China Academy of Telecommunication Technology

3GPPRAN-workshop on 5G
Phoenix, USA, Sep.17 - 18, 2015

RWS-150003

Document for: Discussion
Agenda Item: 2

Key Technologies and Standardization for 5G Radio Access

CATT

Outline

- Overview of 5G radio access
- 3GPP standardization for 5G radio access
- 5G network architecture
- Key technologies for 5G radio access

Drivers and Challenges for 5G

Drivers

1990s

PC → Internet

Voice → Data

Individual Machine/Devices → M2M

2010s 2020s

Mobile Internet

Internet of Things

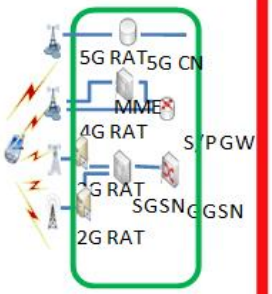
5G IMT-2020

Challenges

Explosion of Mobile Traffic

Massive Connection

Green ICT



Various Scenarios

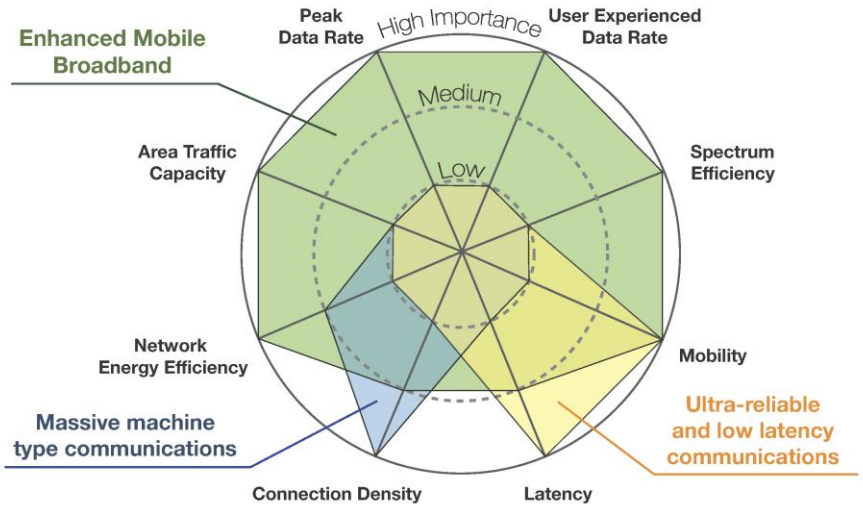
Critical MTC

Spectrum Scarcity

5G Application Scenarios and Requirements

ITU IMT-2020: 3 types of scenarios

- **eMBB**: user experienced data rate, peak data rate, spectral efficiency, traffic density, network energy efficiency, mobility
  - Wide area coverage
  - Hotspot coverage
- **Massive MTC**: connection density, low cost, low power consumption
- **Critical MTC**: latency, reliability, mobility



KPIs	Traffic density	Connection density	latency	mobility	Energy efficiency	User experienced data rate	Spectral efficiency	Peak data rate
ITU value	10 Tbps/ Km^2	1 million /Km^2	1ms (over the air)	500 Km/h	100x (network side)	0.1-1Gbps	3X(5x)	10Gbps (20)

Reference: NEW RECOMMENDATION ITU-R M.[IMT.VISION]

3GPP 5G RATs

3GPP 5G RAT(s) = LTE Evolution + New RAT

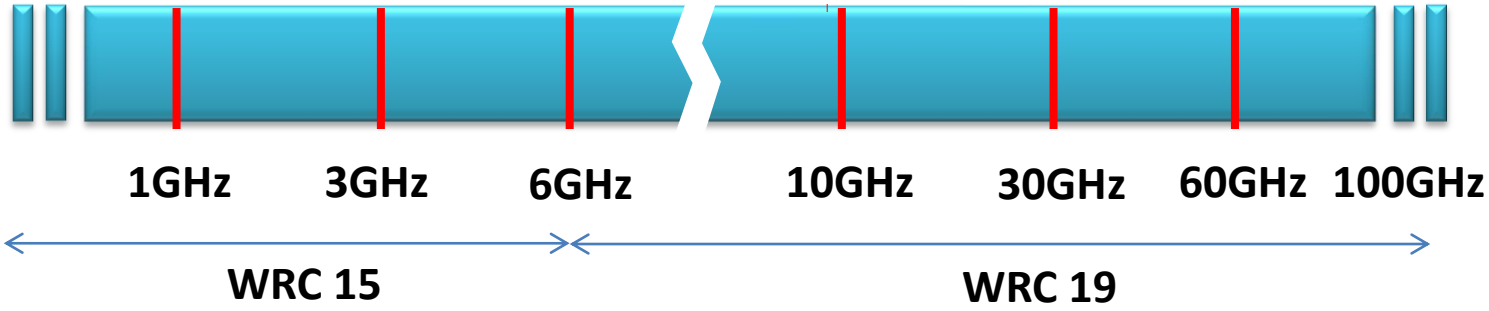
5G RATs

Backward Compatible RAT
(LTE Evolution)

Non-backward compatible RAT
(5G new RAT)

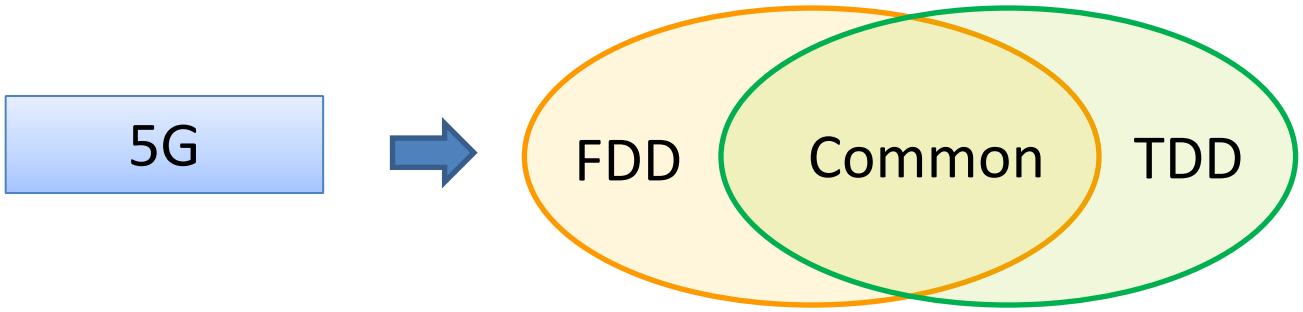
lower frequencies(<6GHz)

