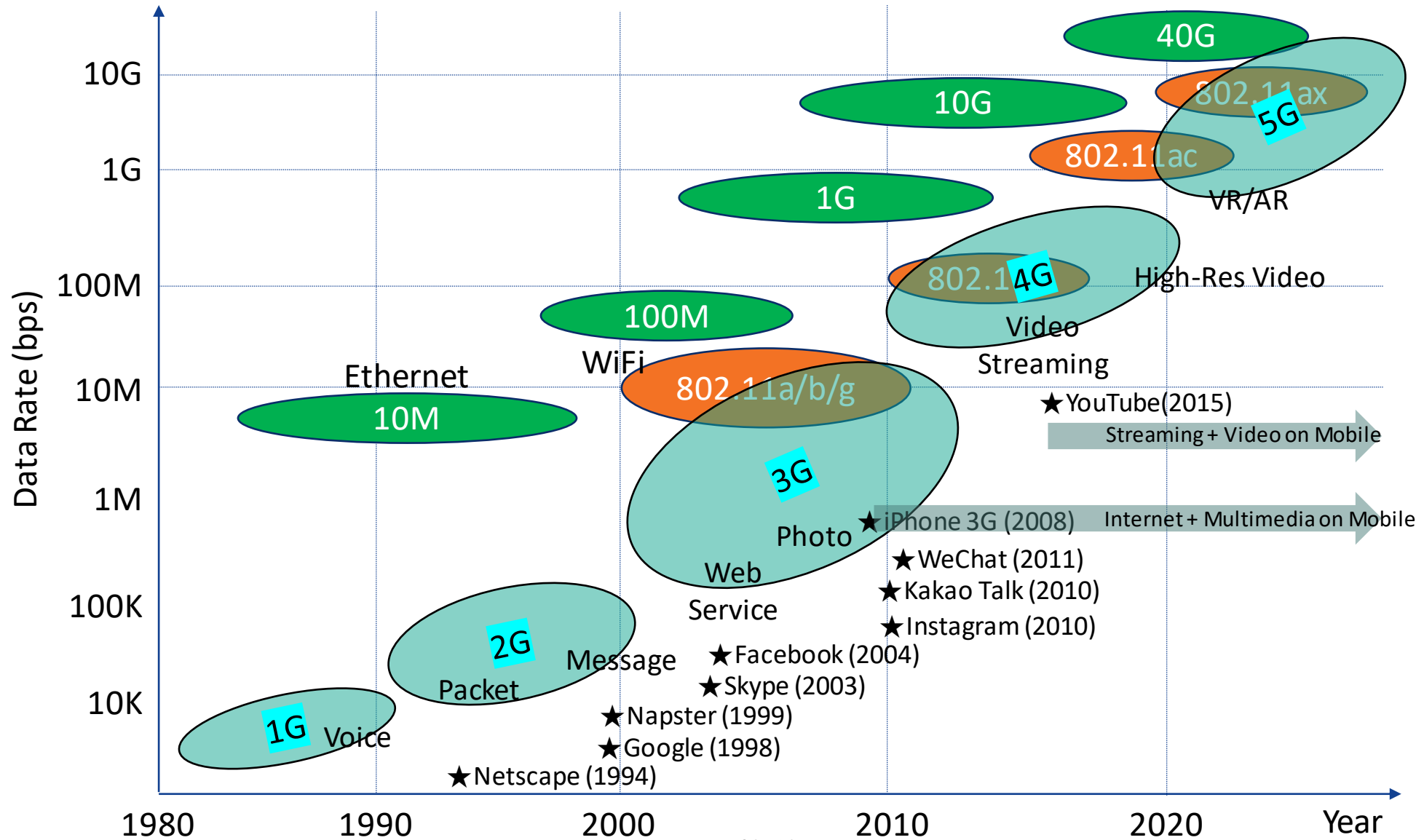
mMTC : massive Machine-Type Communication

mMTC is about a massive number of devices such as various sensors and meters, remote equipment monitoring and so on. Need to support devices which is low cost with very low energy consumption requiring relatively small amount of transmitted data

- Full coverage / High capacity (number of devices) / Low cost (CAPEX and OPEX)



2. Generations and Data Rate



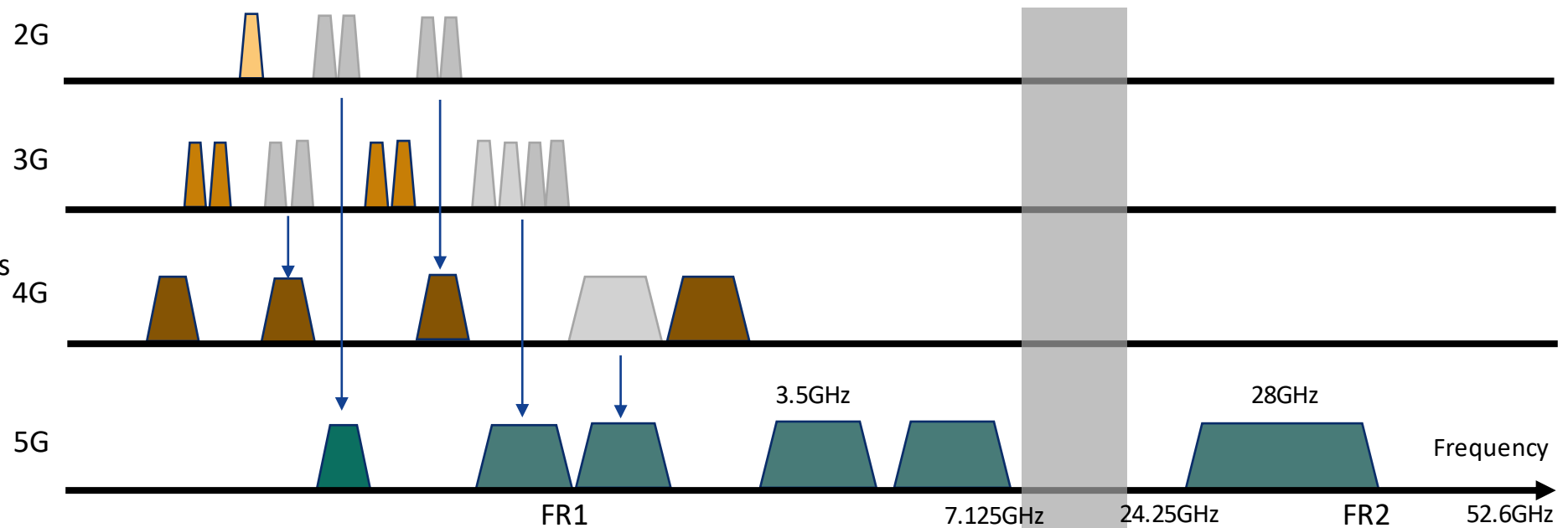
3. How to Achieve Higher Data Rate?

