5G Radio Access Technologies and Standardization

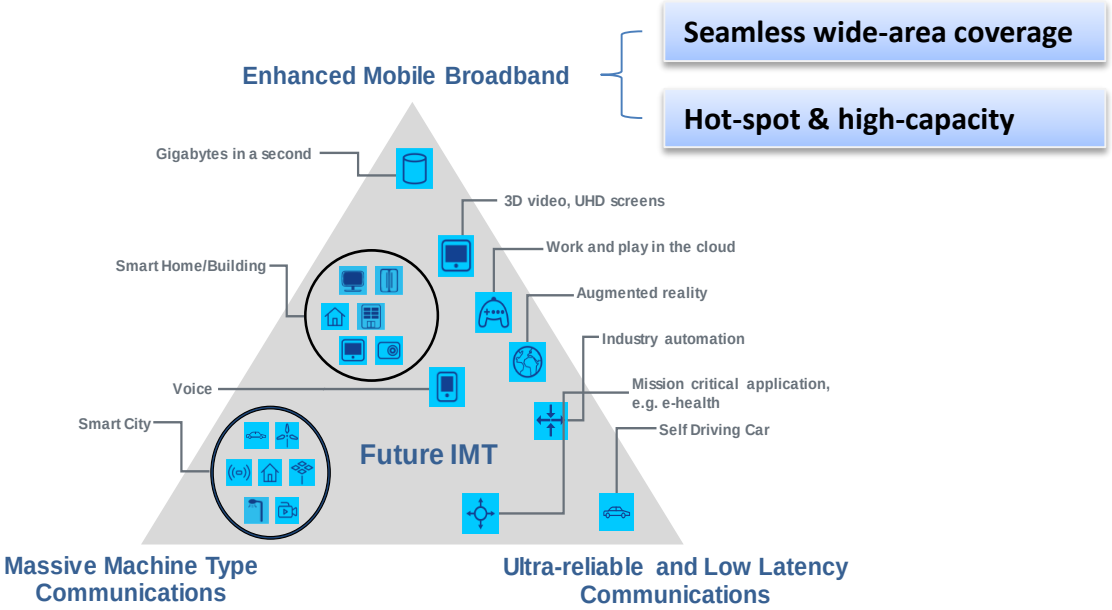
CATR

2015.9.17-18
3GPP 5G workshop

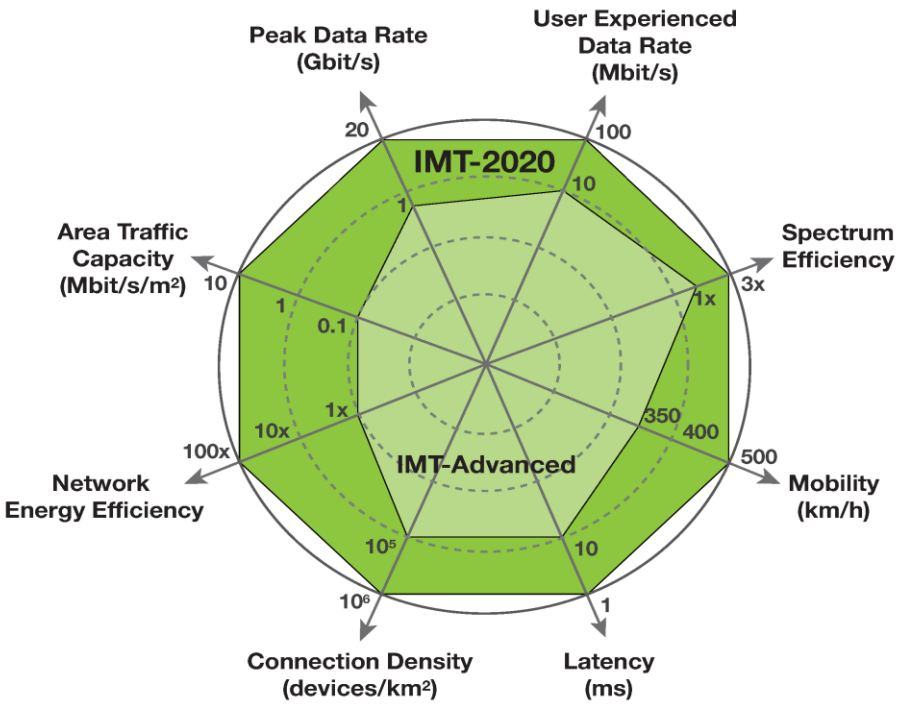
General 5G Vision

- Main drivers of 5G: Mobile Internet and Internet of Things (IoT)

- Main market trends
  - Mobile Data Traffic: Thousands of times growth
  - Mobile Device & IoT Connections: Up to 100 billion