Whole 5G spectrum range

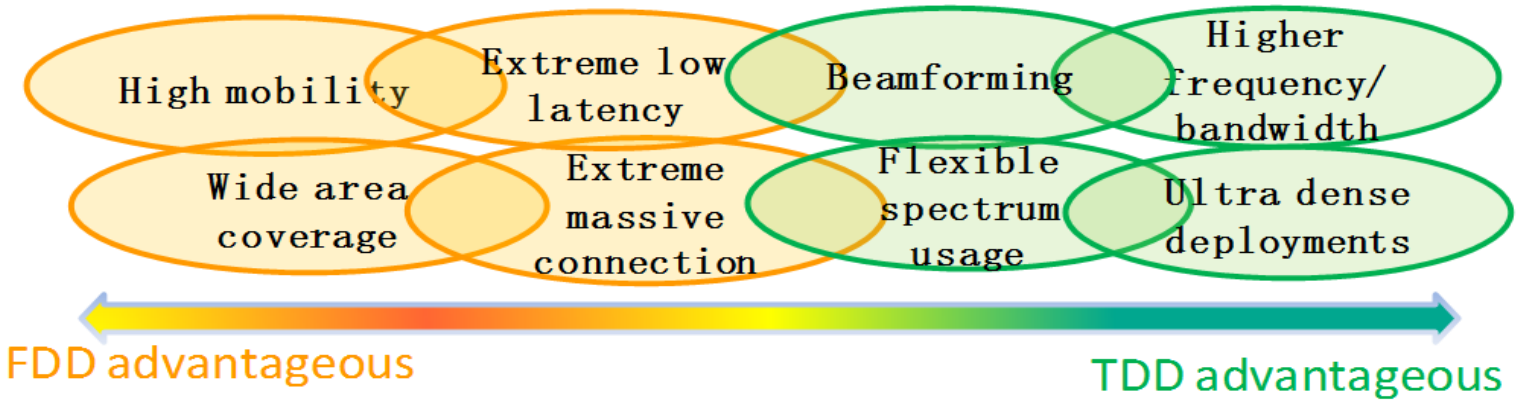


Duplex modes for 5G

Further Convergence for FDD and TDD in 5G



Evolution targeting 5G requirements will continue for both FDD and TDD



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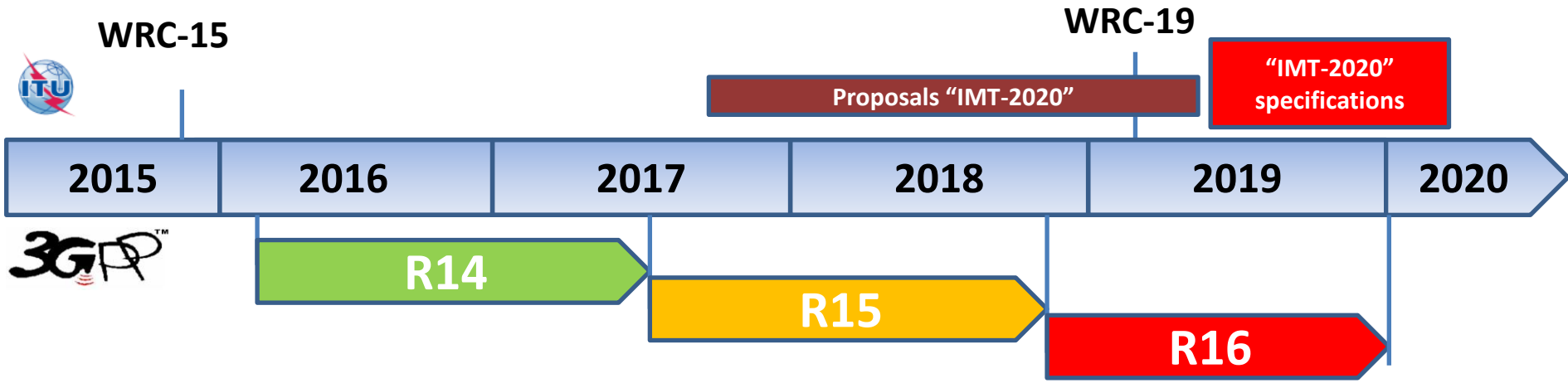
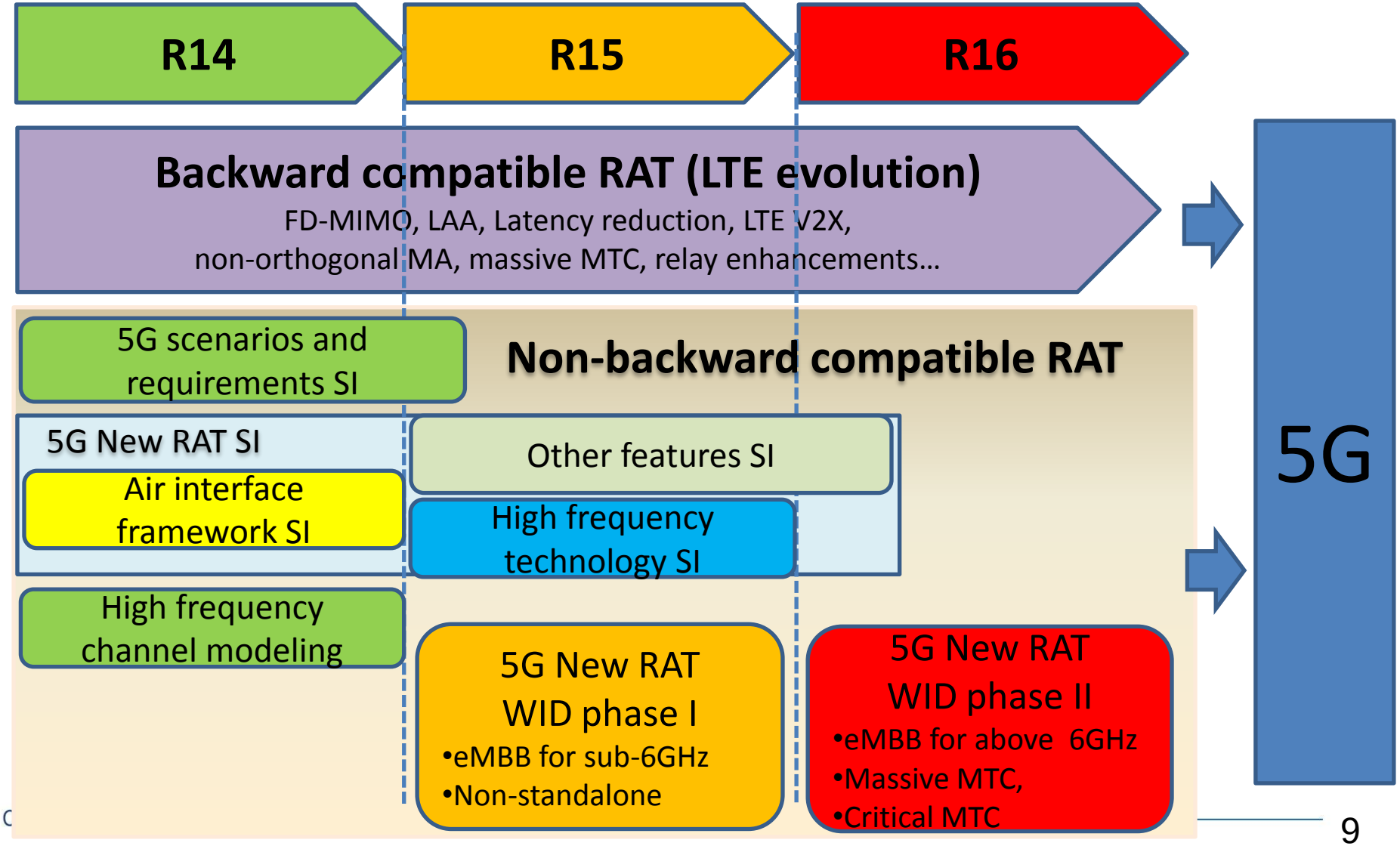
3GPP 5G Timeline in RAN