More Spectral Efficiency

- MIMO / Beamforming
- Higher Rate Modulation

More Frequency Bands

- Higher Frequency / More Bands
- Reuse 2G/3G/4G frequency

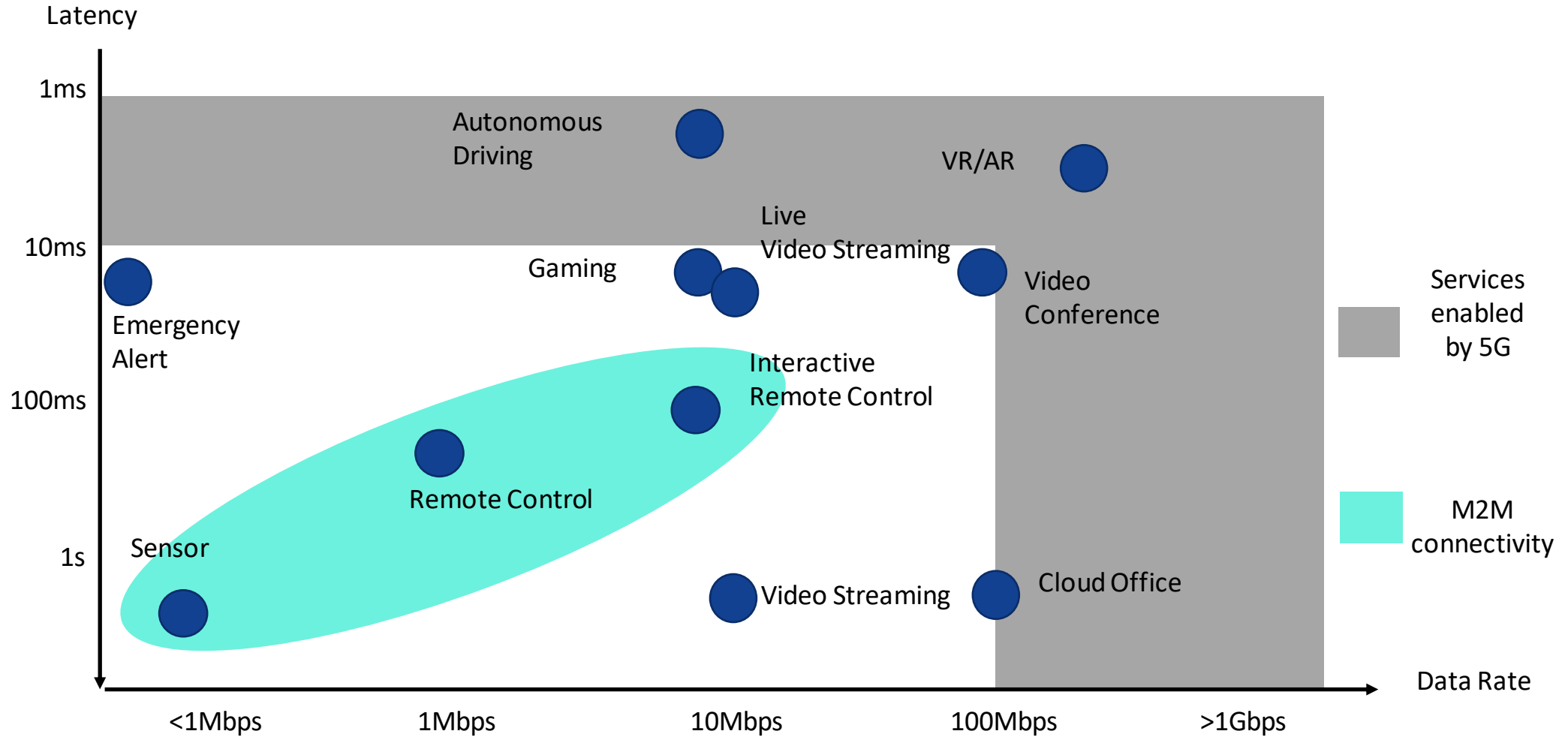


Reducing the number of users per cell

- Small Cells / Heterogeneous Network

Type	Tx Power	Cell Radius	Number of Users	Location
Enterprise Small Cell	250mW~1W	50m~100m	32~64	Indoor / Outdoor
Macrocell	10W~50W	8km~30km	2,000	Outdoor

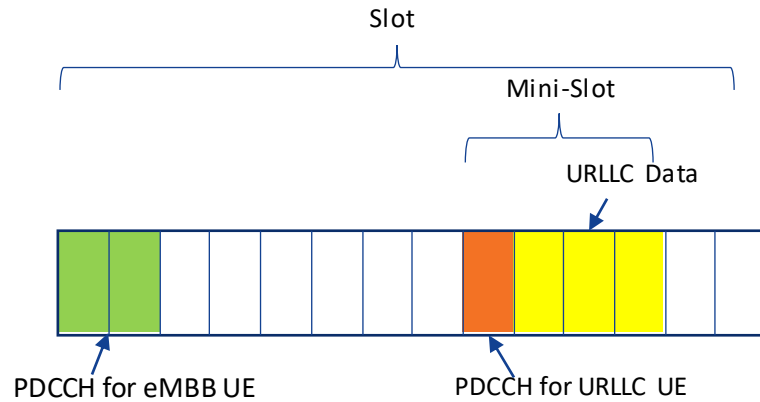
4. Latency and Data Rate for Applications



