5G Mobile Communications for 2020 and Beyond

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How 5G will be different?

What is 5G ?

5G Service Vision

Everything on Cloud

Desktop-like experience on the go

Immersive Experience

Lifelike media everywhere

Ubiquitous Connectivity

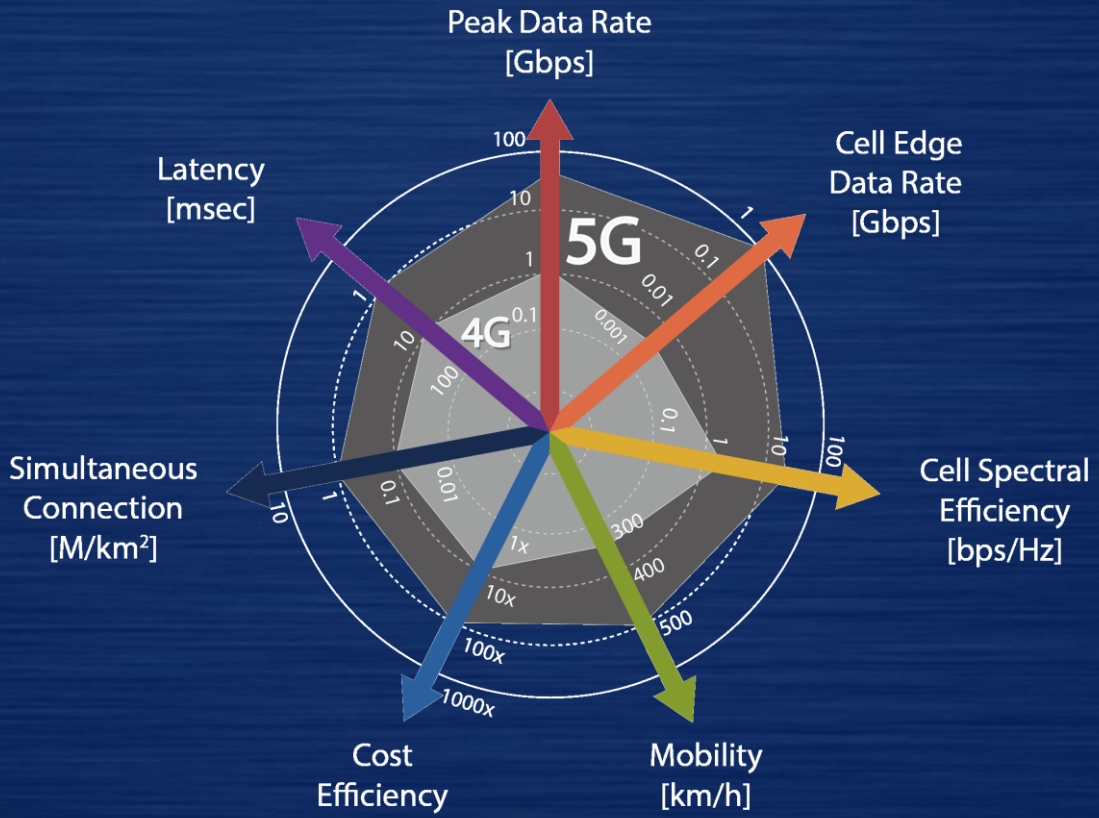
An intelligent web of connected things

Telepresence

Real-time remote control of machines

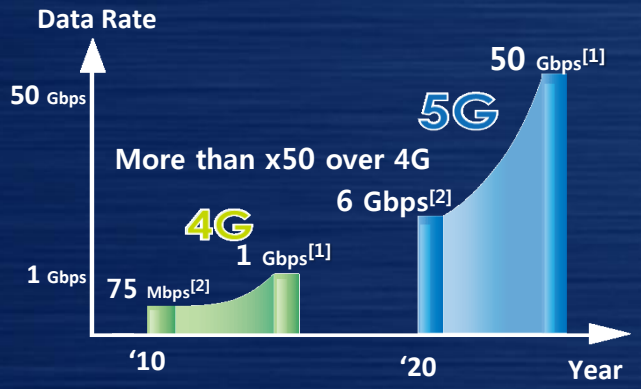
Technical requirements for 5G

5G Rainbow of Requirements

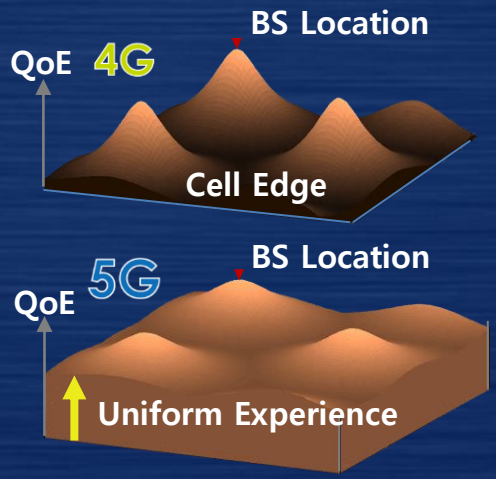


Superior User Experience

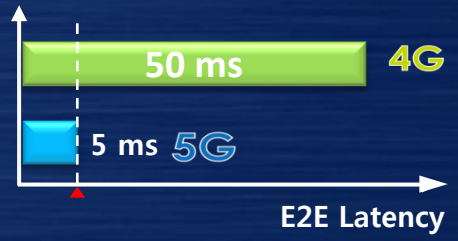
Peak Data Rate > 50 Gbps



1 Gbps Anywhere



E2E Latency < 5 msec



Air Latency < 1 msec

[1] Theoretical Peak Data Rate
[2] Data Rate of First Commercial Products