- 3GPP should submit the final specs at the 5D meeting in Feb 2020, based on functionally frozen specs by Dec 2019
- 3 releases of 5G work in 3GPP RAN
  - Rel-14: 2016.3 – 2017.6
  - Rel-15: 2017.6 – 2018.9
  - Rel-16: 2018.9 – 2019.12

3GPP standardization of 5G RATs



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5G system – A User Centric Network

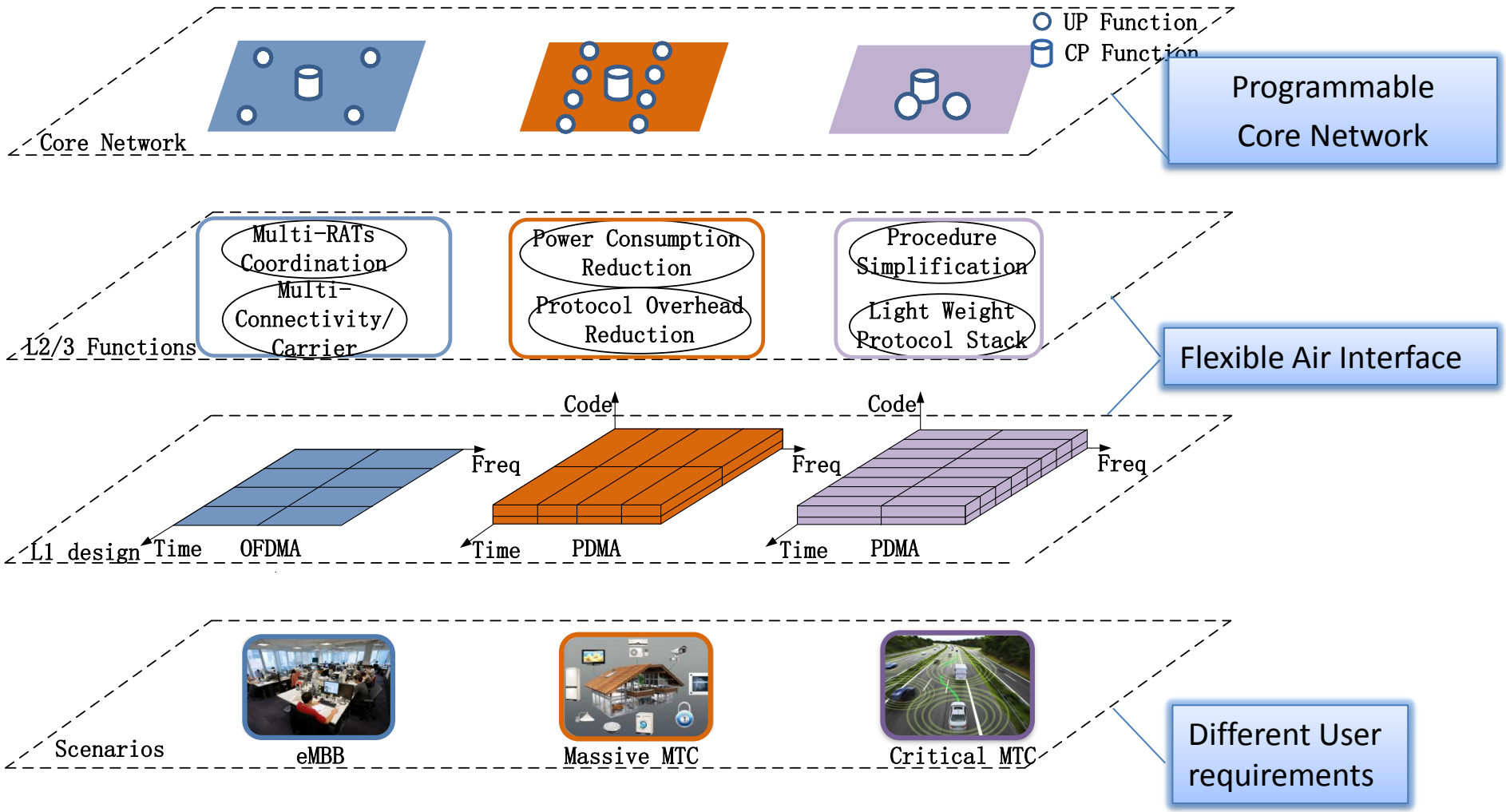
Visions

- Intelligent Network Knowing User
- Dynamic Network Following User
- Flexible Network Serving User

Key Features

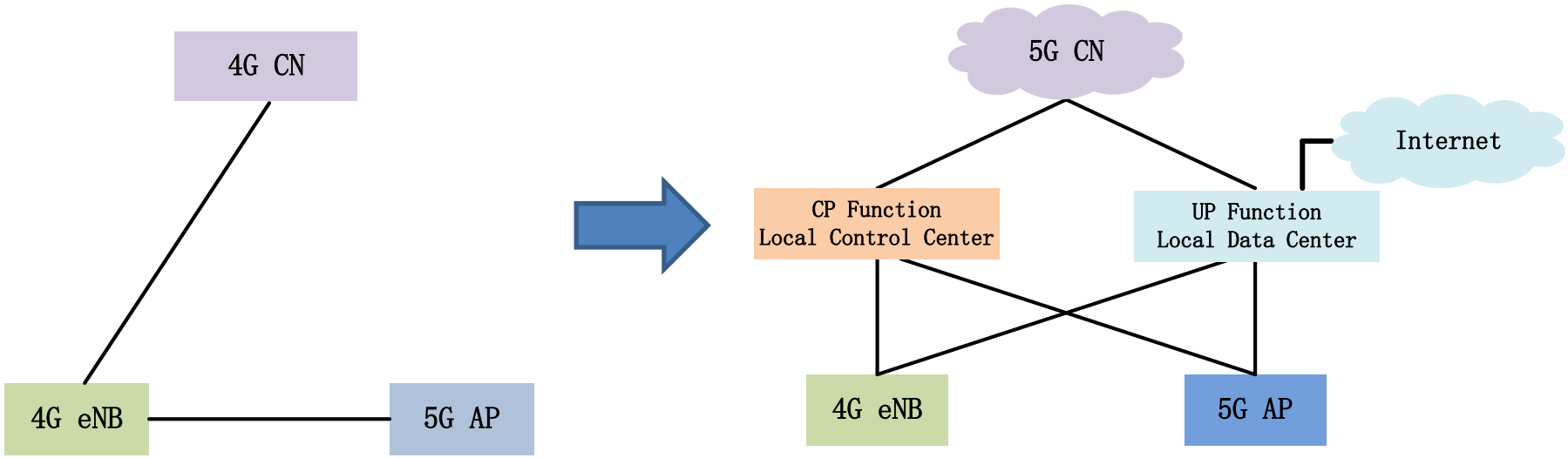
- Programmable Core Network
- Agile RAN Architecture
- Flexible Air Interface

