



RWS-150002

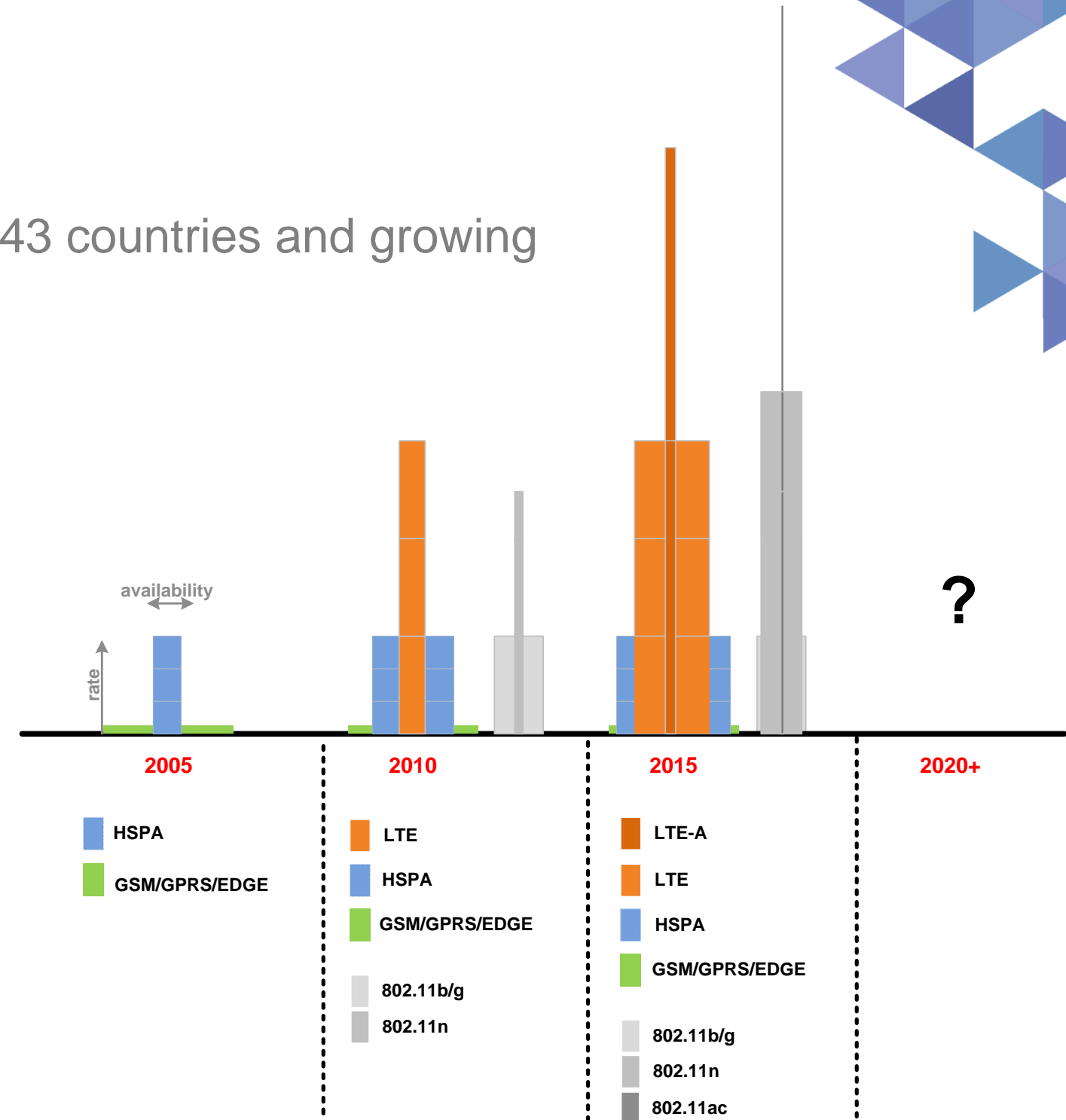
Views on Next Generation Wireless Access

