

Welcome to IEEE 5G World Forum

Sanjay Jha, Santa Clara, July 9th

3 Pillars of 5G

EXTREME DATA



10+ Gbps peak data rate
100+ Mbps on demand

MISSION CRITICAL



<1 ms radio latency
Zero mobility interruption

DEVICE DENSITY



1,000,000 devices per km²
10-yr battery life

Coverage & Capacity in sub-6GHz;
Ultra-high capacity in mmWave

2022 for Machine Comms

Advancing 4G to 5G

5G



Multiple Simultaneous connections



Network selection by service type



Complete Network in the Cloud

4G

One Radio Connection at a time

Common Network for broadband & machine type communications

First set of cloud services ushered in by 4G

5G is the most dramatic advance in wireless technology since data

5G Spectrum Allocation

US

verizon✓



28GHz
39GHz

2.5GHz
600MHz
3.5GHz

Europe



Telefonica

3.5GHz
26GHz
700MHz

China



中国移动通信
CHINA MOBILE



3.5GHz

Japan & Korea



3.5GHz
4.5GHz
28GHz
39GHz

Harmonization across Europe, China and Korea to deploy 5G in 3.5GHz

What applications will drive 5G deployment?

- Explosion of cameras and real-time understanding of image
 - Image becomes data: it can be analysed and understood
 - Autonomous vehicles, retail, healthcare, security...
- Explosion in Mobile display resolution
 - AR, VR, mixed-reality
- Explosion in real-time AI applications on the edge
- IOT
- Tactile Internet

Lets not wait for the “killer app”

5G

will impact every industry



...and spark the innovation of unforeseen industries for decades to come

5G Challenges: Devices

RF design:

- multiple carrier aggregation between 4G & 5G

- mmWave antenna arrays increasing cost, size & power consumption

- Selection diversity

Beam-forming & beam-tracking techniques to mitigate LOS issues in mmWave

New Radio (NR) waveform

5G Challenges: Network & Deployment

Capex for mmWave network buildout

Spectrum sharing (CBRS Alliance)

Balancing downlink with uplink

Phased rollout: NSA (LTE-assisted) followed by Standalone Mode (NR)

Prototyping, testing, global interoperability, network & services rollout

IEEE Future Directions Initiatives



SMART MATERIALS

Symbiotic Autonomous
Systems



Incubation

ieee.org/futuredirections

Phase 3

In Conclusion...

- Spectrum allocations, RFP and RFQ process have already begun in the US
- US is leading in mmWave deployment
- 5G will enable a huge innovation in wireless application
- No need for wait for the killer app: the business case is here already!
- Some fundamental problems to be solved. Those who do will win big
- Lets get this done!