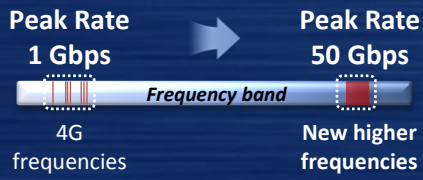
Enabling Technologies - RAN (1/2)

Disruptive RAN Technologies for Significant Performance Enhancements

- Peak Data Rate
- Cell Edge Data Rate
- Cell Spectral Efficiency
- Mobility
- Cost Efficiency
- Simultaneous Connection
- Latency

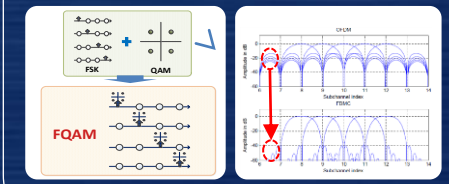
Technology for Above 6 GHz

Peak Data Rate Increase



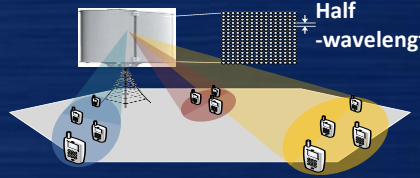
Post-OFDM

Spectral Efficiency & Cell Edge Enhancement



Advanced MIMO & BF

Cell Capacity Enhancement



BF : Beamforming

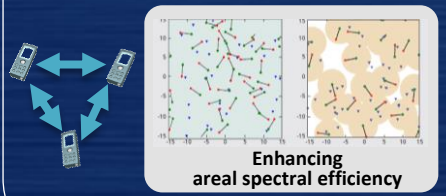
Enabling Technologies - RAN (2/2)

Disruptive RAN Technologies for Significant Performance Enhancements

- Peak Data Rate
- Cell Edge Data Rate
- Cell Spectral Efficiency
- Mobility
- Cost Efficiency
- Simultaneous Connection
- Latency

