

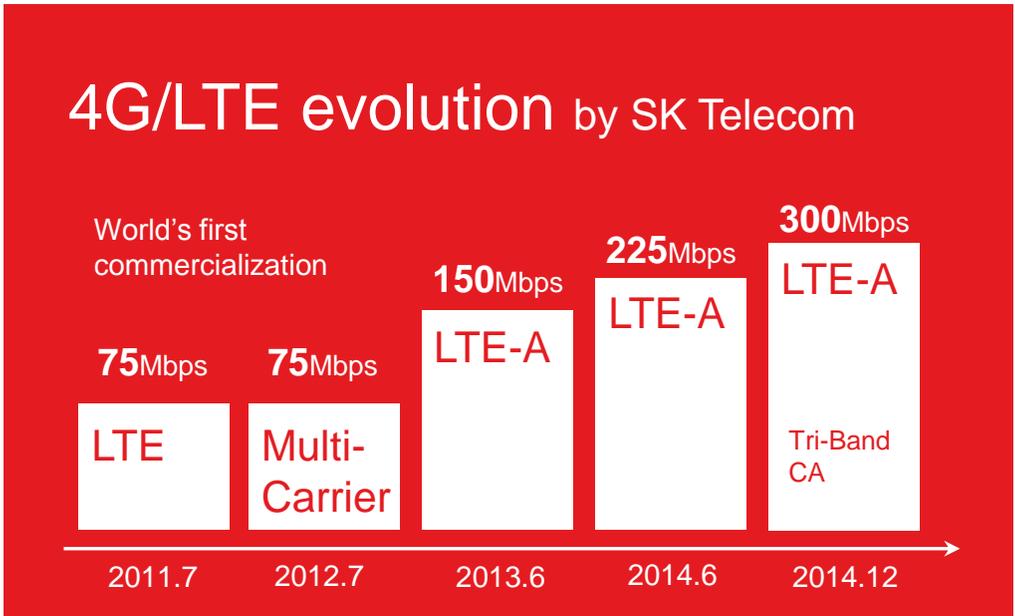
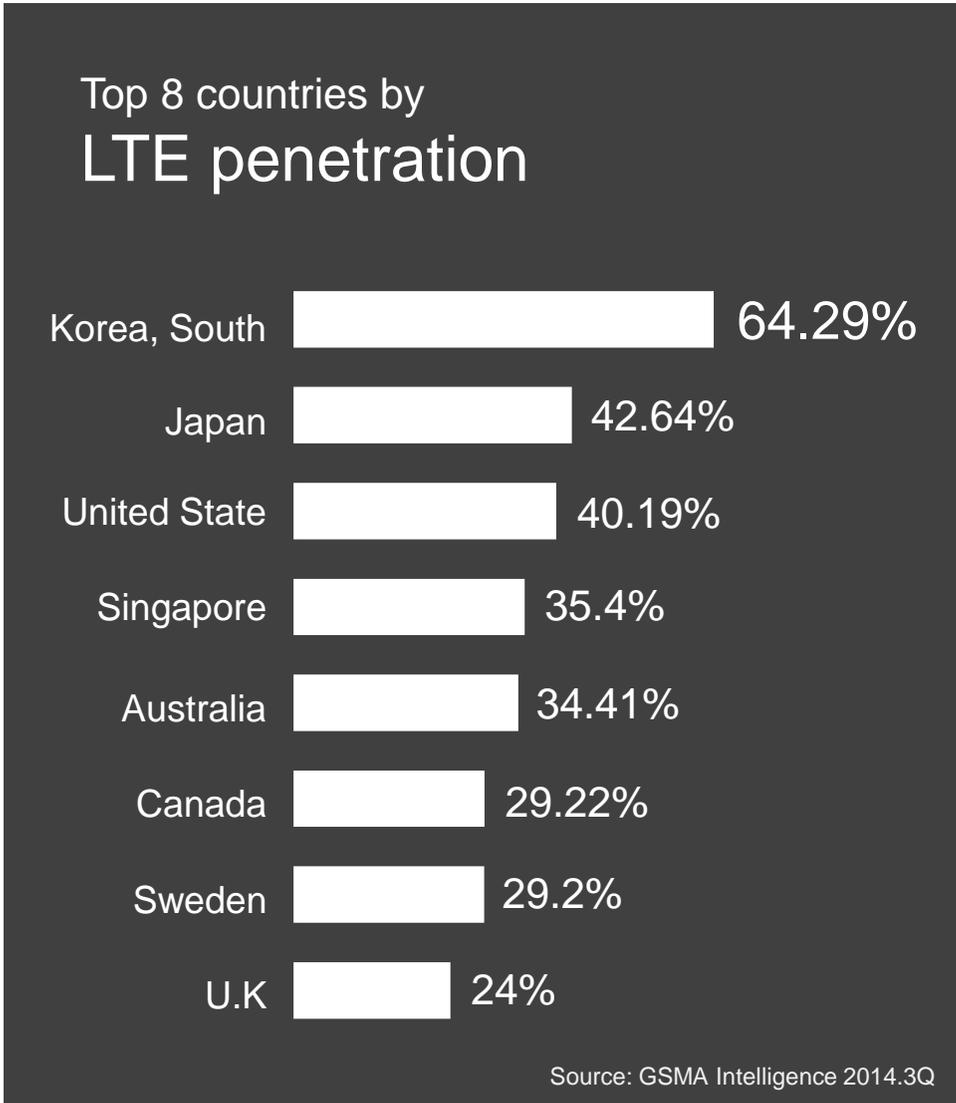
5G