3GPP RAN Workshop on 5G, Sep 2015
Lenovo, Motorola Mobility



Where are we

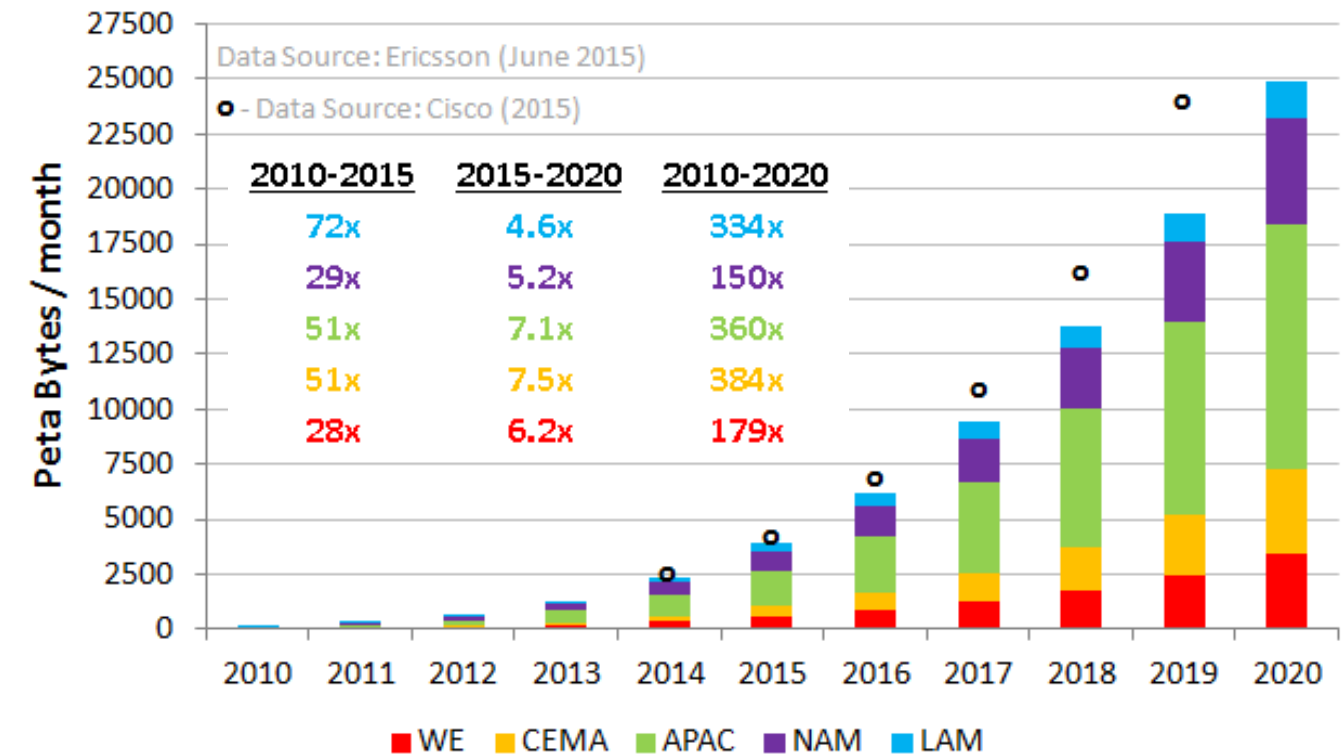
- LTE a mega success...422 operators, 143 countries and growing
 - Constant enhancements from Rel-8
 - MIMO – up to 8 spatial layers; FD-MIMO
 - Densification - eICIC , Small Cells
 - New topologies – D2D, Dual Connectivity
 - Unlicensed spectrum operation
 - MTC with improved coverage
- Remarkable connectivity growth...
 - LTEA/LTE/HSPA/UMTS/EDGE
GPRS/GSM and 802.11a/b/g/n/ac
 - ... time to explore next generation (NG) of connectivity



New Opportunities

- Demand for mobile broadband continues to proliferate
 - More consumers ...
 - LAM, CEMA, APAC
 - ... and more data per consumer
 - WE, NAM
- Increasing demand for driving mobile broadband technologies into new markets
 - Automobile incl. v2x,
 - Smart/connected homes/cities/infrastructure
 - Healthcare,
 - Factory automation
 - Drones, OTT