Programmable CN and Flexible Air Interface



Agile RAN Architecture

- Local centralization
  - Part CN functions shifted to RAN: e.g. mobility management, GW
  - Multiple-RATs coordination and multiple sites coordination
- RAN C/U splitting
  - Flexible deployment
  - Reduce latency/Increase efficiency



Phase 1 non-standalone 5G NEW RAT

Phase 2 standalone 5G NEW RAT

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5G radio access technologies

eMBB

- Massive MIMO
- LAA
- UDN
- New MA
- mm Wave

Massive MTC

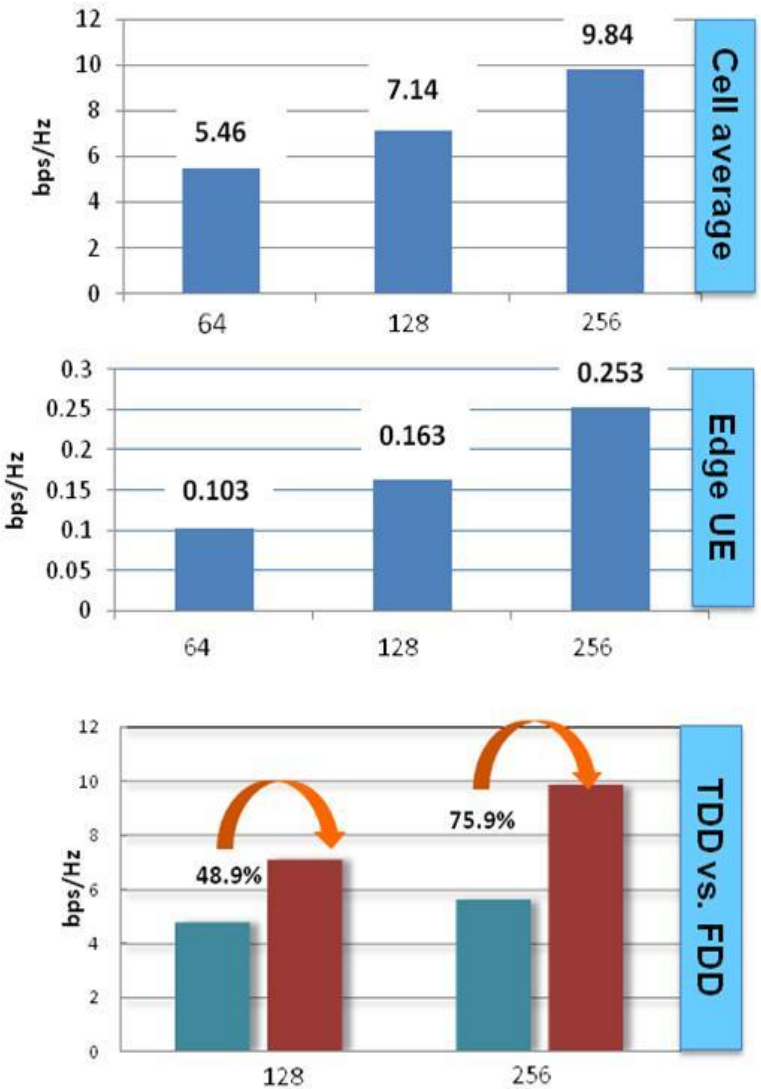
- Coverage
- Cost
- Battery life
- Massive connection
- Procedure simplification

Critical MTC

- Latency reduction
  -air interface & network
- High reliability
  - Diversity & redundant transmissions
- V2X

Massive MIMO

- Extension of Rel-13 FD MIMO beyond 64 antennas
- TDD advantage over FDD due to availability of more accurate channel information
  - High overhead for very large antenna array if only relying on UE CSI feedback
- MIMO for mmWave
  - Path loss compensation with array gain
  - Hybrid analog and digital beam-forming
  - Sub-6GHz assisted analog beam search and tracking



Novel Multiple Access

- Spectrum efficiency gain in both DL and UL
- Massive connection
  - Up to 1 million devices/km2
  - Control channel capacity limitation
- Low latency deployment
  - Healthcare, automatic driving, collision control and avoidance …