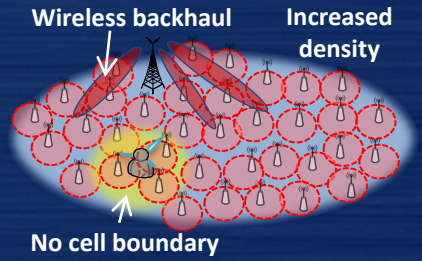
Enhanced D2D

Areal Spectral Efficiency Increase



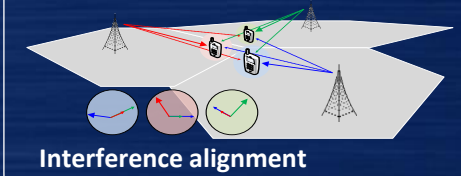
Advanced Small Cell

Capacity & Cell Edge Enhancement



Interference Management

Cell Edge Data Rate Enhancement



D2D : Device-to-Device

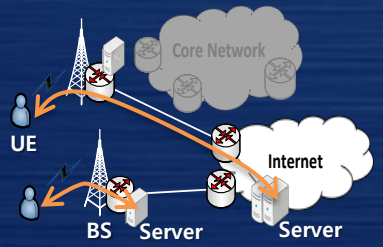
Enabling Technologies - Network

Innovative Network Technologies for Enhanced User Experience and Cost Reduction

- Peak Data Rate
- Cell Edge Data Rate
- Cell Spectral Efficiency
- Mobility
- Cost Efficiency
- Simultaneous Connection
- Latency

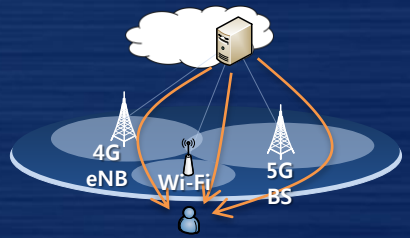
Flat Network

E2E Latency Reduction



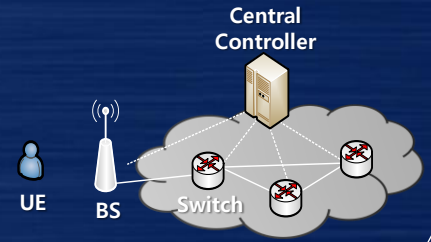
Multi-RAT Interworking

Radio Capacity Enhancement



Mobile SDN

Energy & Cost Efficiency Increase



SDN : Software Defined Network

5G

What we have achieved?

Channel Measurements

Three Types of Environments : In-Building, Campus, and Urban at 28GHz

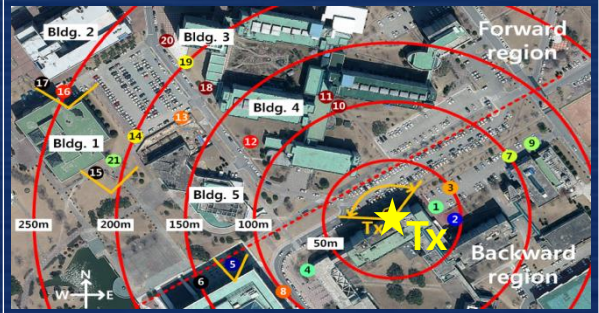
In-Building

☐ Similar to Indoor Shopping-Mall
- Five-story Building
- Spacious Atrium Lobby

☐ Total 35 Rx Locations
- Both for LoS and NLoS
- Tx-Rx Distance : 10m ~ 55m

Campus

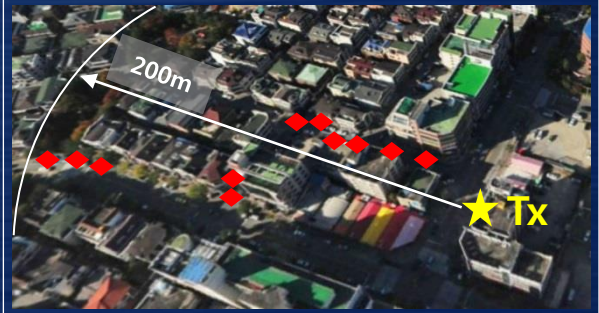
☐ Suburban Environments
- KAIST Outdoor Campus
- Tx Height 15 meters



☐ Total 25 Rx Locations
- Mainly for NLoS
- Tx-Rx Distance : ~ 270m

Urban

☐ Urban Environments
- Daejeon City
- Tx Height 15 meters



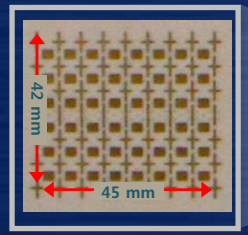
☐ 11 Rx Locations
- Mainly for NLoS
- Tx-Rx Distance : ~ 200m

mmWave Testbed - Overview

World's First 5G mmWave Mobile Technology (May, 2013)