>150x Smartphone Data Traffic increase by 2020 vs. 2010



- 2010→2015 (30x): LTE + HSPA + WiFi offloading
- 2015→2020 (6x): LTE, Densification, offloading, S.E., CA
- 2020→2025 (6x): Spectrum, Flexible Network ...
- Mobile wireless demand managed via throttling, pricing, offloading, & network/spectrum expansion & S.E. gains

Spectrum

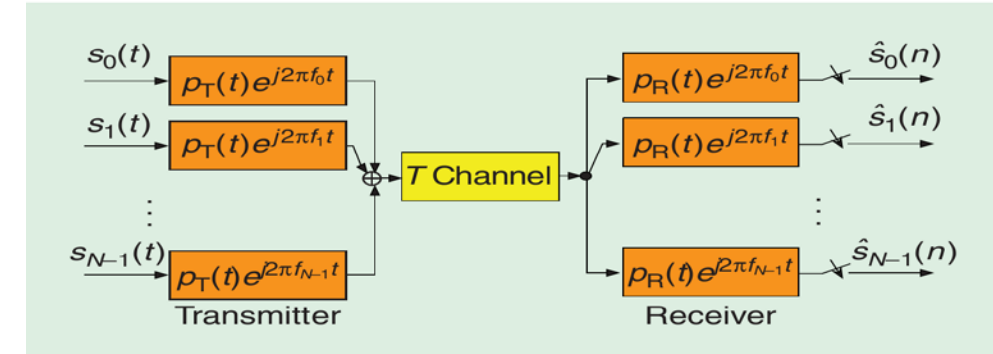


- Biggest challenge - projected spectrum not meeting demand
- New spectrum allocations:
 - WRC-15 (<6GHz) pushback from satellite, broadcast, automotive industries
 - WRC-19 (>6GHz) must target specific NG band(s), preferably harmonized global band
- Lower millimeter wave band (27-45 GHz) - promising for NG
 - Large bandwidth, compact antenna arrays - but engineering & supply chain challenges
 - 28 GHz and 38 GHz potential NG global bands. Promote 100MHz+ allocations.
- Regulatory policies changing to accommodate demand
 - Shared Access – but geographical region limited – FCC's 3550-3700 MHz band
 - Licensed, unlicensed, & hybrid shared models proposed for higher frequency bands
 - NG should support all models of spectrum access

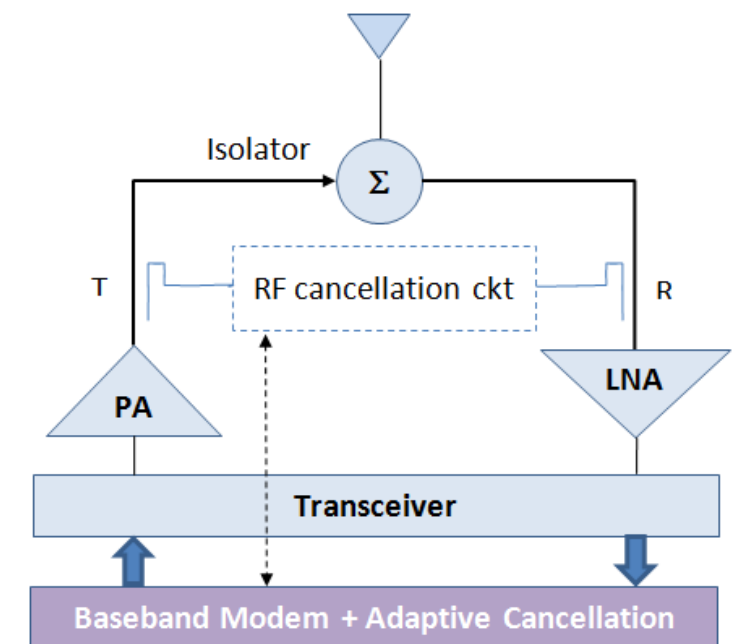
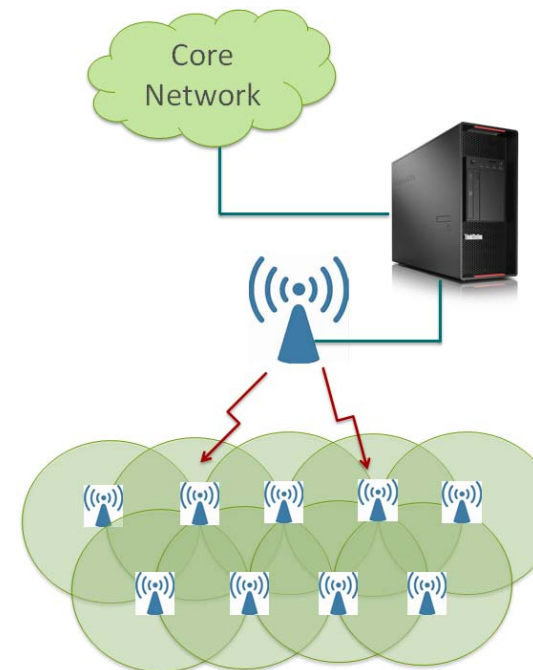
New Technology Adoption