RAN architecture and standardization timeline

SK Telecom,
Korea

Korea targeting the first 5G trial in 2018

4G/LTE markets and technologies have already matured in Korean market



First 5G trial

Korean government and SK Telecom

2018

Market share

SK Telecom

49.8%

Target 5G use cases

1) Virtual experience, 2) Mission-critical IoT, 3) Massive IoT

Virtual Experience

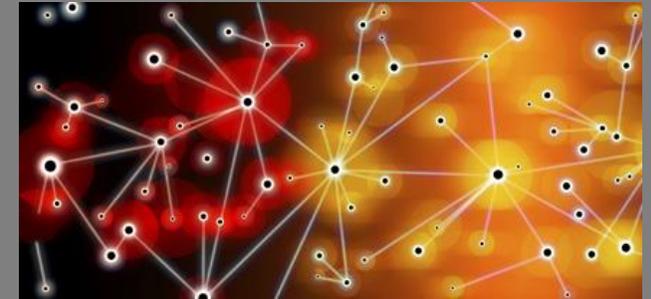
Incl.
Mobile broadband



Mission-Critical Internet-of-Things (IoT)

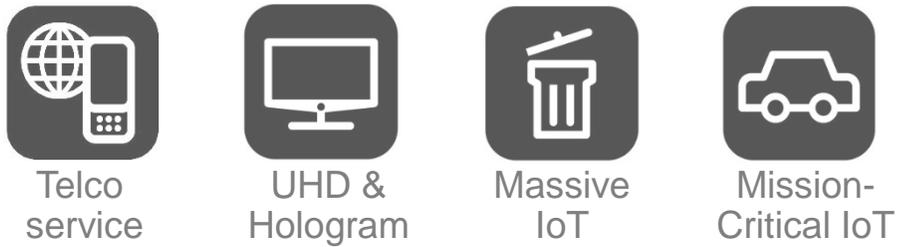


Massive Internet-of-Things (IoT)

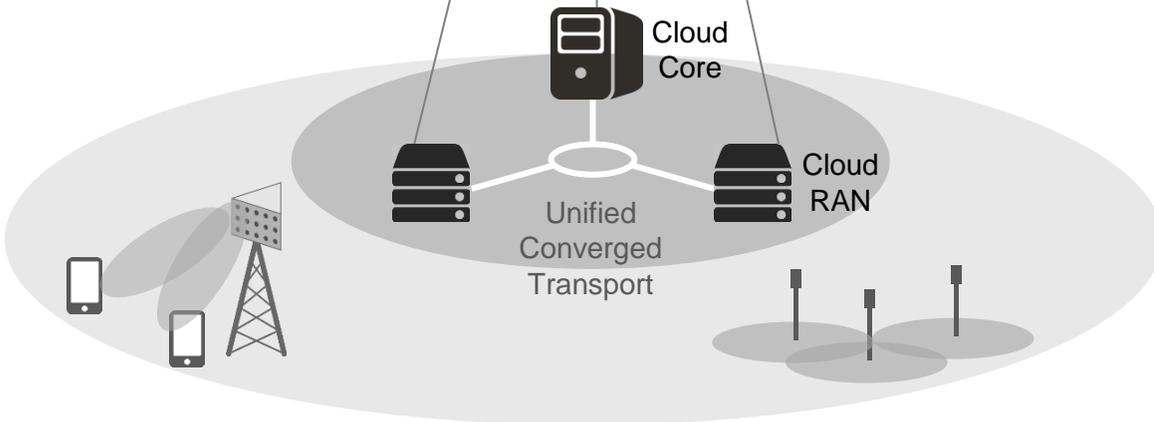
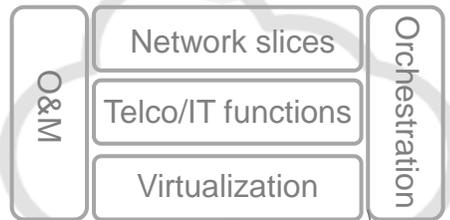


