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Transport Requirements for a 5G Broadband Use Case

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Transport Requirements for a 5G Broadband Use Case

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Verizon 5GTF Specifications Summary

Goal of Verizon 5GTF (5G Technical Forum)

Develop a common and extendable platform for Verizon's 28/39 GHz fixed wireless access deployment

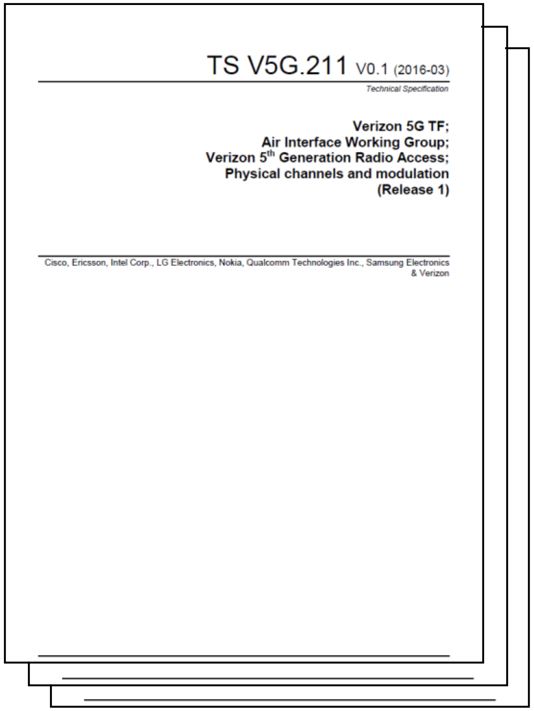
Scope

The specifications facilitate early 5G deployments for Verizon's fixed wireless use case and requirements.

Promote interoperability among network and CPE/chipset vendors.

Format

Developed jointly by Verizon and ecosystem partners (Nokia, Ericsson, Samsung, Qualcomm, Intel, Cisco, and LG)


TS V5G.211 V0.1 (2016-03)

Technical Specification

Verizon 5G TF;
Air Interface Working Group;
Verizon 5th Generation Radio Access;
Physical channels and modulation
(Release 1)

Cisco, Ericsson, Intel Corp., LG Electronics, Nokia, Qualcomm Technologies Inc., Samsung Electronics & Verizon

Website: http://5gtf.org

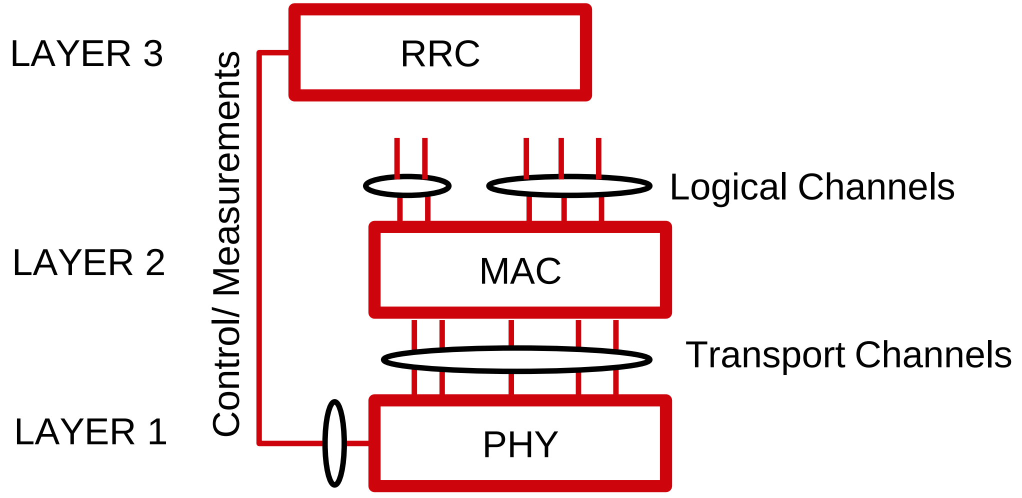
5GTF: General Protocol Architecture

Radio Interface is composed of Layers 1, 2 and 3, and covers the interface between user equipment and the network

V5G.200 series describe the Layer 1 (Physical Layer)

V5G.300 series describe Layers 2 and 3 (MAC, RLC, PDCP, RRC)