5. How to Reduce Latency

Air Latency

- Mini-slot that allows to transmit data within a part of slot (TTI in LTE)

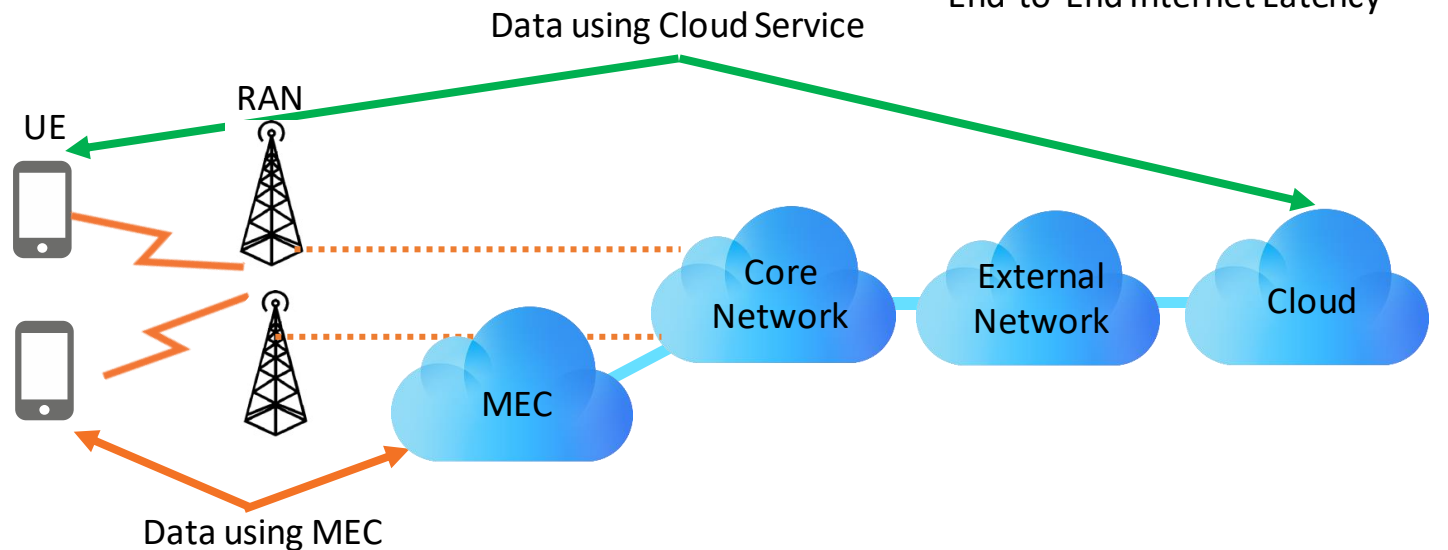
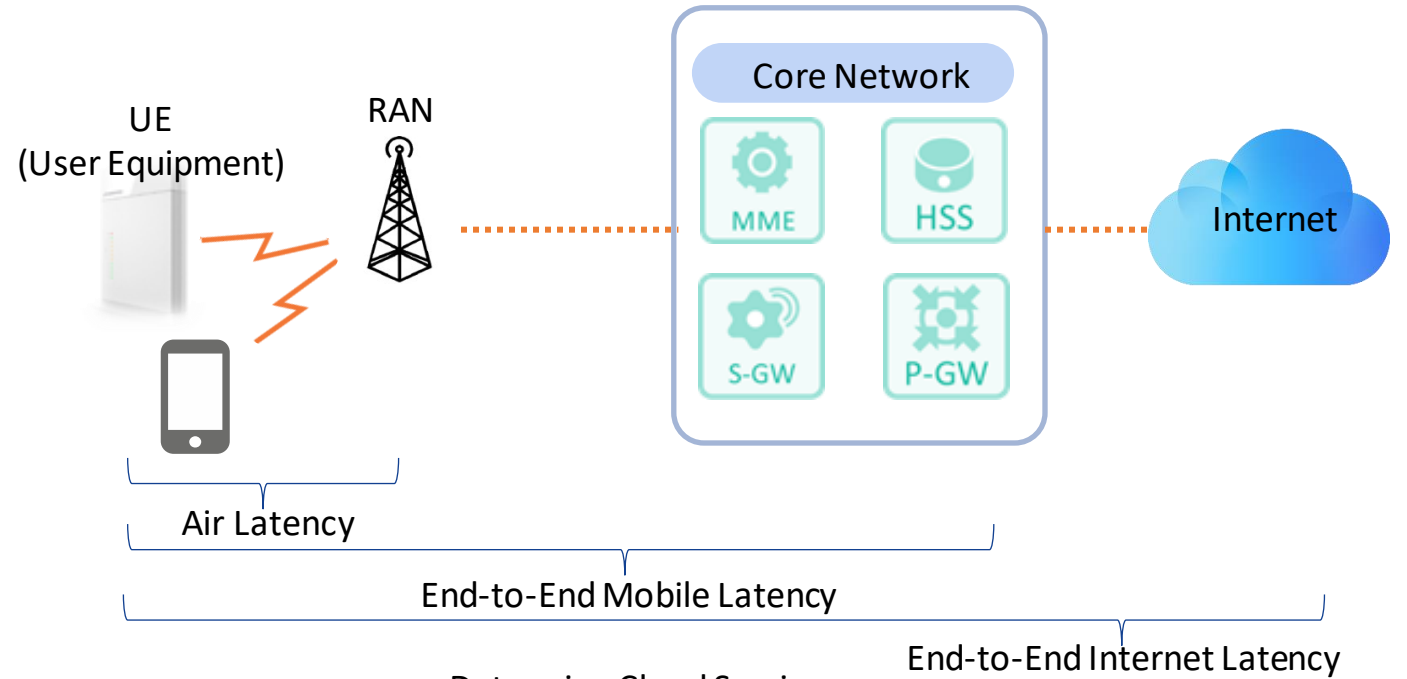


End-to-End Mobile Latency

- Enhancement / Re-architect Network

End-to-End Internet Latency

- MEC (Mobile Edge Computing)
- (TSC) Time-Sensitive Communication



6. RAN (Radio Access Network)

RAN provides connection between user equipment (such as a mobile phone) and core network through radio connections.