5G architecture

A common 5G architecture needs to support various 5G use cases with diverse requirements



Telco API



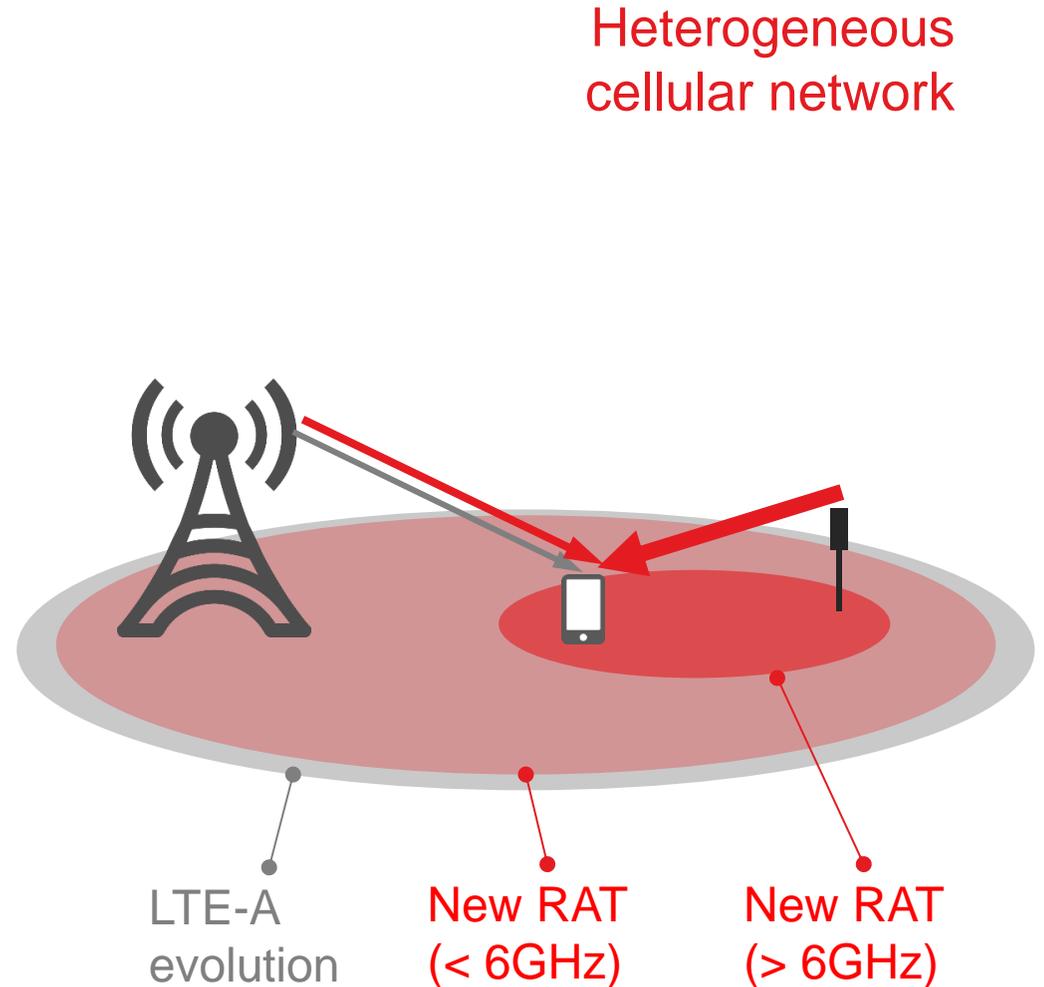
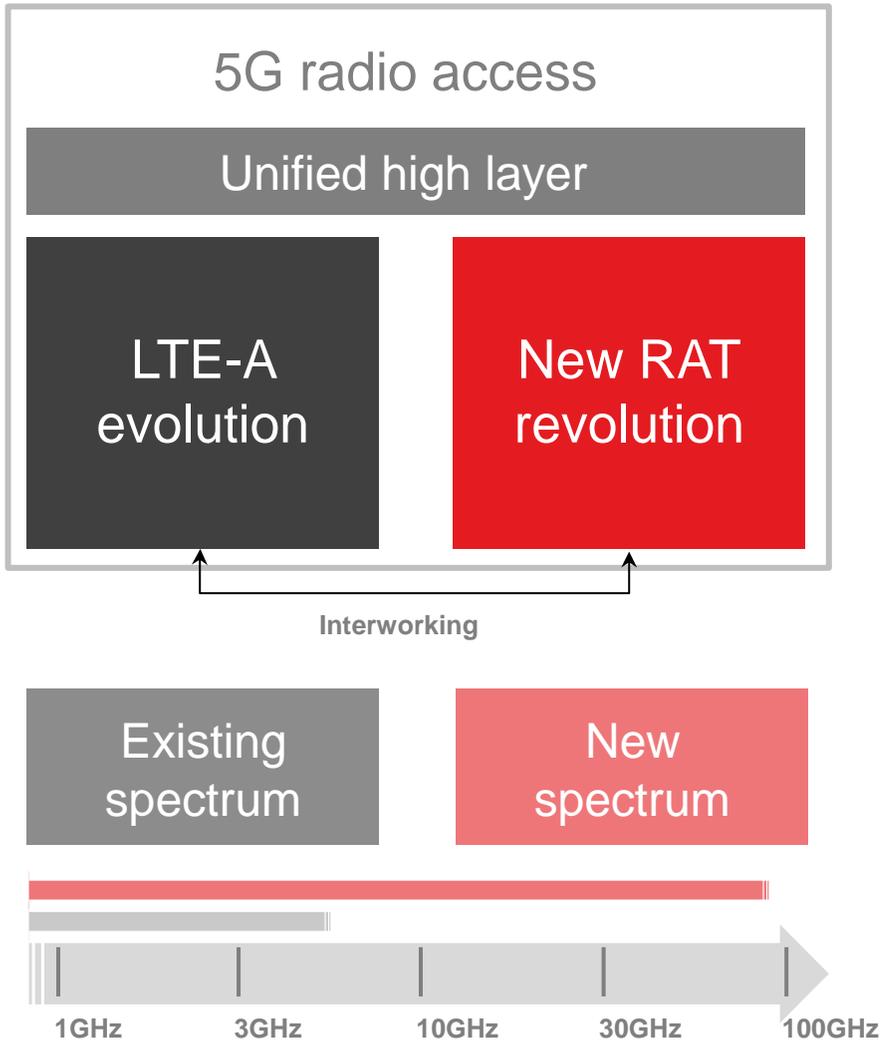
Innovative Services
for virtual experience, massive IoT, critical IoT