V5G.401 describes the Stage 2 level overall network reference architecture, and Stage 3 level NAS specifications



5GTF: Key Air Interface Features

New RAT Numerology

Short subframe duration with reduced latency

Utilize large bandwidth @ 28/39 GHz

Flexibility for different scenarios & different frequency bands

Flexible Frame Structure

Dynamic UL/DL allocations to support various traffic conditions

Flexible framework additional future use cases and scenarios

Advanced Beamforming

Improve coverage, throughput and densification of cells

Ensure a robust 5G system

Multi-site beamforming/switching

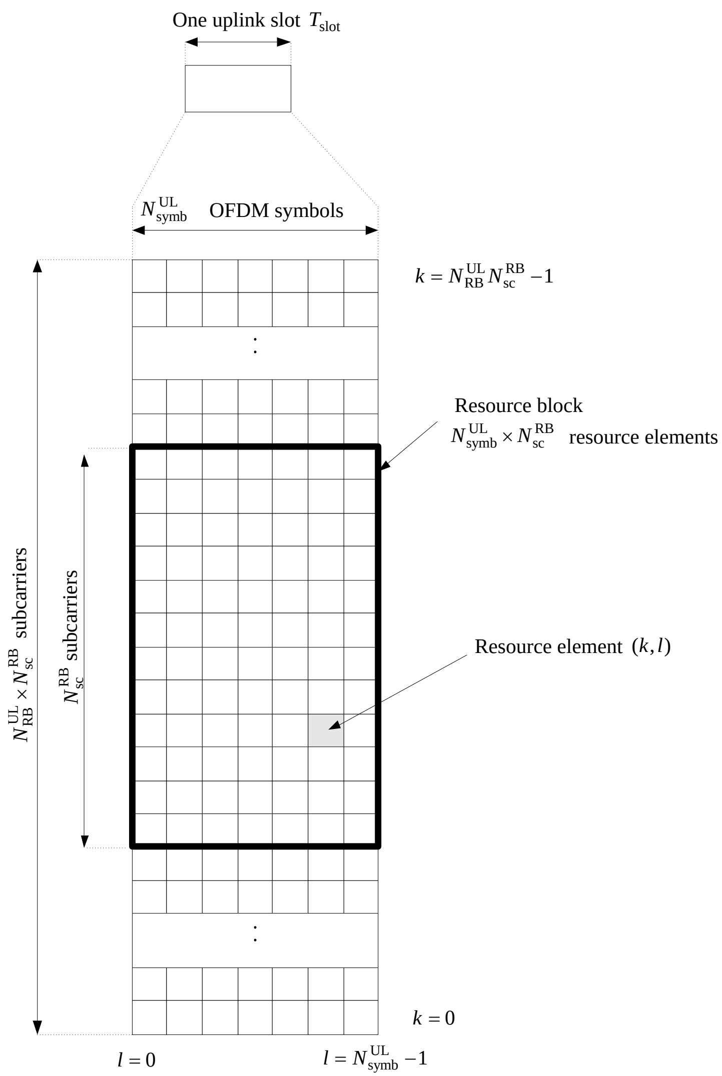
Fast initial acquisition and beamforming training

Physical Layer (L1) Outline

Technology Components	Details
Spectrum	28 GHz
Bandwidth	Component carrier BW = 100 MHz
Duplex	Dynamic TDD
Waveform	OFDM (DL/UL)
Subcarrier Spacing	75 KHz (5 x LTE)
MIMO	Up to 2 layers, MU-MIMO
Beamforming	Hybrid (Digital + Analog)
Modulation	Up to 64 QAM (DL/UL)
Channel Coding	LDPC
TTI length	0.2 ms (LTE / 5)
# of subcarriers	1200 per component carrier
Structure	Self contained frame structure

Numerology Details

Component Carrier BW	**100 MHz**
Sampling rate	153.6 MHz
FFT Size (N)	2048
Subcarrier spacing (Δf)	75kHz
Basic Sample Time Unit (Ts)	1/(75000x2048) sec
Subframe duration	0.2 ms (30720 samples)
OFDM symbols per subframe	14
Symbol Duration	13.3 microsec (2048 samples)
CP length	160 samples (1042 ns, symbol 0/7) 144 samples (940 ns, other symbols)
Occupied Subcarriers	1200
Radio Frame Duration	10 ms (50 subframes)