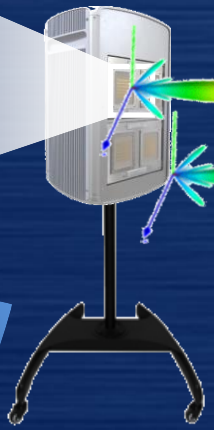
Adaptive array transceiver technology operating in mmWave frequency bands for outdoor cellular

Base Station

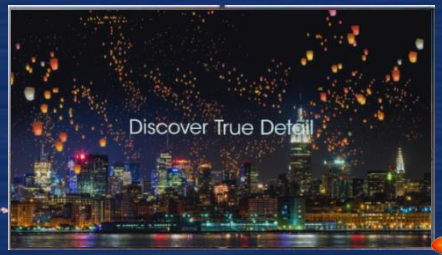


Array Antenna
8x6 (=48) Antenna Elements

RF + Array Antenna



RF + Array Antenna



UHD Streaming

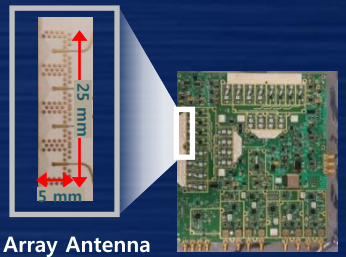
FTP Transfer

Ray-Tracing Simulation

	BS	MS
Carrier Frequency	27.925 GHz	
Bandwidth	800 MHz	
Beamwidth (Half Power)	10°	20°(AZ) /140°(EL)

Mobile Station

RF + Array Antenna



Array Antenna
4x1 (=4) Antenna Elements

Baseband Modem

mmWave Testbed - Recent Updates

World's First 5G Data Transmission at Highway Speeds (Oct, 2014)

Record-breaking 1.2Gbps data transmission at over 100km/h, and 7.5Gbps in stationary conditions using 28GHz spectrum

5G Mobility Test
1.2Gbps @110km/h

Peak Data Rate
7.5Gbps

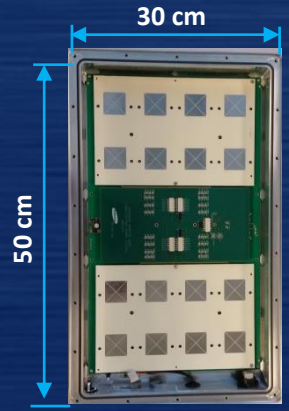
[1] "Samsung Electronics Sets 5G Speed Record at 7.5Gbps, Over 30 Times Faster Than 4G LTE", Samsung Tomorrow, 15 Oct 2014. (http://global.samsungtomorrow.com/?p=43349)