All-IT Infrastructure
for value creating network, monetization

Hyper-connected radio
for massive and multi-Gbps connectivity

5G radio = LTE-A evolution + New RAT revolution

LTE-A keeps evolving while new RAT starts to be developed. For new RAT, Below 6GHz and Above 6GHz are equally important



New RAT revolution: Above 6GHz

Higher peak rate in >6GHz is obviously attractive, however ensuring consistent user experience while minimizing cost is still challenging even with beamforming capability

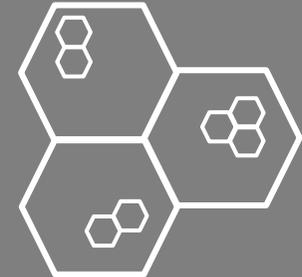
Wider bandwidth
available in higher frequency

Higher
peak rate



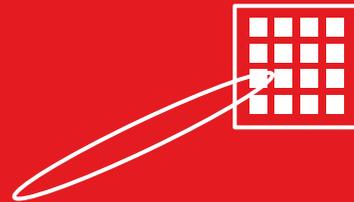
Larger path-loss

More
cells



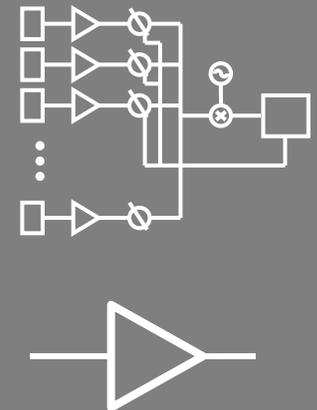
Smaller antenna size

Higher
beamforming
gain



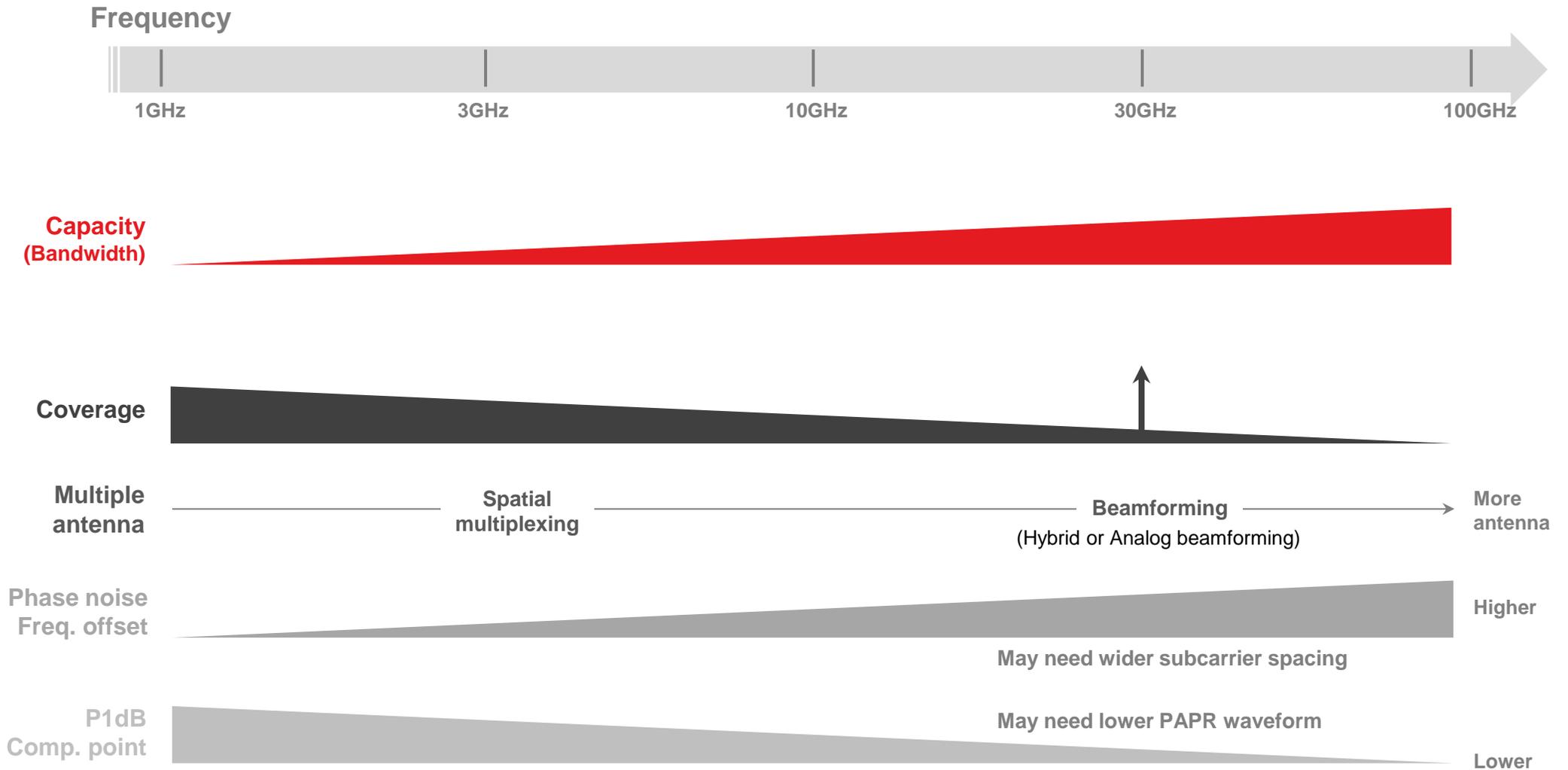
Higher RF complexity

More RF chains
Higher power amplifiers



New RAT revolution: Above 6GHz

Many technical challenges still remain. Therefore, we need to start studies and discussions now



New RAT revolution: Below 6GHz

An operator may choose a new RAT for < 6GHz if lower latency, less inter-cell interference, lower energy/cost and of course higher capacity than LTE-A evolution are provided

LTE-A or New RAT for < 6GHz?