Spectrum for 5G

FCC NEWS from the Federal Communications Commission

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For Immediate Release

FCC TAKES STEPS TO FACILITATE MOBILE BROADBAND AND NEXT GENERATION WIRELESS TECHNOLOGIES IN SPECTRUM ABOVE 24 GHZ
New rules will enable rapid development and deployment of next generation 5G technologies and services

WASHINGTON, July 14, 2016 – The FCC today adopted new rules for wireless broadband operations in frequencies above 24 GHz, making the United States the first country in the world to make this spectrum available for next generation wireless services. Building on the successful, flexible approach to spectrum policy that enabled the explosion of 4G (LTE), these rules set a strong foundation for the rapid advancement to next-generation 5G networks and technologies in the United States.

This high-frequency spectrum will support innovative new uses enabled by fiber-fast wireless speeds and extremely low latency. While 5G technologies are still under development, today's action by the Commission to put rules in place will provide vital clarity for business investment in this area.

These new rules open up nearly 11 GHz of high-frequency spectrum for flexible, mobile and fixed use wireless broadband – 3.85 GHz of licensed spectrum and 7 GHz of unlicensed spectrum. The rules adopted today creates a new Upper Microwave Flexible Use service in the 28 GHz (27.5-28.35 GHz), 37 GHz (37-38.6 GHz), and 39 GHz (38.6-40 GHz) bands, and a new unlicensed band at 64-71 GHz.