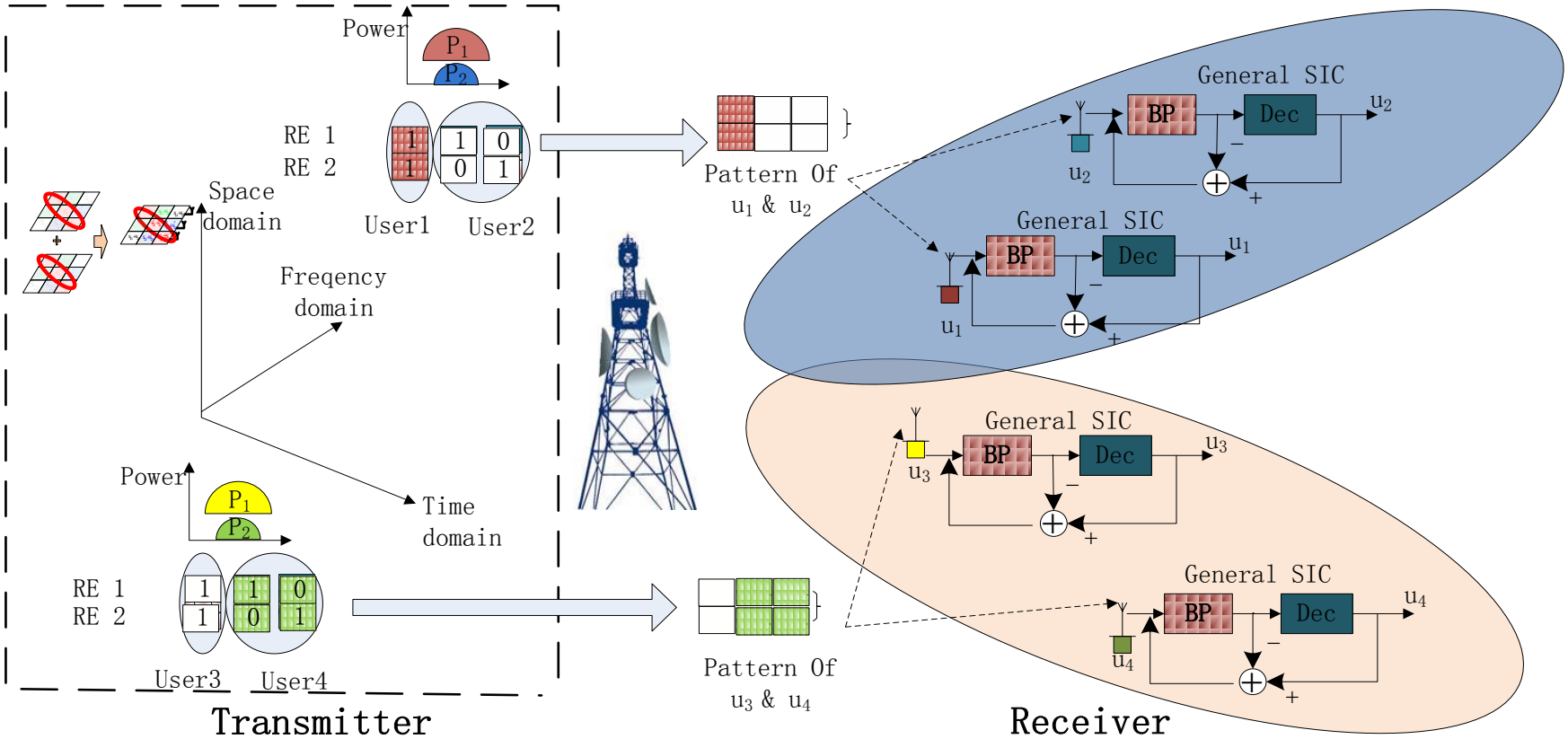
Massive connection

Low latency application

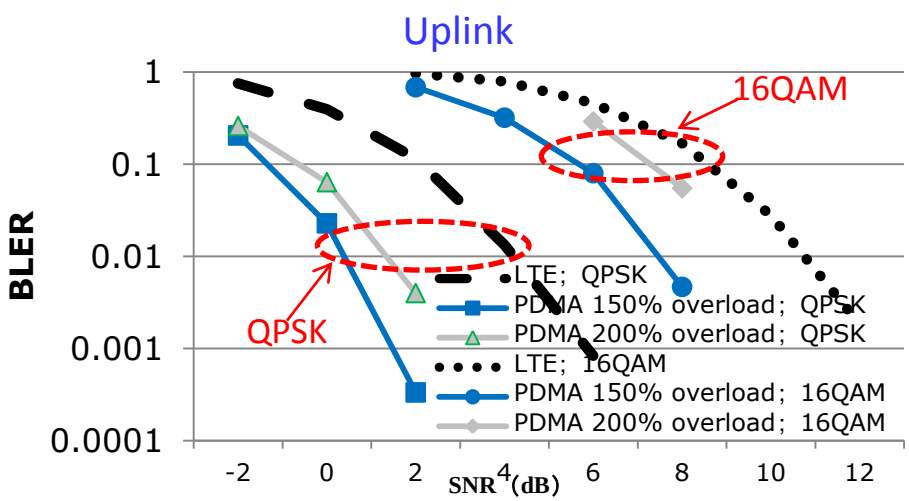
	Orthogonal Multiple Access		Non-Orthogonal Multiple Access
Spectrum efficiency	Limited by orthogonal resource allocation	→	Improved spectrum efficiency
Connection density	Limited by spectrum resource	→	Increased connected devices
Latency	Limited control channel capacity, higher scheduling latency	→	Reduced latency by Grant-free transmission and simplified procedures

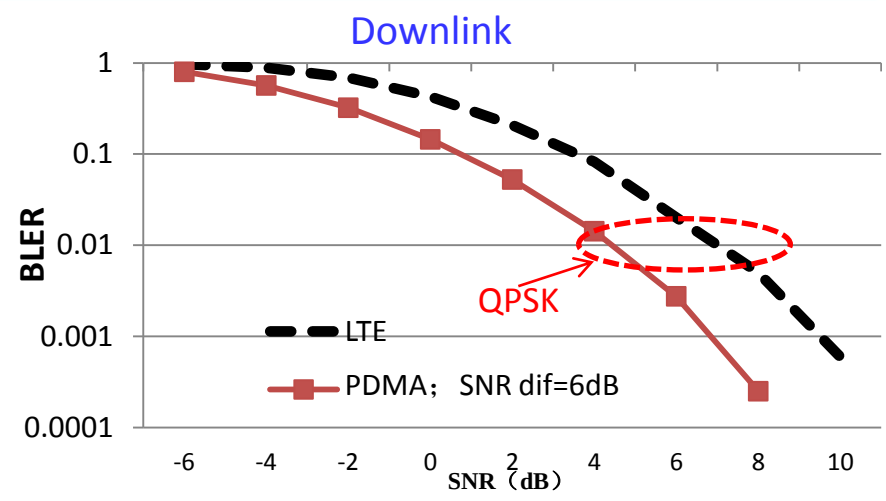
Pattern Division Multiple Access(PDMA)

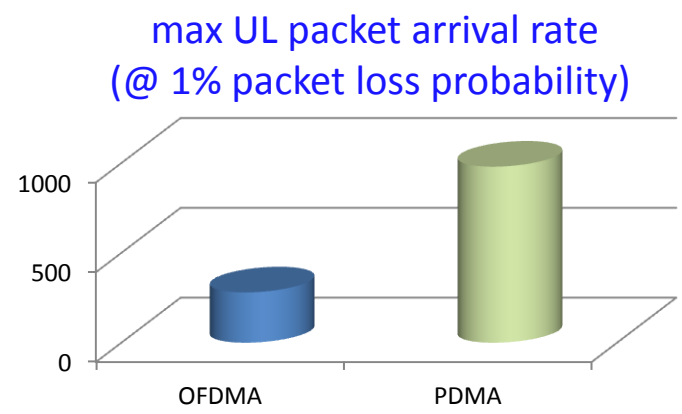
PDMA：A novel multiple access technology, with joint design of SIC-amenable pattern in time/frequency/space/power/code domain at the transmitter and low-complexity SIC-based detection at the receiver.

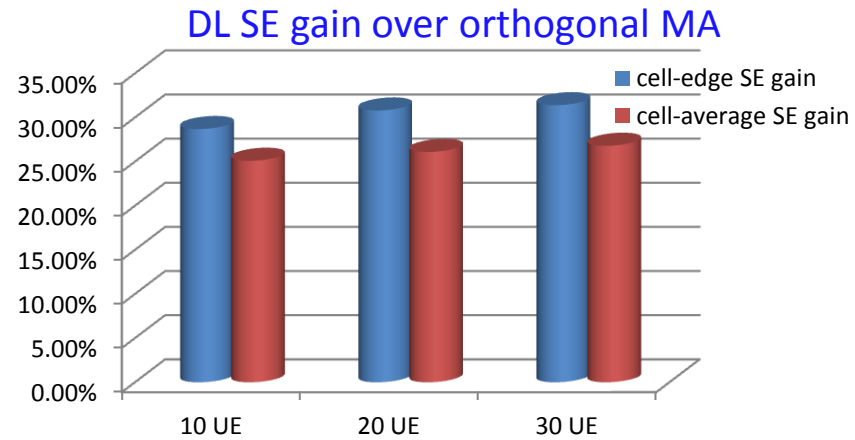


Benefits of PDMA







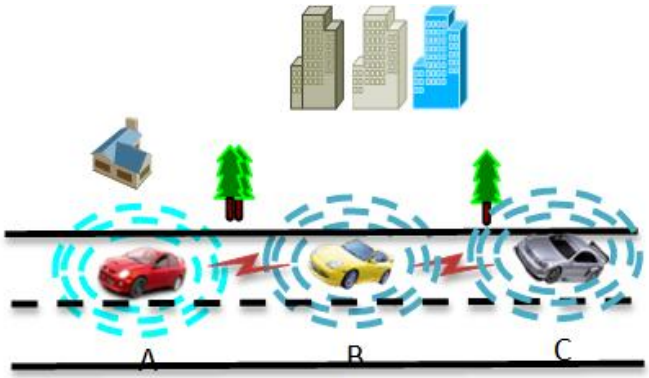


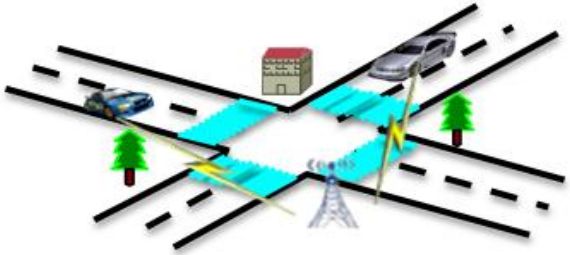
PDMA compared to LTE:

1. Link level: 3dB gain at working SNR.
2. System level : 3x accessing user number in UL; 30% spectrum efficiency gain in DL.

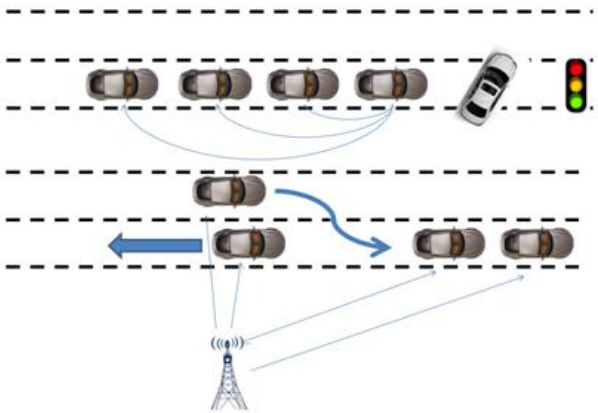
V2X

- Strong interests on V2X from vehicle manufacturers and cellular operators
  - Proximity safety services
  - Commercial applications
- Support of LTE-based V2X is urgently desired from market requirement
  - The market for V2V communication in particular is time sensitive
  - Many research projects and field tests of connected vehicles in some regions, such as China/US/Europe/Japan/Korea
- Requirements on V2X
  - Low latency and high reliability





Scenarios for road safety



Scenario for automatic driving

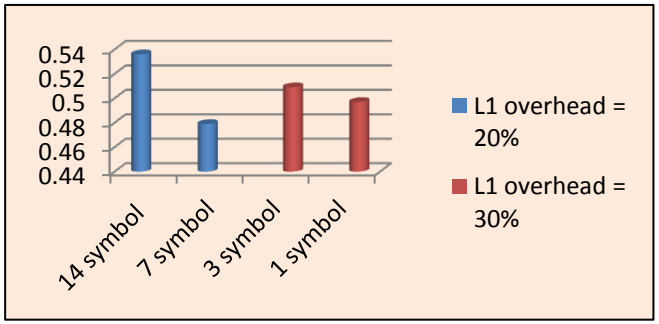
V2X for road safety

- Benefit to road safety and MNOs based on combination of Telematics and direct V2V (dual-mode)
  - V2V on dedicated spectrum
  - Satisfy both in coverage and out of coverage scenario
  - V2V through cellular network forwarding can provide further assistance at particular occasions
- Main technologies for V2V based on LTE
  - Enhancement of DMRS adapting to high mobility
  - Resource allocation enhancement to reduce collision
  - Consideration on synchronization to achieve unified timing

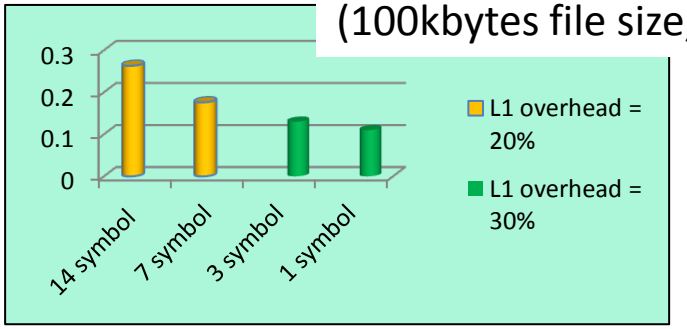
Low Latency transmission

- Targeting IMT-2020 requirement : 1ms over the air latency
- TTI shortening
  - LTE-evolution
    - L1 overhead increase for very short TTI
    - Impact of legacy UEs should be considered
  - 5G New RAT
    - Targeting 1ms over the air latency

Latency vs. TTI length
(100kbytes file size, 10MHs BW)



(a) 10RB for latency critical UEs

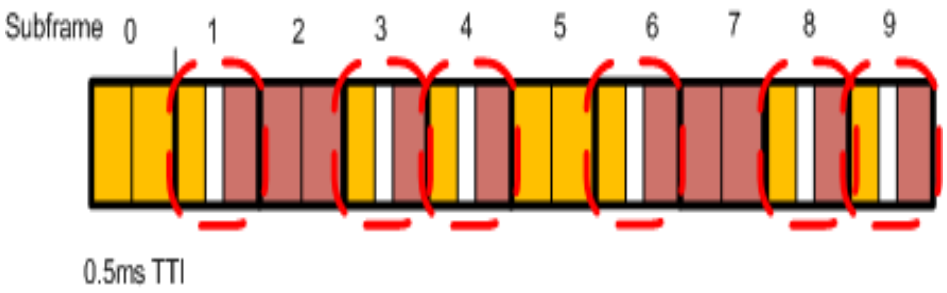


(b) 50RB for latency critical UEs

0.5ms TTI for LTE-evolution
0.2ms or shorter TTI for 5G new RAT

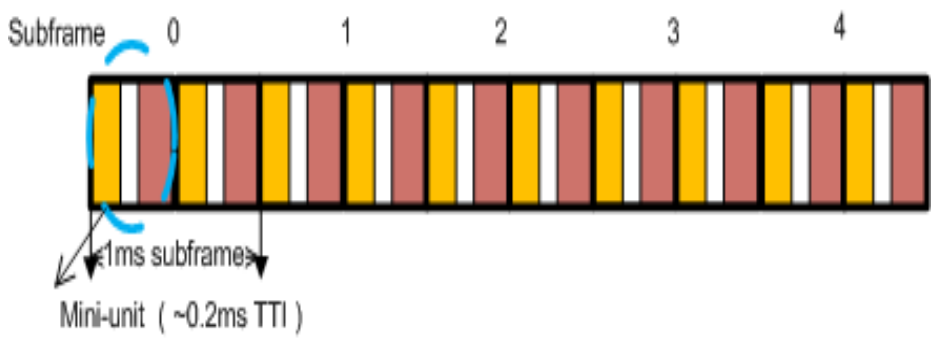
TDD Frame structure for latency reduction