- LTE-A keeps evolving. Therefore New RAT may offer a little higher spectral efficiency



- LTE-A has been used for > 5 years, meaning that it promises
 - excellent stability of N/W operation
 - full backward compatibility to legacy

Key drivers for New RAT < 6GHz

- “New RAT needs to offer additional values other than just higher capacity”



Lower
Latency



Less
Inter-cell
Interference



Lower
Energy &
Cost

New RAT revolution: Interworking

A consistent/seamless user experience and latency performance are key enablers for virtual reality and mission-critical IoT services → Multi-site and Multi-RAT connectivity

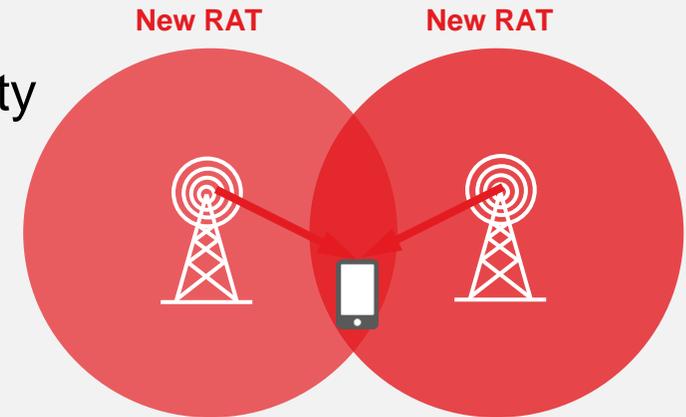
Anywhere ~1Gbps

- is important to provide immersive and virtual services seamlessly
- also important for mission-critical IoT service requiring ultra-high reliability