C-RAN stands for

- “Centralized” RAN
- “Cloud-based” RAN

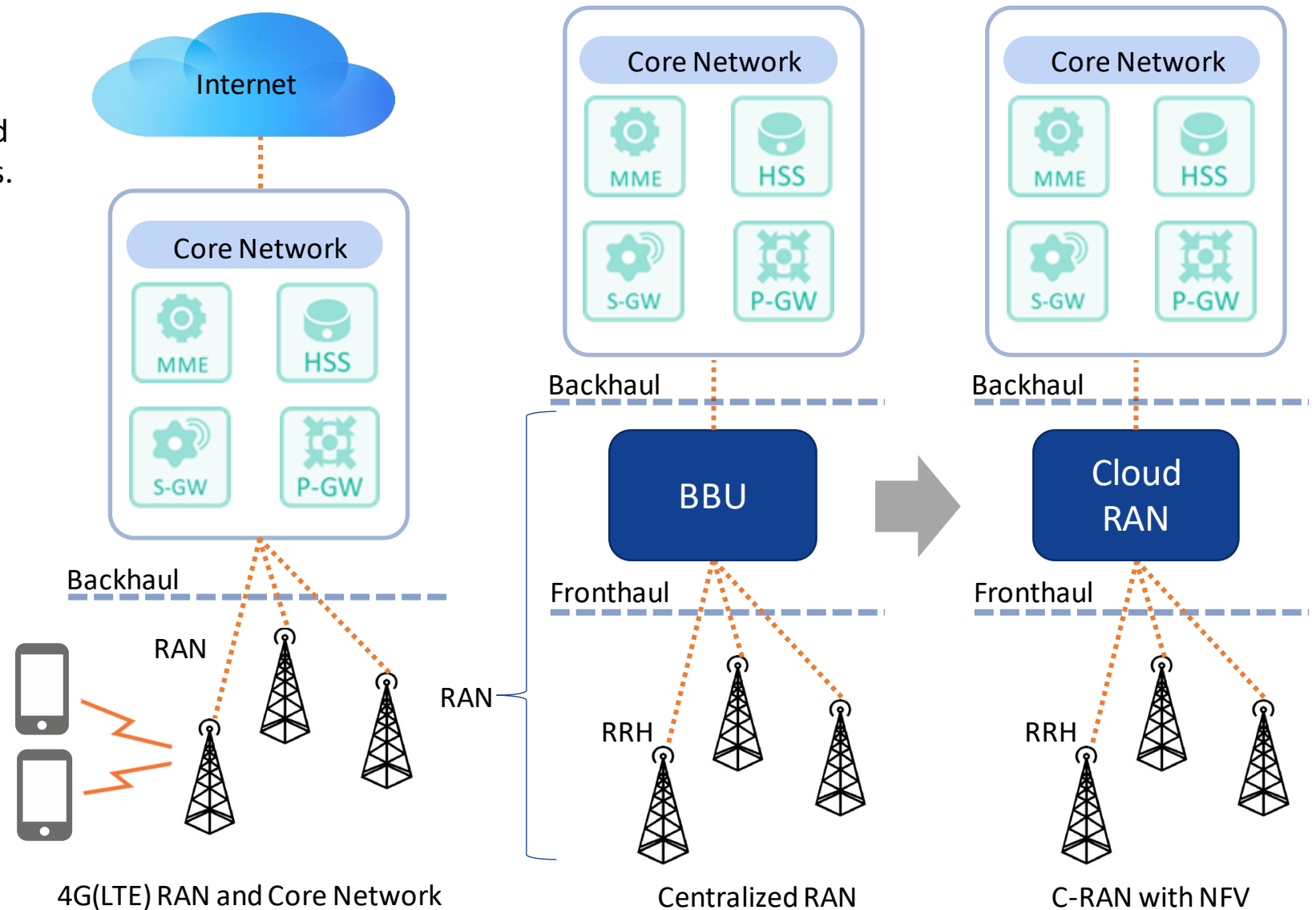
1. BBU at cell-site

2. Multiple BBUs at remote location

- using high capacity fiber fronthaul
- COTS servers

3. Cloud-based RAN

- some network functions start being virtualized in “the cloud.”
- Simplify network management
- Enable resource pooling / scaling