- LTE-evolution



Description	Averaged U-plane latency	
	DL (ms)	UL (ms)
Tx Processing Delay	0.5	0.5
Frame Alignment	0.65	0.65
TTI duration	0.5	0.5
Rx Processing Delay	0.75	0.75
Total one way delay	2.4	2.4

- 5G New RAT



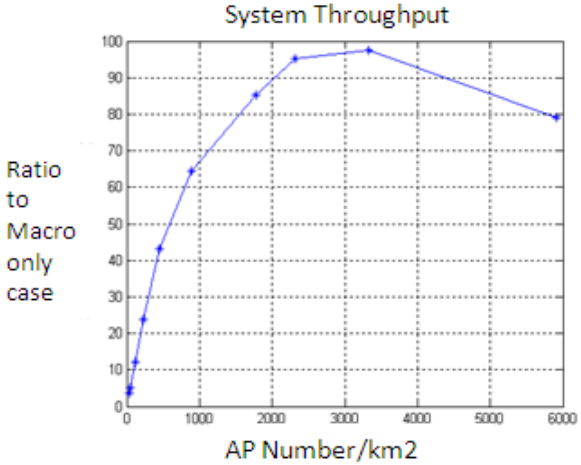
Description	Averaged U-plane latency	
	DL (ms)	UL (ms)
Tx Processing Delay	0.2	0.2
Frame Alignment	0.25	0.25
TTI duration	0.2	0.2
Rx Processing Delay	0.3	0.3
Total one way delay	0.95	0.95

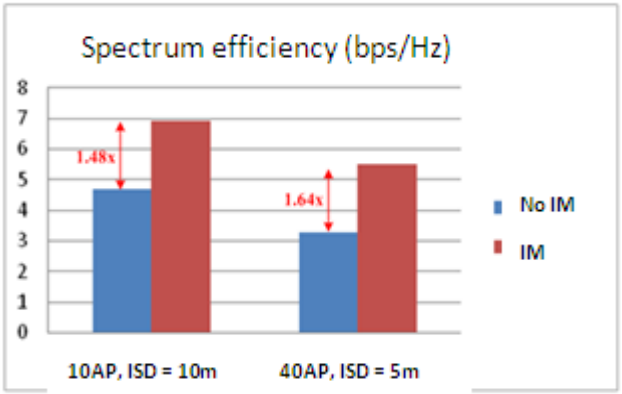
High Frequency Communication

- Target for 5G new RAT with high frequency
  - High data rate (>10Gbps)
  - High traffic density (10Tbps/km2)
- TDD has priority for high frequency communication
- Working areas for high frequency communication
  - High frequency Channel Modeling (6GHz~100GHz)
    - Channel measurement work -> see appendix
  - Key features
    - New frame structure and parameters
    - Beam forming and tracking
    - Mobility management
    - Interworking of high and low frequency carrier

Ultra Dense Network

- Large throughput gain provided higher frequency reuse
- Challenges
  - Frequent handover
  - Serious interference
  - Limited wireless backhaul resource
- Potential solutions
  - Cell virtualization
  - Interference management enhancement
  - Backhaul/access integration
  - Intelligent networking





Observations:

-Interference increase with the cell density

-Significant throughput gain by efficient interference management.

Massive MTC

Large coverage

- PSD boosting
- Channel repetition
- Longer TTI

Massive connection

- Scheduling overhead reduction
- New multiple access scheme
- Signaling procedure optimization

Low cost

- Narrower bandwidth
- Smaller transport block size

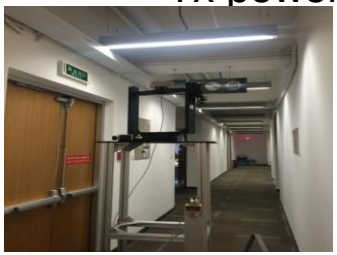
Long battery life

- Longer DRX/PSM
- Functionality simplification

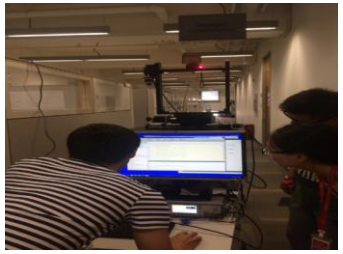
THANK YOU

Appendix – High frequency channel measurement

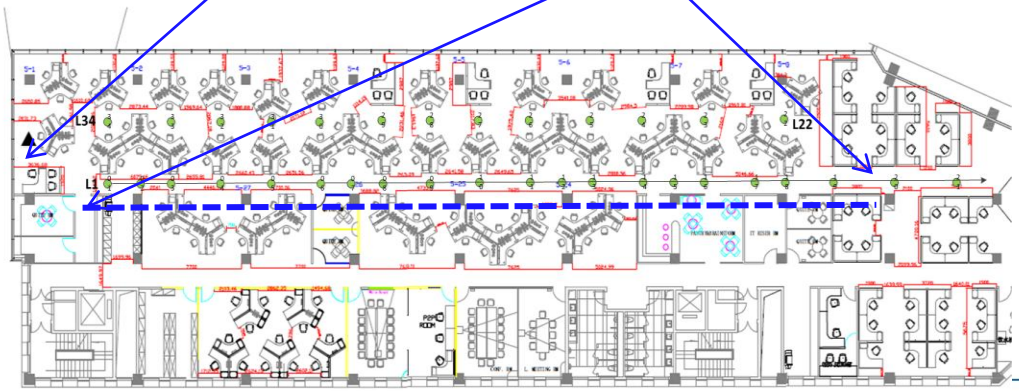
- Channel measurement
  - Scenario: indoor LOS/NLOS
  - Frequency: 26GHz
  - Bandwidth: 1GHz
  - Tx/Rx height：2.3/1.87m
  - Tx power: 23-26dBm