5G key capabilities and Technical Challenges



eMBB

Seamless wide-area coverage

- User experienced data rate: 100 Mbps

Hot-spot & high-capacity

- User experienced data rate: 1 Gbps
- Peak data rate: 10 Gbps
- Traffic volume density: Tens of Tbps/km^2

Massive machine type communications

- Low power consumption, low cost, large coverage
- Massive connections (10^6/Km^2)

Ultra-reliable and low latency communications

- Air interface latency: 1 ms
- End to end latency: ms level

IoT

5G Technology Roadmap

- New RAT(s)
  - Both 5G mobile Internet and IoT demands should be taken into account from the very beginning.
  - Considering transmission characteristic of low and high frequency, new RAT(s) should include set of numerologies .
- Close interworking between low and high frequency access part, close interworking between new RAT(s) and 4G evolution.
- Many technical points studied for new RAT could be introduced in 4G evolution.

New RAT(s) ⇨ New design to meet all 5G requirements, without backward compatibility and to be deployed on …100MHz~100GHz

4G Evolution ⇨ Enhancement based on LTE framework, to meet at least part of 5G requirements and focus on sub 4GHz

5G design and Enabling Technologies

System design

- Waveform
- Numerology
- Frame structure

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Key wireless technologies

- Novel Multiple Access
- Ultra-dense networking
- Massive MIMO
- Flexbile/Full Duplex
- Advanced Coding and Modulation
- D2D
- Spectrum sharing

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Advanced Network Architecture

Waveform

- **OFDM as fundamental waveform**
  - Efficient wider bandwidth design
  - Flexible resource schedule scheme, to support 5G diverse services
- **New waveform** to meet eMBB and IOT spectrum utilization requirement, at the same band and the same time.
- There are some candidates, adding filter on subcarrier or subchannel, e.g Filter-OFDM, Filter-Bank Multi-carrier(FBMC), Universal Filtered Multi-Carrier(UFMC)
- Following features should be evaluated during new waveform scheme down-selection
  - Anti-multipath fading
  - Out-band emission
  - Complexity
  - Integration with MIMO
  - Parameter flexibility
  - …

Numerology

- Motivation
  - 5G challenge requirement, e.g. 10Gbps peak data rate, 100M~1Gbps user experienced data rate, tens of Tbps/km^2 traffic volume density…
  - Expect new wider IMT bandwidth on low and high frequency
- For new RAT design, wider fundamental channel bandwidth is a straightforward way to meet these challenges

	Low frequency (e.g <6GHz)	High frequency (e.g >6GHz)
Duplex mode	FDD, TDD	TDD
Channel bandwidth	40MHz, 80MHz…	hundreds of Mhz
Subcarrier bandwidth(N*15kh)	e.g. 60kHz	hundreds of kHz, e.g. 300khz
Symbol length (1/N/15kHz)	e.g. 16.7us	e.g. 3.3 us

- **5G numerology set should match all 5G scenarios,** e.g. wide coverage, UDN…

Frame Structure

- Frame structure and TTI design are highly related to air interface latency
  - eMBB: support very low latency and high reliability human-centric communication in ITU vision
  - IoT scenario: Supporting very low latency and high reliability machine-centric communication in ITU vision

- Design principle
  - Expect **unified** FDD and TDD design, unified design for low and high frequency in 5G
  - Support **scalable** TTI design to meet diverse latency requirements and wide frequency range
  - **Acceptable** GP overhead to support all 5G scenarios for TDD part, especially wide area scenario

Novel Multiple Access

- As fundamental technology, novel multiple access for new RAT should meet eMBB and IoT demands.
- Motivation
  - Up to 100 Billion connections
  - ‘Zero’ Latency User Experience
  - Fiber-like Access Data Rate and High SE
- **Superposition coding based** novel multiple access
  - Multiple users share spectrum resource, which improve spectrum efficiency greatly and support more user connection
  - enable Grant-free transmission, which will simplify signaling process and reduce latency

Massive MIMO

- One of the most effective schemes to improve system throughput, and fundamental technology for mmWave

- Technical points
  - Base band beamforming
  - Hybrid beamforming
  - Complexity reduction
  - Common channel/signal design
  - CSI feedback

- It is very important to fully utilize channel reciprocity in TDD system

Ultra Dense Network

- Motivation
  - High DL/UL traffic density in office and dense urban area, e.g, 15T and 2T bps/km^2 for DL and UL respectively

- UDN would be deployed on low(3~6GHz) and high frequency.