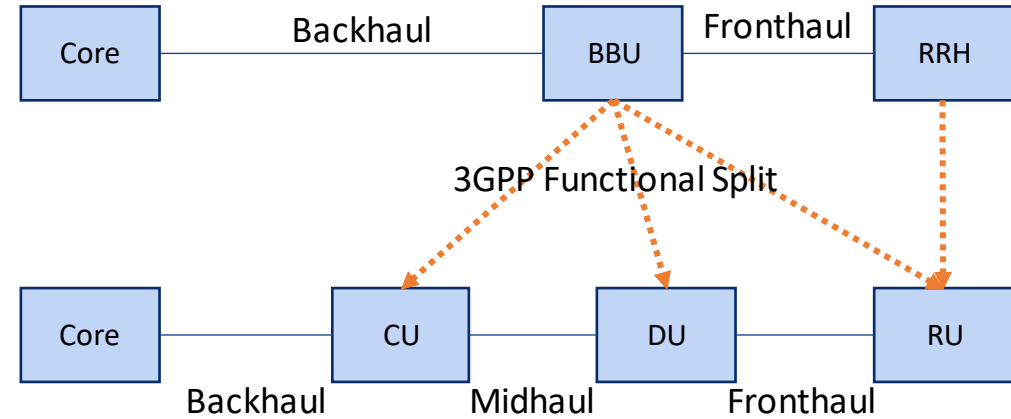
7. 5G C-RAN Function Split

3GPP 5G C-RAN Architecture

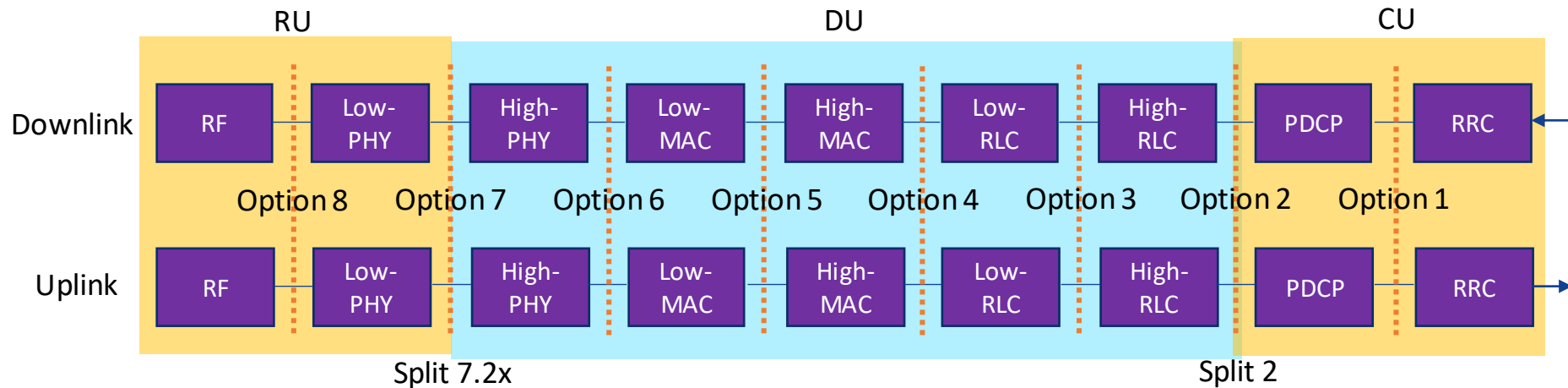
- CU (Central Unit)
- DU (Distributed Unit)
- RU (RU)

Function Split

- 8 Split Options offer a different trade-off between centralization benefits and fronthaul network requirements.



5G C-RAN Architecture



Functional Split Options for 5G

8. Open RAN

Open RAN Concept

Interoperability and Standardization of RAN elements

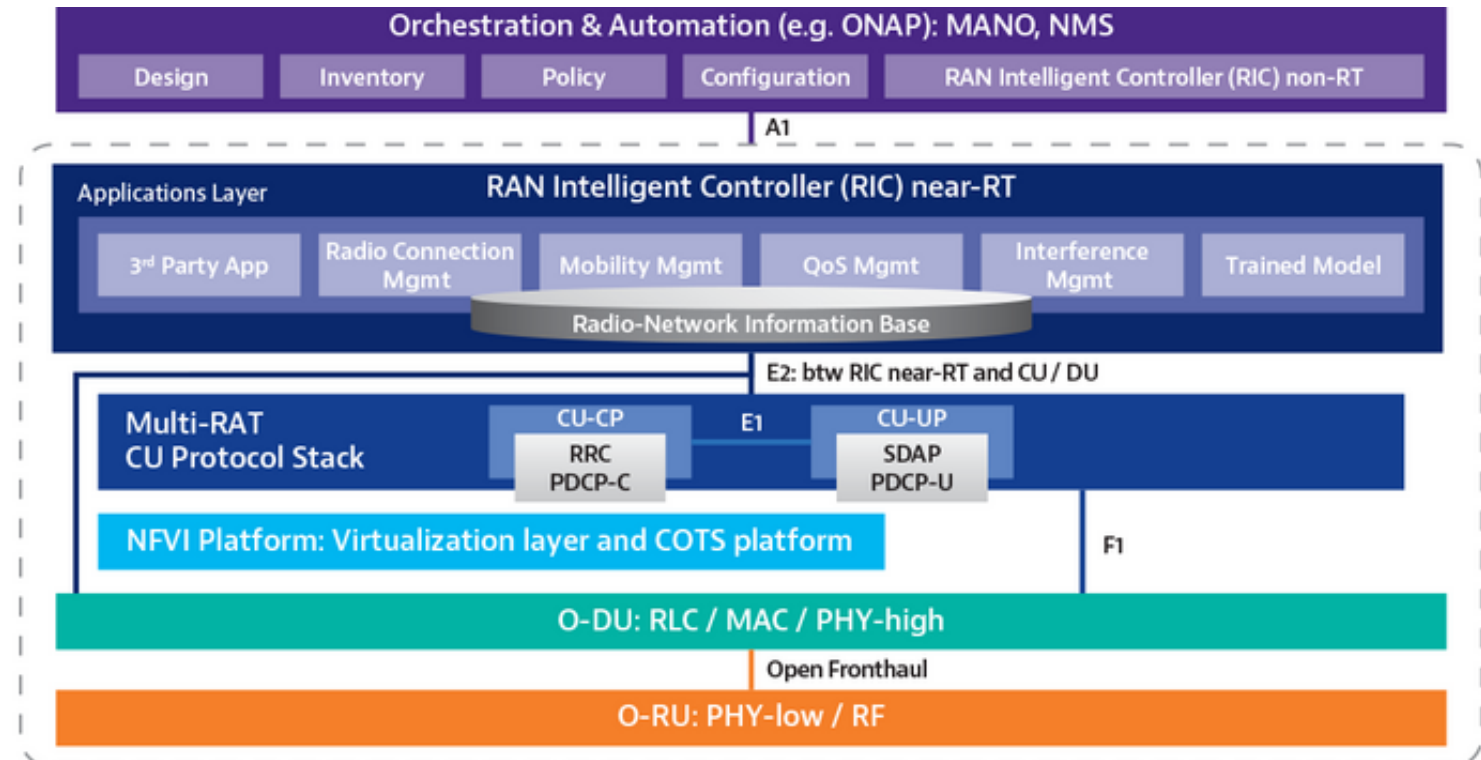
- Interconnection standard for (white-box) hardware and (open source) software elements from different vendors.
- Modular base station software stack on off-the-shelf hardware
- Allows baseband and radio unit components from discrete suppliers to operate seamlessly together.