...time to explore next generation of technologies

- mmWave, massive MIMO, very large BWs
- new Waveforms
- full duplex
- more flexible radio interface
- native support for unlicensed spectrum
 - including in mmWave bands
- network coding
- integrated wireless front/backhaul support
- new network architectures
 - centralized operation support
- ...



Behrouz Farhang-Boroujeny, "OFDM vs. Filter Bank Multicarrier" IEEE 2011



Hong et al, "Application of self-interference cancellation in 5G and beyond" IEEE Communications Magazine, Feb. 2014

Next Generation Targets

- Consumers

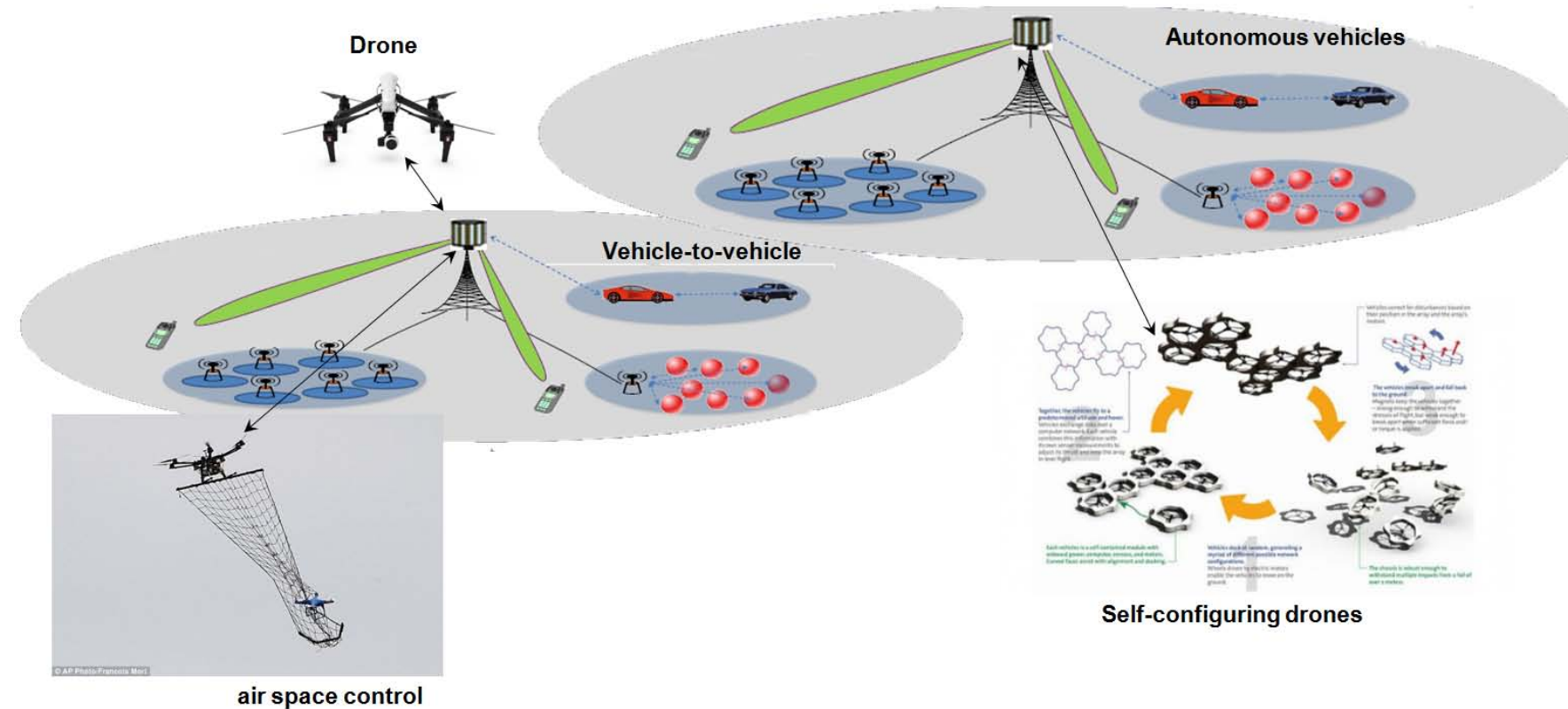
- Higher data rates
 - “50 Mbps everywhere”
- Ubiquitous support for real-time voice/video