Full-Dimension MIMO

Higher Order MU-MIMO with 3D-Beamforming achieving 3-Fold Capacity Increase

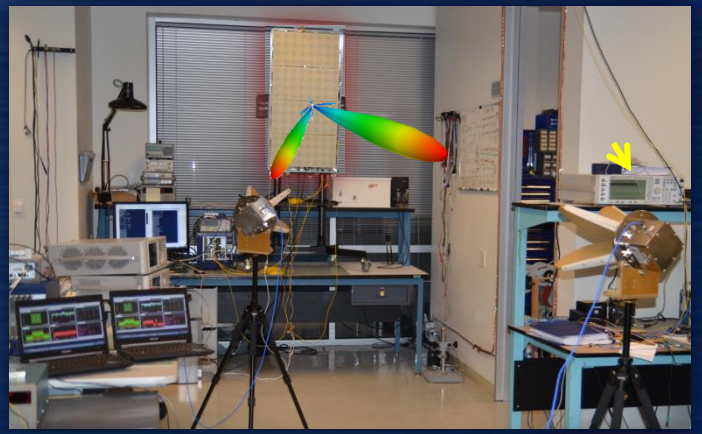
Innovative FD-MIMO Prototype

Macro-Cell eNB

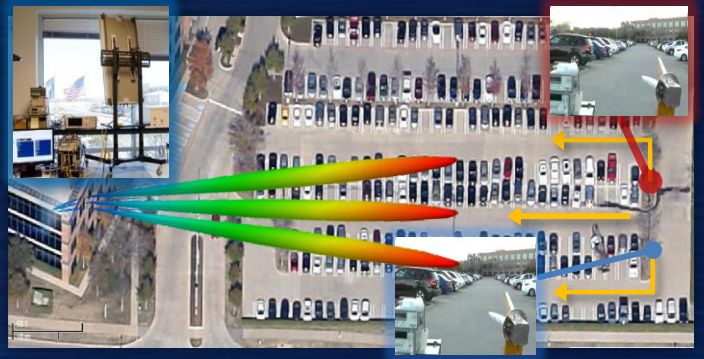


Small-Cell eNB

Indoor Test



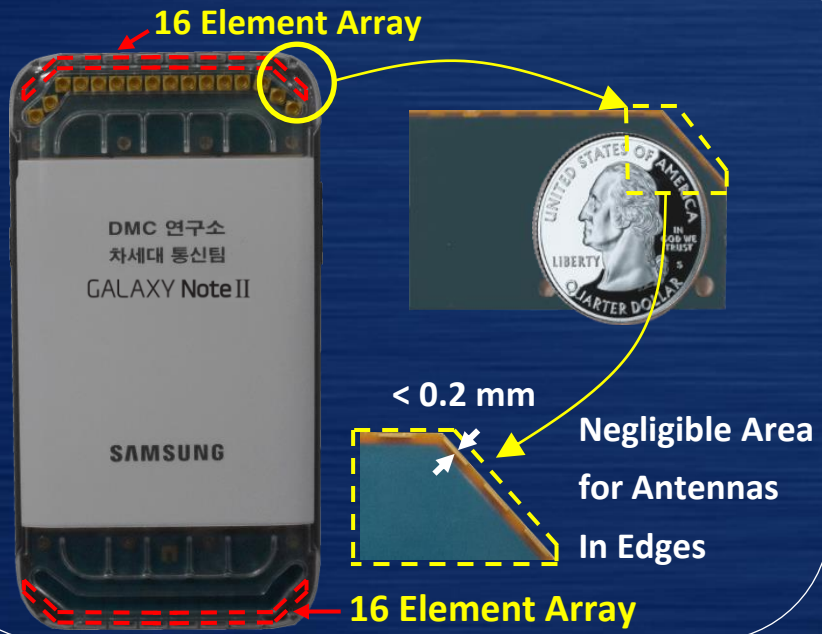
Outdoor Test



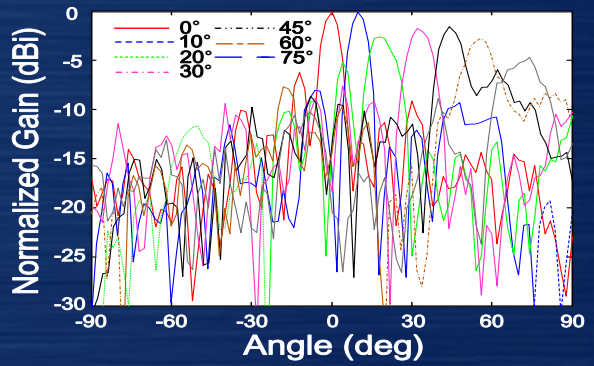
Device Feasibility - Antenna Implementation for Devices

32 Elements Implemented on Mobile Device with "Zero Area" and 360° Coverage

"Zero Area" Design



Measurement Results

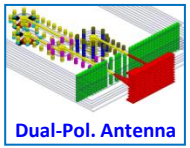


mmWave Antenna/RFIC

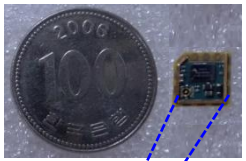
60GHz Antenna and RFIC Based on IEEE 802.11ad

360° Coverage antenna and 16-chain beamforming CMOS RFIC (Tx/Rx EVM -25 dB)