O-RAN ALLIANCE

The O-RAN ALLIANCE was established in 2018 by a global consortium of network operators with the stated goal of evolving radio access networks around the world.

O-RAN Architecture

- RIC non-Real-Time layer, near Real-Time layer
- Multi-RAT CU protocol stack
- O-RU, O-DU through an O RAN fronthaul interface



O-RAN Architecture

9. Role of Small Cells with Generations



3G
Home Coverage

Lte
Indoor Coverage
Low Cost for Densification

5G
Indoor Coverage/Performance
Cost-Effective Nationwide/Local

Coverage

Capex Optimization & Densification

Performance & Capacity

Residential

Enterprise, Urban
Rural Outdoor

In-Building, Distributed (C-RAN) / O-RAN
Hotspot, eMBB , Massive IoT

Licensed Spectrum

Shared Spectrum, Private LTE
Fixed Wireless Access

Local Licensed 5G
Industry Digitalization
Replacement of Cables

Femtocell

Residential / Enterprise / Outdoor

All-In-One / Distributed (C-RAN)

10. Small Cell Use Cases

Nationwide Mobile Network Service

Residential

SOHO

Enterprise

Hotspot

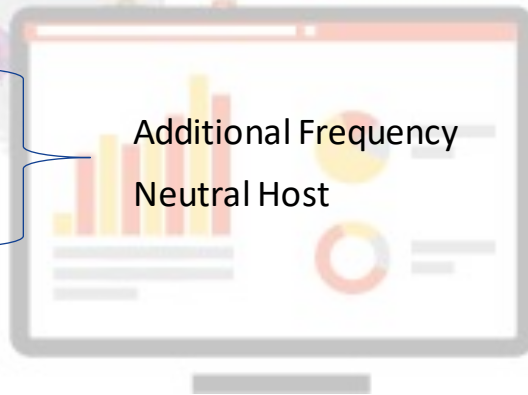
Rural Outdoor

In-Building Distributed

Shared Frequency

Local Licensed Frequency

- Coverage Hole
- Keeping/Increasing Subscriber
- Macro Offload
- User Experience
- High Performance Service
- Cost-Effective Deployment
- Replacement of Repeater



Local / Private Wireless Network Service

Enterprise

In-Building Distributed

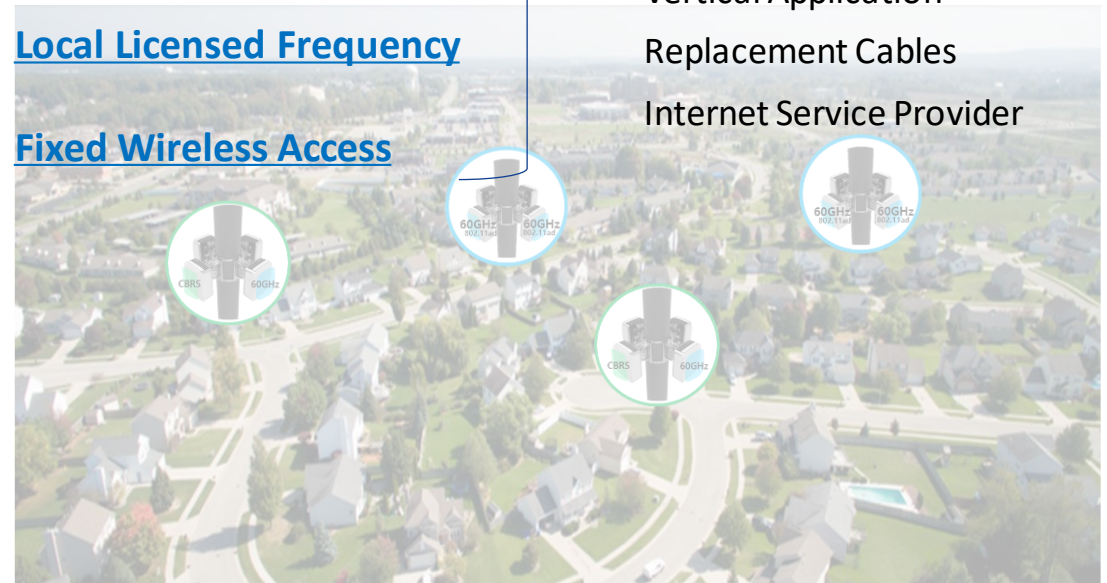
Unlicensed Frequency

Shared Frequency

Local Licensed Frequency







Fixed Wireless Access

- Private / Internal Calls
- Secured Network
- Local IoT Network
- High Performance / Low Latency
- Smart Factory
- Vertical Application
- Replacement Cables
- Internet Service Provider

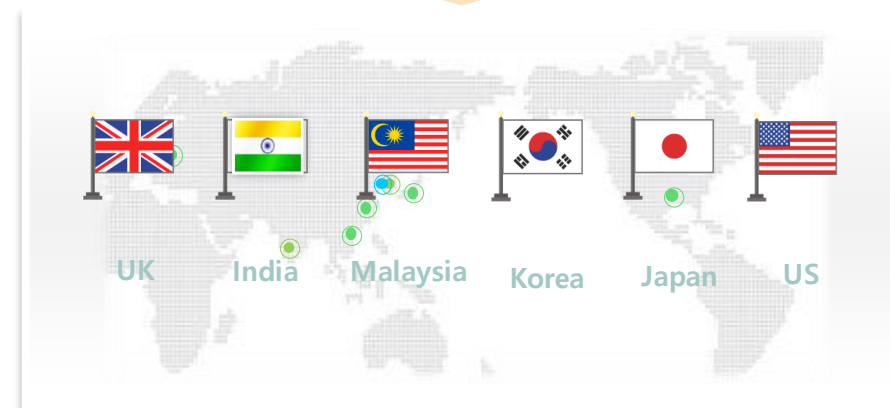


11. QUCELL® Small Cells (1/2)

“Offering a variety of Small Cells for major operators around the world ”