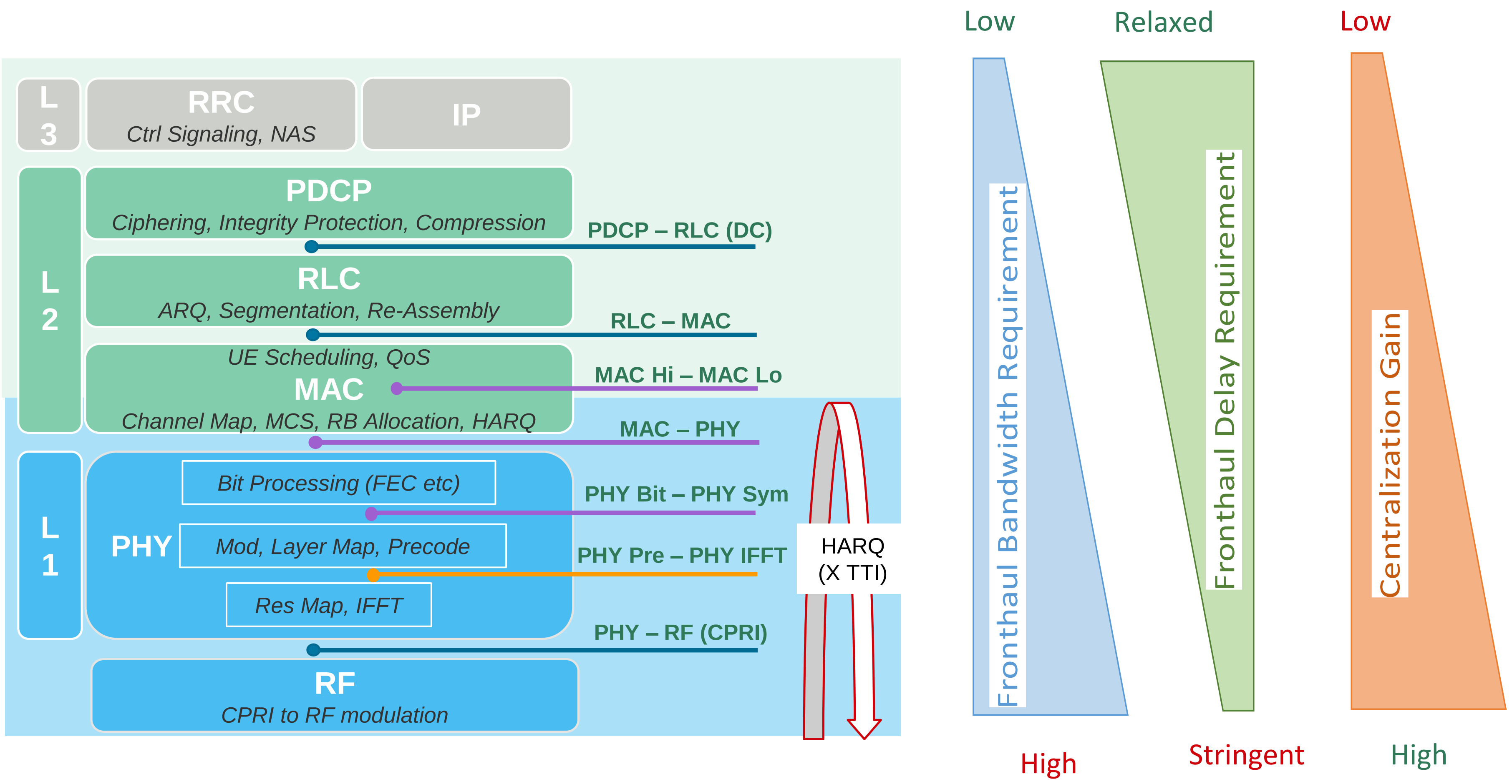
RAN Architecture Considerations

1. **Flexible RAN Split Options (Central Unit CU and Remote Unit RU)**
    - Enables Centralization gains and cost efficient design
    - Different RAN split options might be optimal for different deployment scenarios
    - Allow different degrees of centralization for user and control plane
2. **5G BW and Latency Requirements**
    - 5G Radio with data rates of order of several Gbps per sector challenges FrontHaul (FH) using legacy CPRI type interface
    - CPRI (PHY – RF split) Limitations
        - 20 MHz 2 x 2 LTE sector requires ~ 2.5 Gbps FH BW
        - Max ~ 25 Gbps, Stringent delay requirements
        - Does not scale with BW and # of antenna elements
        - Closed ecosystem
    - Need to study alternate RAN architectures and split options
3. **Interaction between RAN protocol and architecture designs**
    - Protocol design should allow for architecture flexibility
    - Impacts and impacted by several aspects including HARQ design, Timing Advance, Scheduling Latency, CSI feedback, Segmentation/Re-assembly etc

RAN Split Benefits/Drivers

Resource Pooling	• Pool resources across multiple eNBs • L2/L3 resources dimensioned on aggregate traffic / connections • L1 resources dimensioned on RF BW & antennas
Cooperative Processing	• Centralized Scheduling and Interference management • UL/DL CoMP schemes
Increased Virtualization	• Enable SDN/NFV with general purpose compute hardware • Efficient scalable RAN
Easier Upgrades and Self Healing	• Reduce hardware/software upgrade & provisioning time • Grow user capacity / connections / features as needed • Virtual machine switchover on failure
Edge Applications	• Faster deployment of new services and features (M2M handling, Edge Analytics (User/Application), Video Optimization etc) • Decouple applications from dedicated physical elements
Energy Savings	• Efficient pooling of compute to lower overall energy consumption • Power down resources during lighter traffic to save energy
Reduce CAPEX/OPEX	• Large scale centralized processing on general purpose hardware • Cost effective Fronthaul transport - some PHY functions at edge • Easier hardware, software and vendor switching