- Operators

- Agile network for diverse services
- Easy deployment / upgrades
- Improved resource utilization
- Reduced maintenance cost

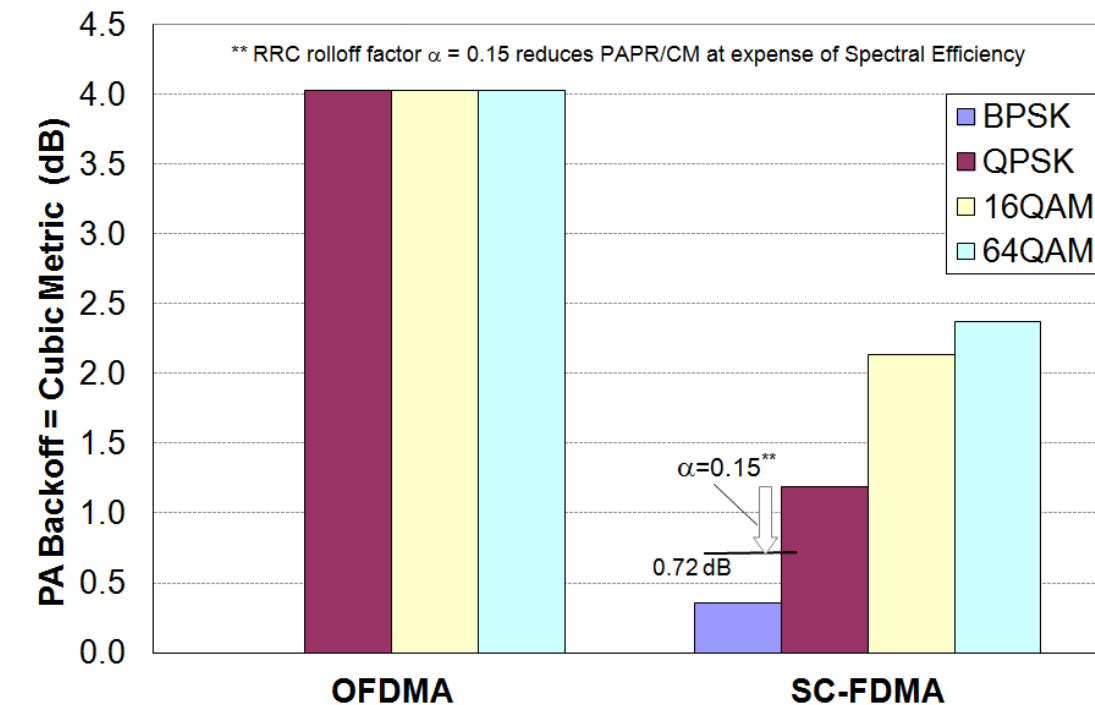
- Infrastructure/Industry

- Massive, low cost, low energy IoT
 - CloT as baseline for NG IoT
- Ultra low latency, high reliability IoT