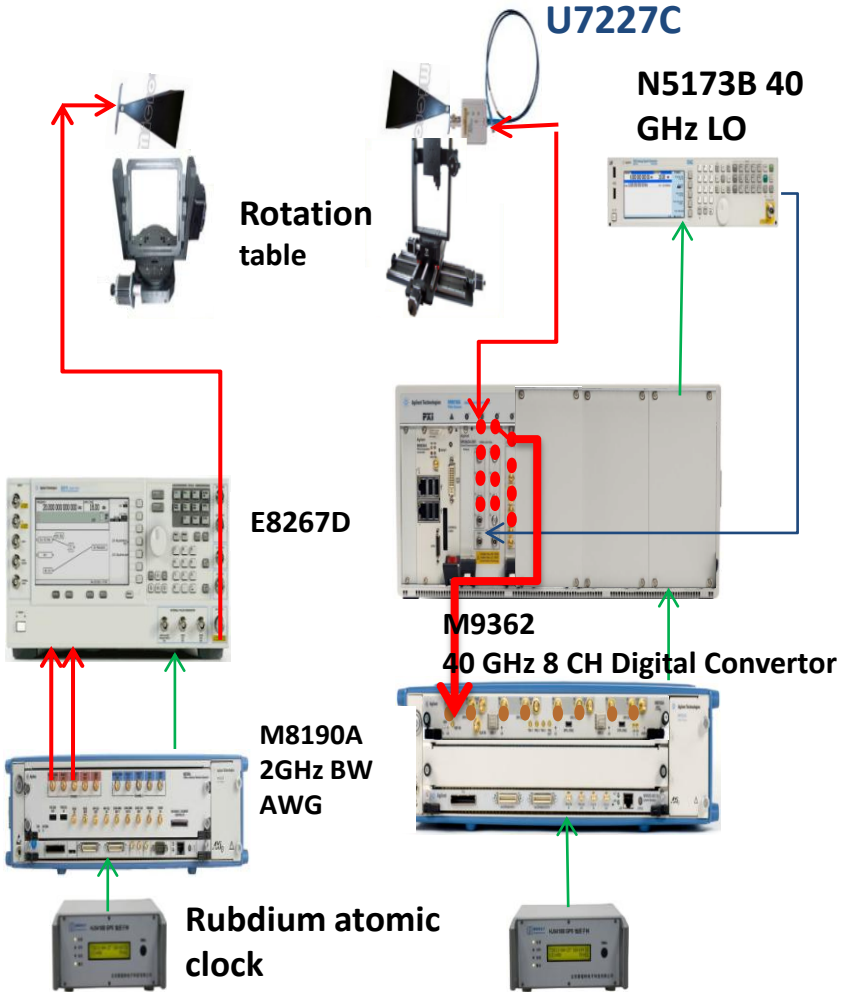


Tx in measurement



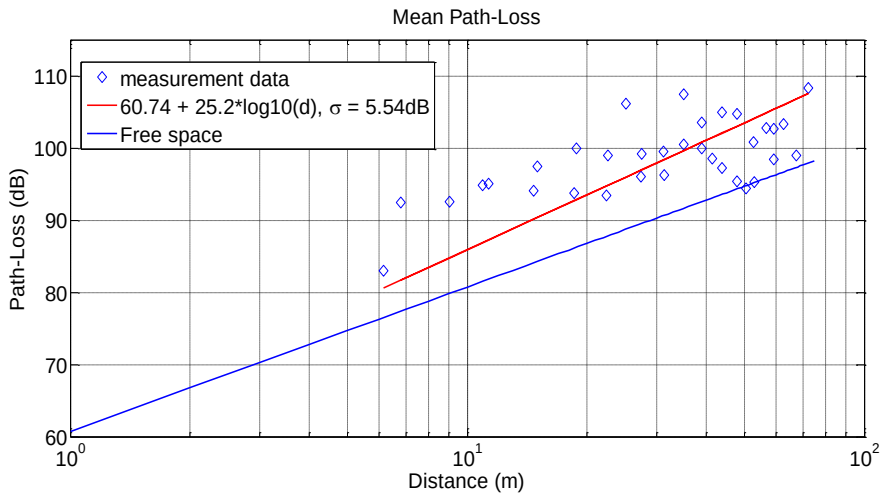
Rx in measurement

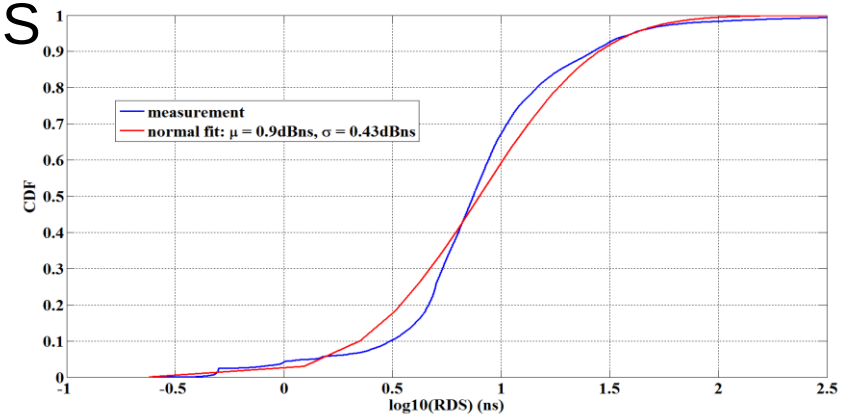


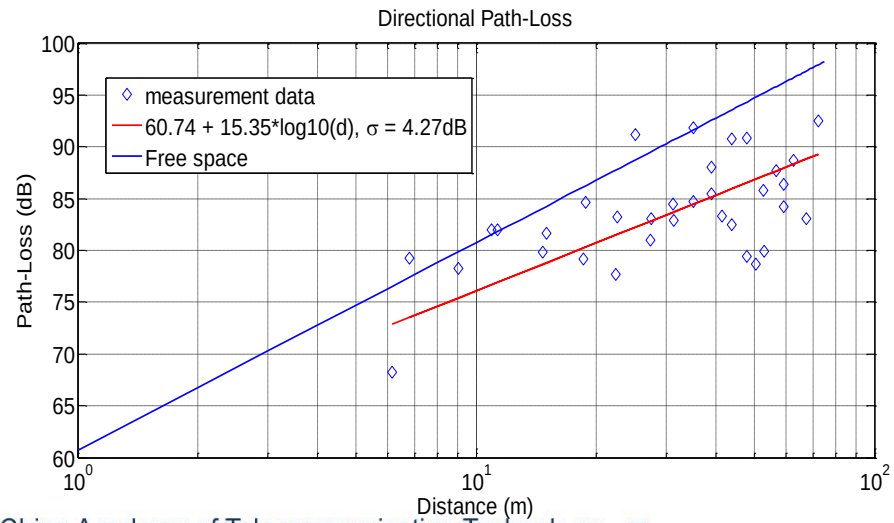


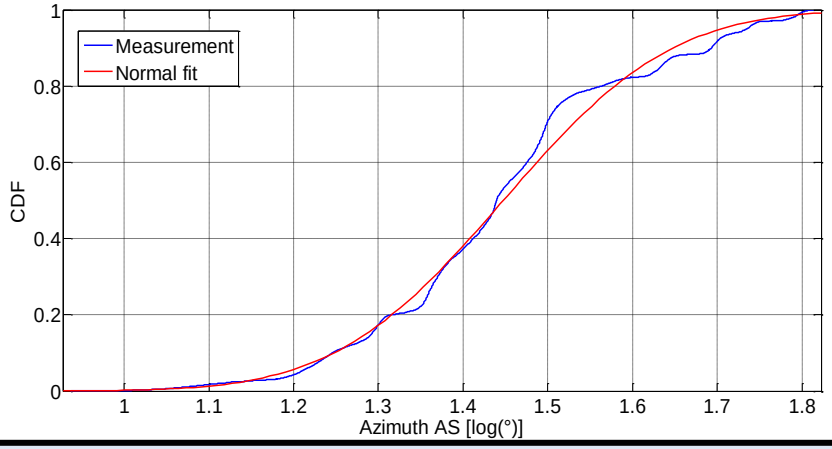
Appendix – High frequency channel measurement

Channel measurement results in LOS









1. Mean PL: n=2.52, sigma=5.54
2. Directional PL: n=1.54, sigma=4.27
3. RMS delay spread: u=0.9, sigma=0.43
4. RMS angular spread: u=1.45, sigma=0.16