Residential/SOHO	Enterprise	Outdoor	Small Cell with Wireless Backhaul	5G All-In-One	5G C-RAN
 <p>Indoor Cost-Effective</p>	 <p>Indoor High Performance</p>	 <p>High Power CBRS Low Power</p>	 <p>Small Cell + UE (Modem) for Backhaul</p>	 <p>Indoor Enterprise Sub-6 GHz / mmWave</p>	 <p>CU/DU/RU/Hub</p>

- 2021 • 5G All-In-One Small Cells
- 2019 • CBRs Small Cell deployment
- 2017 • World 1st CA /256QAM TD-LTE Small Cell Live Demo
- 2014 • Starts Providing Small Cells to Global Mobile Operators
- 2012 • One of World 1st Massive LTE Small Cell Deployment in Korea
- 2010 • LTE Small Cell R&D Starts
- 2009 • LTE Test Set with Base Station Emulator => Agilent(Keysight)
- 2007 • World 1st WiMAX Test set with Base Station Emulator => Agilent(Keysight), R&S
- 2006 • Base Station Technology – WiMAX Base Station/Mobile Station Emulator



11. QUCELL® Small Cells (2/2)

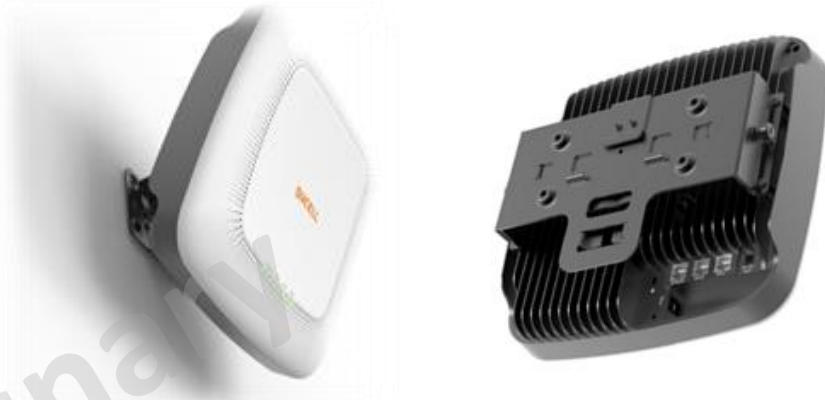
5G Sub-6 GHz Indoor Enterprise Small Cell



- Integrated Small Cell for Indoor Enterprise Usage
- All-In-One (RU+DU+CU. CU is optional)
- 5G NR Sub-6 GHz (LTE is optional)

Frequency Band	5G NR (n77/n78/n79/n48) + LTE (optional)
Antenna	Internal. NR: 2 Antennas, LTE: 2 Antennas
TX Power	NR: 30dBm (EIRP), LTE: 23dBm (EIRP)
Backhaul	Ethernet 2.5G Base-T / SFP+
Mount Type	Bracket for Ceiling Mount / Wall Mount
Indoor / Outdoor	Indoor Enterprise
Synchronization	IEEE1588v2, GPS (optional)

5G mmWave Indoor Enterprise Small Cell



- Integrated Small Cell for Indoor Enterprise Usage
- All-In-One (RU+DU+CU. CU is optional)
- 5G NR mmWave (LTE is optional)

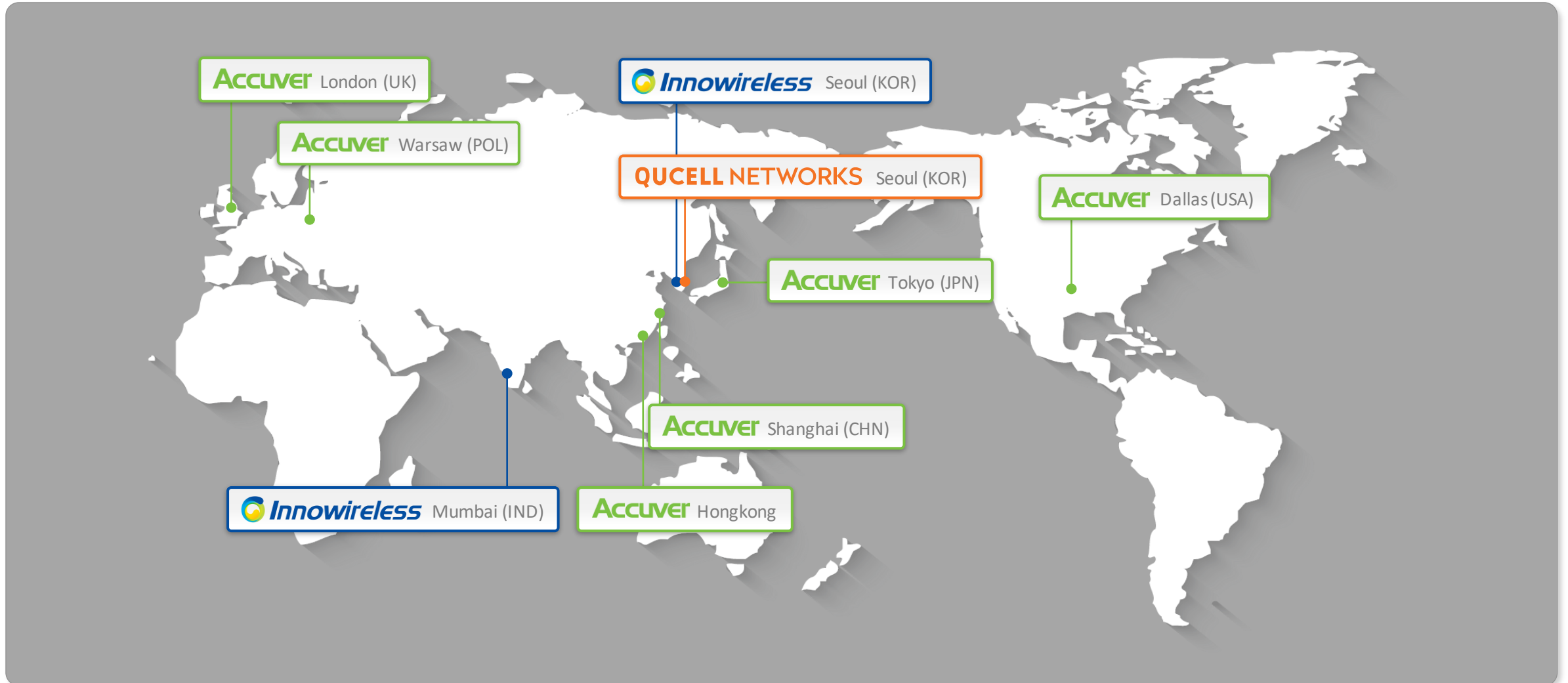
Frequency Band	5G NR (n257) + LTE (optional)
Antenna	Internal. NR : 128 Tx / 128 Rx, LTE : 2 Antennas
TX Power	NR: < 48dBm (EIRP), LTE : 23dBm (EIRP)
Backhaul	Ethernet 10G Base-T / SFP+
Mount Type	Bracket for Wall Mount
Indoor / Outdoor	Indoor Enterprise
Synchronization	IEEE1588v2, GPS (optional)