- Technologies
  - Relay or D2D based enhancement to improve transmission capacity
  - Joint access and backhaul design, fast access and backhaul resource assignment for in-band case
  - CoMP enhancement for data channel, and CoMP scheme for control channel
  - Fast control and fast negotiation between TPs on backhaul

Higher frequency technologies

- Advanced Beam forming and Tracking is fundamental technology for mmWave

- Close integration between Low and High Frequency
  - Control layer on low frequency and data layer on high frequency, i.e C/U plane splitting
  - Rethink existing dual connectivity protocol structure and process, considering high frequency feature(e.g. GHz bandwidth, unstable channel, sensitive to latency)

- Adaptive Backhauling
  - Frame structure
  - Interference management
  - Unified Radio Access and Backhaul

Internet of Things

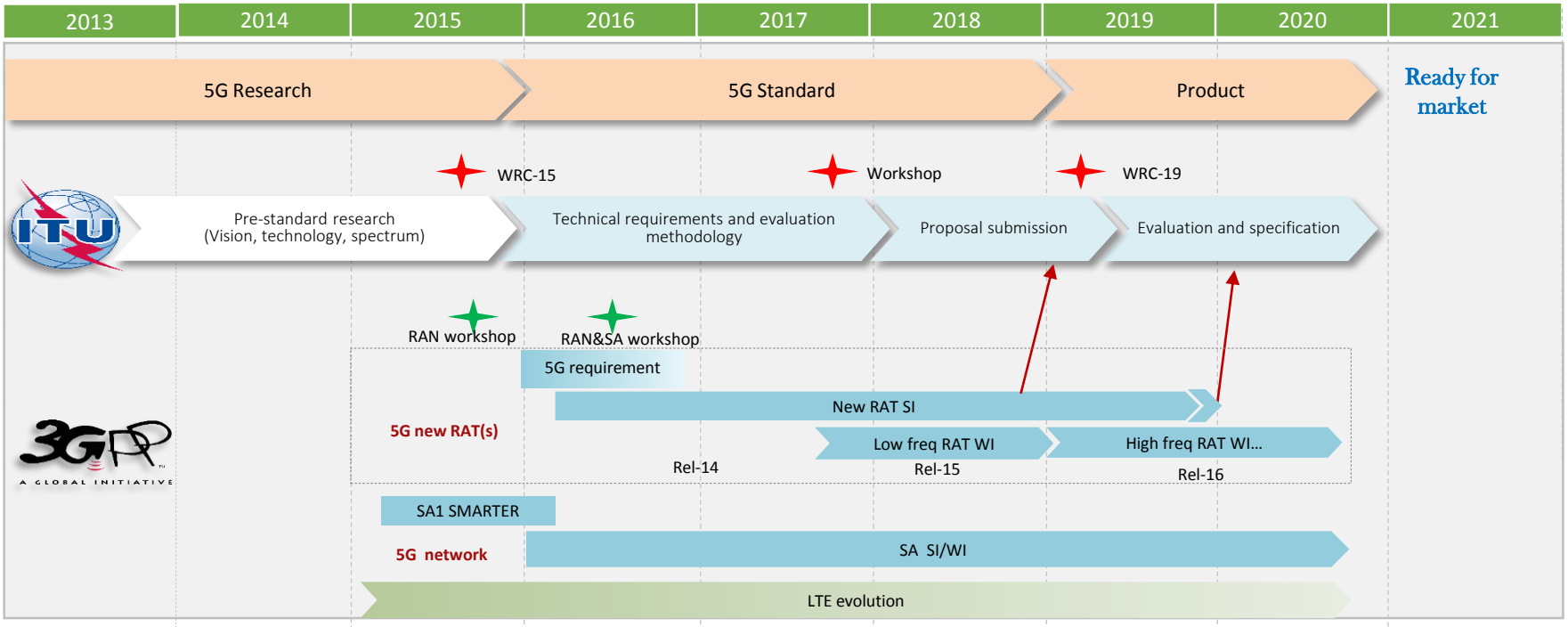
Ultra-reliable and Low latency communication

- Short frame & optimized signaling
- Novel multiple access
- D2D based communications
- Adv. MCS & retransmission

Massive Machine Type communication

- Novel multiple access
- FBMC / F-OFDM
- D2D communications
- Adv. modulation and coding

View on 5G Standardization



R14 will focus on 5G framework study

- General 5G study and technologies study, including numerology, frame structure, novel multiple access, enhanced waveform, UDN, massive MIMO, new coding and modulation scheme….

R15 will be the first 5G standard release

- **Focus on new RAT sub 6GHz standardization including eMBB ,IoT**
- Study high frequency specific technologies from 6GHz to 100GHz.

R16 will meet all ITU requirements and be submitted as ITU IMT-2020 specification

Thanks for your attention!

3GPP RAN workshop on 5G
Phoenix, AZ, USA, September 17-18, 2015.