60GHz Antenna



60GHz Module with Array Antenna



Module size: 9.0 X 7.9 mm²

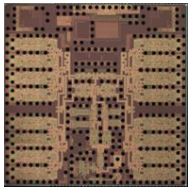
360° Coverage

Polarization Loss < 3 dB

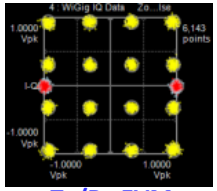
D2D Active Measurement System

60GHz RFIC

Beamforming CMOS RFIC



CMOS RFIC

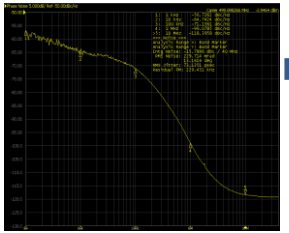


Tx/Rx EVM

EVM -25 dB

16-chain Beamforming

Measured Low Phase Noise



Phase Noise

Phase Noise -99 dBc/Hz

5G

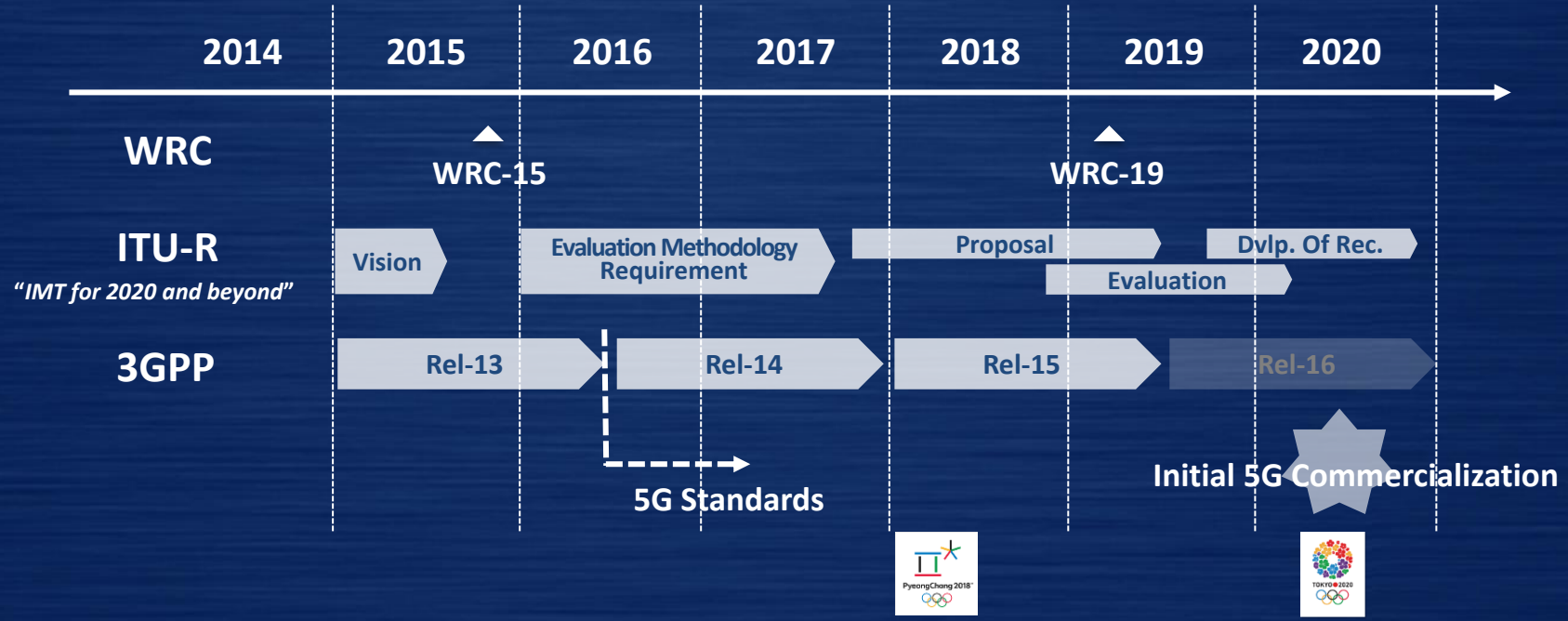
Global R&D Activities & Timelines

Global R&D Activities

Current Global 5G Research Initiatives and Samsung's Active Engagements

Expected 5G Timelines

Standards in 3GPP, spectrum allocation in WRC-19, ITU approval in 2020



WRC : World Radiocommunications Conferences
ITU-R : International Telecommunication Union Radiocommunication Sector

Dvlp. of Rec. : Development of Recommendation

COMMUNICATIONS RESEARCH TEAM

Thank You