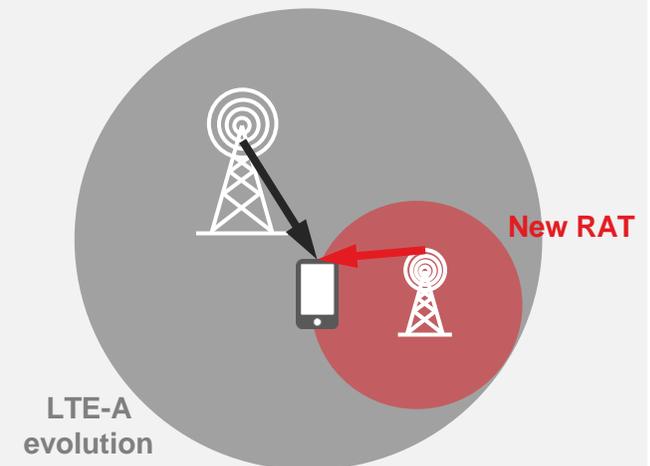


Multi-connectivity is essential for commercial deployment

Multi-sites Connectivity



Multi-RATs Connectivity



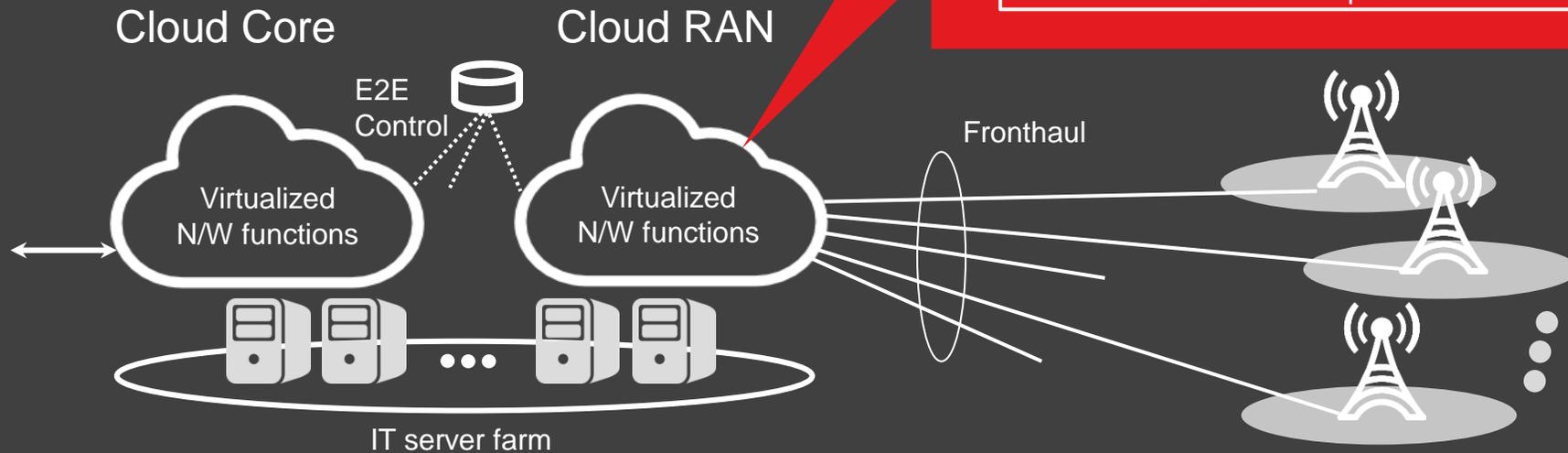
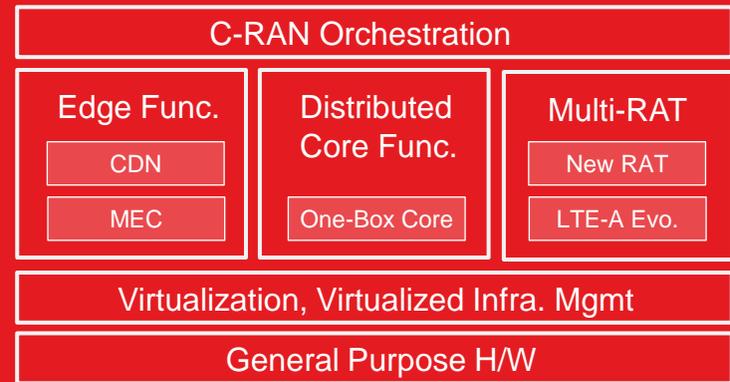
New RAT revolution: Cloud-RAN (C-RAN) in All-IT infrastructure

Cloud RAN becomes more widespread because of its structural advantages to provide multiple connectivity, RAN intelligence and flexibility with IT/virtualization technologies

All IT infrastructure

- Virtualized (COTS H/W, Open-source SW)
- Programmable
- Intelligent

Cloud RAN



New RAT revolution: Flexible C-RAN depending on fiber infrastructure

5G C-RAN should be flexible so that it can be deployed with any fiber infrastructure. To support it, different levels of multiple connectivity and coordination have to be considered