Waveforms

- Candidates
 - OFDMA/SC-FDMA
 - per-subcarrier (FBMC, GFDM) or subcarrier group (UFMC) filtering using linear/circular conv.
- OFDMA/SC-FDMA
 - Best suited for large contiguous bandwidth carriers
 - S.E. improvements via CP selection & RF filtering (improved BW occupancy)
- New Waveforms should show clear benefits
 - OOB emissions
 - MIMO integration, pilot generation
 - Waveform PAPR/CM esp. for UL & higher-frequency bands
 - Spectral efficiency, time/frequency sync robustness
- Potential use cases for new waveforms
 - Fragmented and shared spectrum access
 - Applications with relaxed synchronization constraints



Numerology

- Flexible Frame Structure
 - ~0.25 ms subframe; Variable TTI; Reduced RTT;
- Sub-6GHz
 - New subcarrier numerology should show clear benefit
 - OFDMA/SC-FDMA, OFDMA/OFDMA likely candidates
 - Lowest BW supported: 5/10 MHz; CIoT: < 5MHz
- 6GHz - 30GHz
 - OFDMA/SC-FDMA, OFDMA/OFDMA likely candidates
 - Lowest BW supported: ~100 MHz
 - Common numerology with 'above 30GHz'
- Above 30GHz
 - LTE subcarrier spacing not suitable due to phase noise
 - SC-FDMA is a likely waveform candidate
 - Low cubic metric waveform/modulation important

Sample numerologies

	Units	LTE	NGmm	NGmm
TTI Duration	ms	1	0.25	0.2
FFT Size	samples	2048	8192	4096
OFDM Sample rate	Msps	30.72	1966.08	307.20
Tu	us	66.67	4.17	13.33
Inter-carrier Separation	kHz	15.0	240.0	75.0
Guard Period (CP)	us	4.69	0.30	0.94
OFDM Symbol Duration	us	71.35	4.46	14.27
OFDM Symbols Per TTI	syms/TTI	14.0	56.0	14.0
#Subcarriers	sc	1201	5040	1584
#Resource Blocks	RBs	100	420	132
#Subcarriers/RB	sc/RB	12	12	12
Occupied Bandwidth	MHz	18.015	1209.6	118.8
Channel Bandwidth	MHz	20	1280	128
total subcarriers/TTI	sc/TTI	16800	282277	22199
Bandwidth occupancy		0.90	0.95	0.93
peak data rate (64QAM, rank2)	Mbps	150	10081	991

MIMO

- Sub-6GHz
 - Leverage continued evolution of 4.5G MIMO techniques
 - Optimization without constraint of backward compatibility
- > 6 GHz
 - Mature channel models needed for accurate design & performance evaluation
 - Practical beamforming design impacts multiple access & waveform choices
 - Waveform orthogonality allows low complexity BF design
 - Large BWs downplay need for higher rank
 - Fast beam tracking and handover techniques