12. Company Overview (1/3)

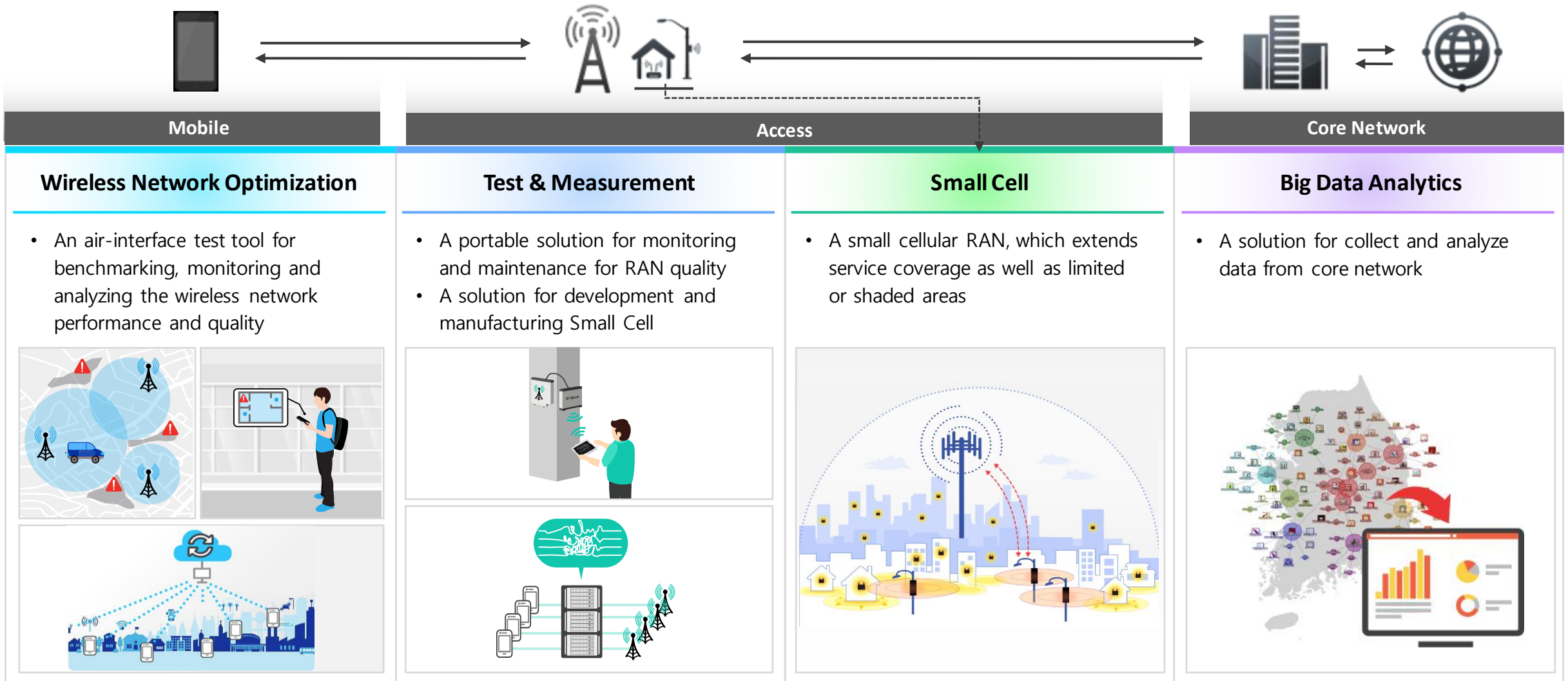
Innowireless	
Founding Date	September 2000
IPO Date	February 2005
Location	<ul style="list-style-type: none"> • Innowireless / QUCCELL Networks : Seongnam-si, Gyeonggi-do, Korea • Accuver : Dallas, London, Warsaw, Tokyo, Shanghai, Hongkong
Employee	<p>460 employees (As of 2021)</p> <ul style="list-style-type: none"> • Innowireless : 315 employees • QUCCELL Networks : 83 employees • Accuver : 62 employees
Business Area	<ul style="list-style-type: none"> • Wireless Network Optimization Products • Big Data Products (Probing & Analytics) • Test & Measurement Products • Small Cell Products
Home Page	<ul style="list-style-type: none"> • www.innowireless.com • www.accuver.com / www.accuver.jp • www.qucell.com



12. Company Overview (2/3)



12. Company Overview (3/3)



Thank You

4G and 5G Small Cell Solutions