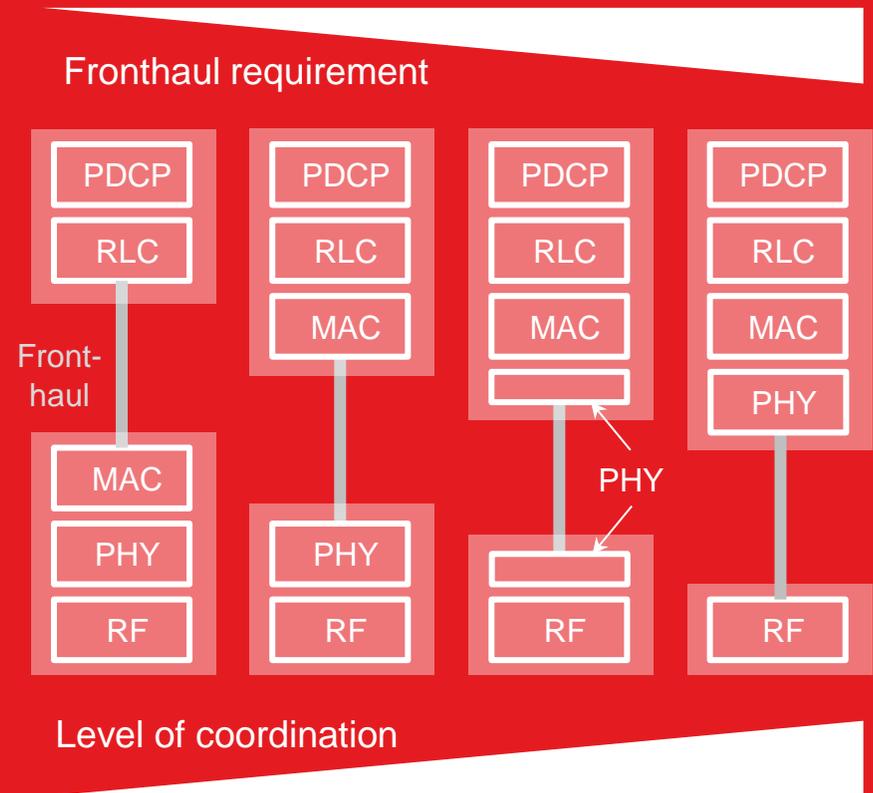
Fronthaul capacity for 5G

- Required data rate just for one sector would be ~ 200Gbps
- 5G lower latency features make fronthaul latency requirements to be even more stringent

Ex)

New RAT bandwidth	100MHz
Sampling frequency	153.6MHz
Bits per sample	16
# of antennas per sector	8
# of carrier aggregations	4
Overhead of FH protocol	25%
<hr/>	
FH data rate per sector	196.608 Gbps

5G Cloud RAN architecture



New RAT revolution: Flexible and efficient 5G radio

With C-RAN, 5G radio should be flexible and configurable to support all different 5G use cases and different deployment scenario

Scalable OFDM numerology

for different bandwidth, frequency, deployment scenario and use cases

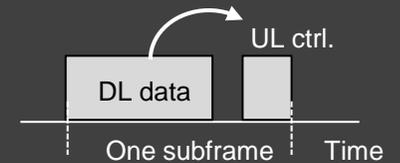
For both UL/DL, possibly with DFT precoding for lower PAPR



Flexible time frame

for lower latency and higher radio efficiency

Shorter symbol length
Self-contained frame
Flexible TTI



Beamforming

for higher user experience and wider coverage

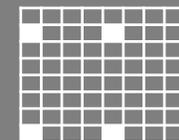
More transmission modes
Reference signal design for beamforming



Lean Carrier

for lower inter-cell interference and lower energy consumption

No periodic reference signals (like CRS)



5G standardization

Strong needs to show “5G brings different values that 4G cannot make” in 2018
Phase 1 needs to show it while providing forward compatibility to phase 2

Phase 1

- Initial 5G specification
- Meeting the most urgent commercial requirements
- Showing the benefit and capability of 5G from service perspective
- MBB and MC-MTC by New RAT and Massive MTC by LTE-A evo.
- Specification completed in 2018
- Forward compatible

Phase 2

- Complete 5G specification
- Meeting all requirements specified in IMT-2020
- Showing novel 5G service with 5G network infrastructure
- MBB, MC-MTC and Massive MTC by New RAT
- Specification completed in 2019
- Backward compatible

Phased approach for 5G standardization

	Phase 1	Phase 2
Target spectrum	Up to 40GHz	No restriction
MTC-related	MBB/MC-MTC by New RAT and Massive MTC mainly supported by LTE-A	Could be extended to New MTC use cases
Radio frame design	Lean carrier and flexible TTI	Could support asynchronous mode
Massive MIMO	Multi-user MIMO and Beamforming	Higher order MIMO
Waveform	OFDM-based	OFDM-based SC could be for > 60GHz
Duplex	FDD and TDD (Flexible Duplex and Dynamic TDD)	Same as Phase 1 IFBD could be introduced
Unlicensed band	Supported	Supported
Core	EPC-based core	5G core*

* A study will be required to find whether or not a new core is needed

Summary

Suggestion for way-forward

- To satisfy rapidly increasing demands for 5G, 3GPP has to develop 5G standards ASAP, meaning Time Unit for 5G should be NOT affected
- Both below 6GHz and above 6GHz are equally important
 - Above 6GHz is attractive in terms of high capacity. However, many technical challenges remain. Therefore, we have to start investigating it now
 - Below 6GHz needs to offer different values that LTE-A cannot provide, which may be low latency, lower inter-cell interference and higher efficiency
 - Multi-RAT and Multi-site connectivity are crucial for commercial services
- Different level of function splits in RAN architecture needs to be considered
 - Cloud-RAN will become more widespread with the help of IT/virtualization technologies. However, front-haul is now bottleneck for 5G requiring wider BW and more antennas
- SK telecom supports phased approach for early commercialization