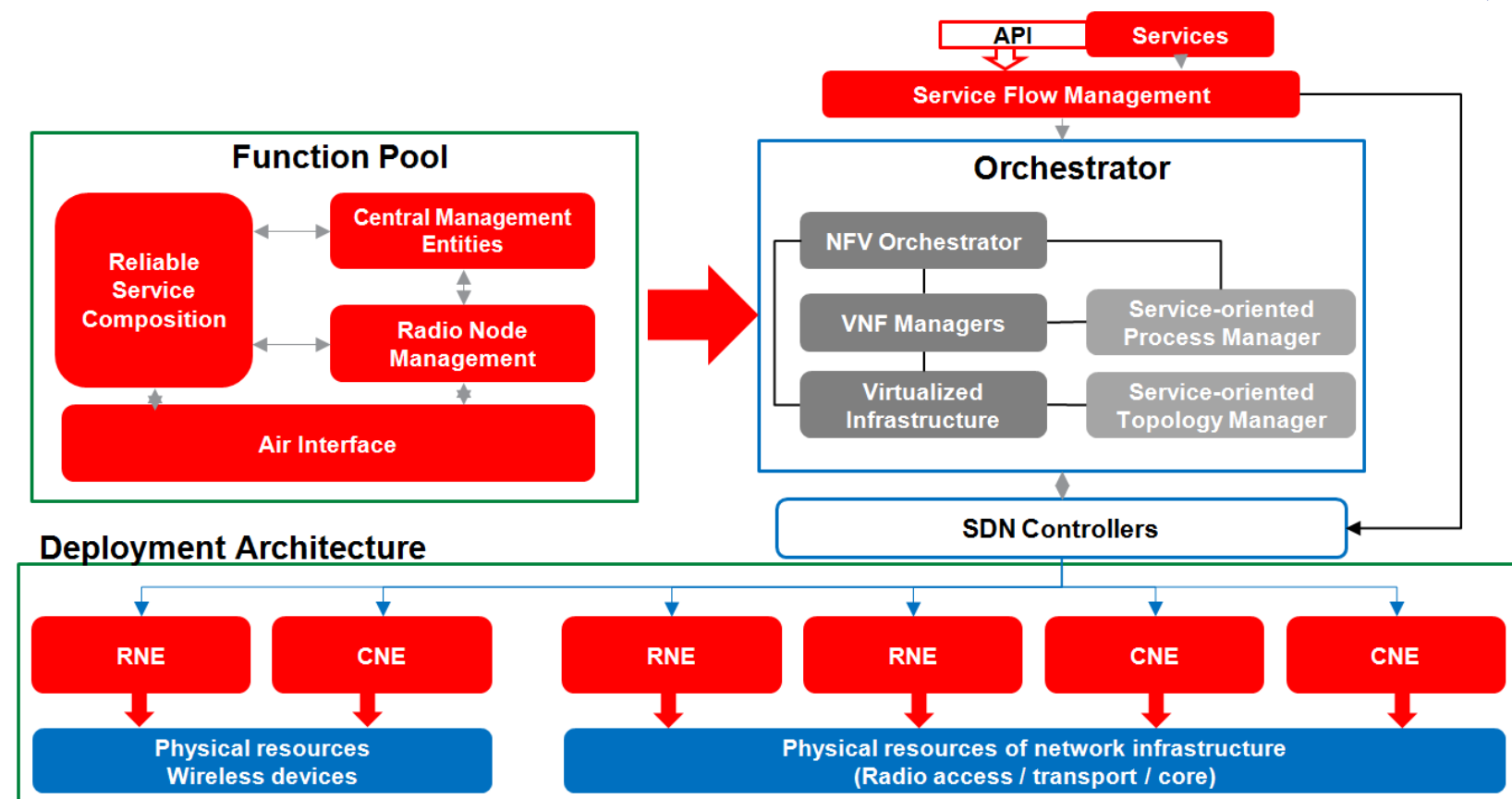


Not Mobile Massive MIMO

Not just PHY

OPEX and other considerations

- Flexible Network architecture
- Control and User plane split
- Connection-less operation
- Energy efficiency
- Multi-connectivity
 - multi site
 - multi RAT



Based on METIS 2020, D6.4, 2015

Work Plan



Rel-13: Channel modeling for mmWave (Start November 2015)

Rel-14: Study item for NG begins 2Q2016 in WGs

- RAN Level SI can start 1Q2016 to discuss Requirements & Deployment Scenarios
- Includes mmWave

Rel-15: RAN Work Item for NG begins 3Q2017

- NG specification 1st release 4Q2018
- ITU-R initial proposal 2Q2019

Rel-16: NG specification 2nd release 4Q2019

Summary

- ❑ Connectivity beyond LTE driven by non-traditional use-cases, increased capacity, increased user data rate, and reduced cost expectations
- ❑ Capacity tools need to be renewed for 2020+:
 - More spectrum, very large bandwidth, new network architecture, massive MIMO
- ❑ Focus on both Radio and Network Architecture flexibility to drive down cost and better address new markets and use cases.
- ❑ Achieving “50 Mbps everywhere”¹
 - Requires >100 MHz of spectrum with LTE. Much less if heterogeneous.
 - NG to reduce large spectrum bandwidth needed and reduce heterogeneous cost
- ❑ mmWave + very large bandwidth + massive MIMO → 1 gigabyte/sec
 - Compelling - but addressing engineering, spectrum, & supply chain issues is key

¹ 400 connections per sq.km in homogeneous macro network; 20Gbps/sq.km traffic density; minimum 50Mbps user rate

thanks