RAN Split Options and Tradeoffs



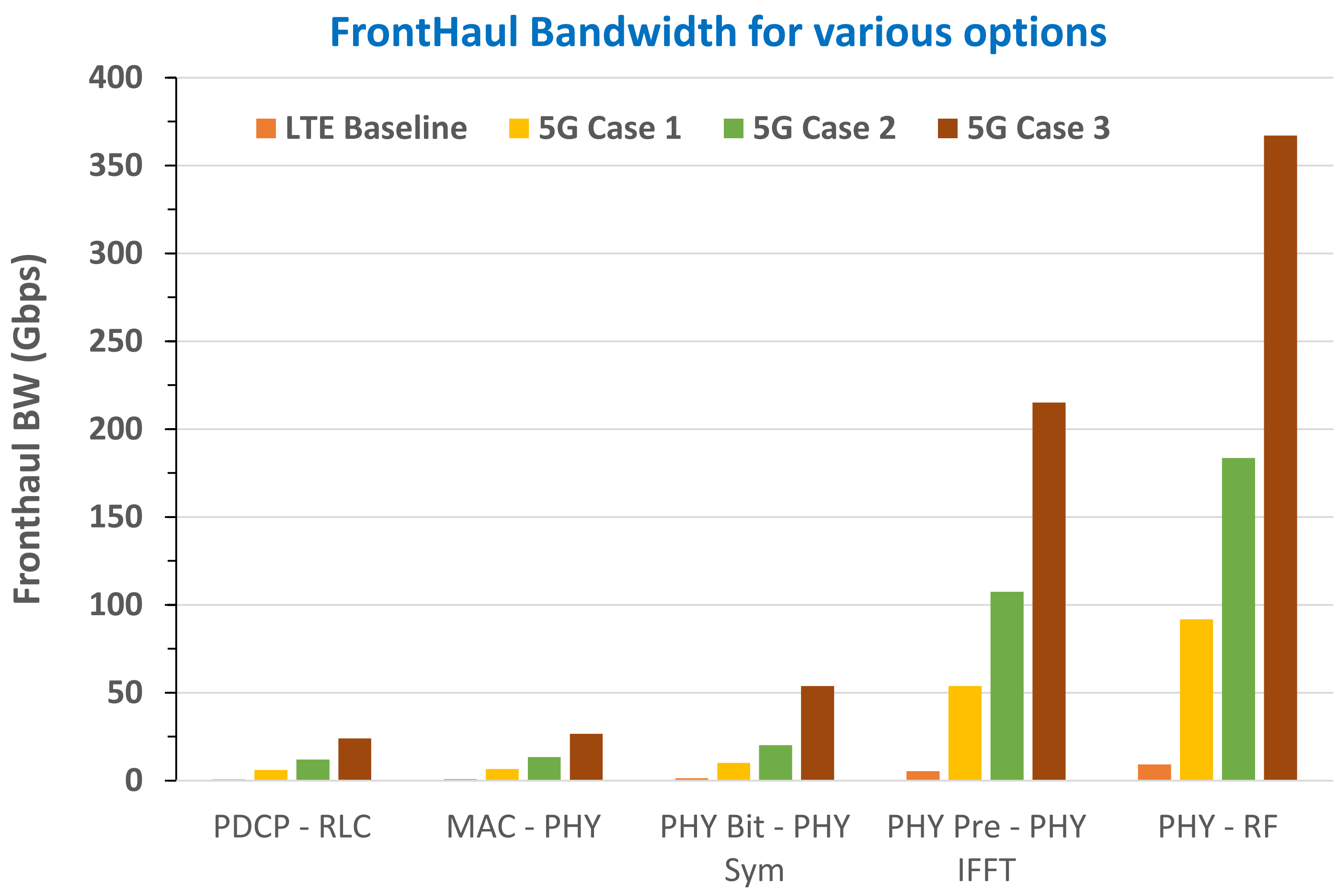
RAN Split Options: Comparison

Group	Split Option		Front Haul Requirement: BW	Front Haul Requirement: Latency	Performance/Operations: Central Sched. & Int. Mgmt.	Performance/Operations: Cent. Gains	Performance/Operations: Interface Complexity	Performance/Operations: FH Cost
High	**Op 1**	PDCP – RLC CU: RRC, PDCP RU: RLC, MAC, PHY, RF	Low	More Relaxed	No	Low	Moderate	Cheaper
High	**Op 2**	RLC – MAC CU: RRC, PDCP, RLC RU: MAC, PHY, RF	Low	More Relaxed	No	Better	Moderate	Cheaper
Mid	**Op 3**	MAC Hi – MAC Lo CU: RRC, PDCP, RLC, MAC Hi RU: MAC Lo, PHY, RF	Lower	Relaxed	Yes	High	High	Cheaper
Mid	**Op 4**	MAC – PHY CU: RRC, PDCP, RLC, MAC RU: PHY, RF	Lower	Strict	Yes	High	High	Cheaper
Low	**Op 5**	PHY Bit – PHY Sym CU: RRC, PDCP, RLC, MAC, PHYx RU: PHYy, RF	Lower	Strict	Yes	High	High	Cheaper
Low	**Op 6**	PHY Pre – PHY IFFT CU: RRC, PDCP, RLC, MAC, PHYx RU: PHYy, RF	High	Strict	Yes	Very High	Low + IFFT	Expensive
Low	**Op 7**	PHY – RF CU: RRC, PDCP, RLC, MAC, PHY RU: RF	Always High	Strict	Yes	Very High	Low Off Shelf H/W	Very Expensive

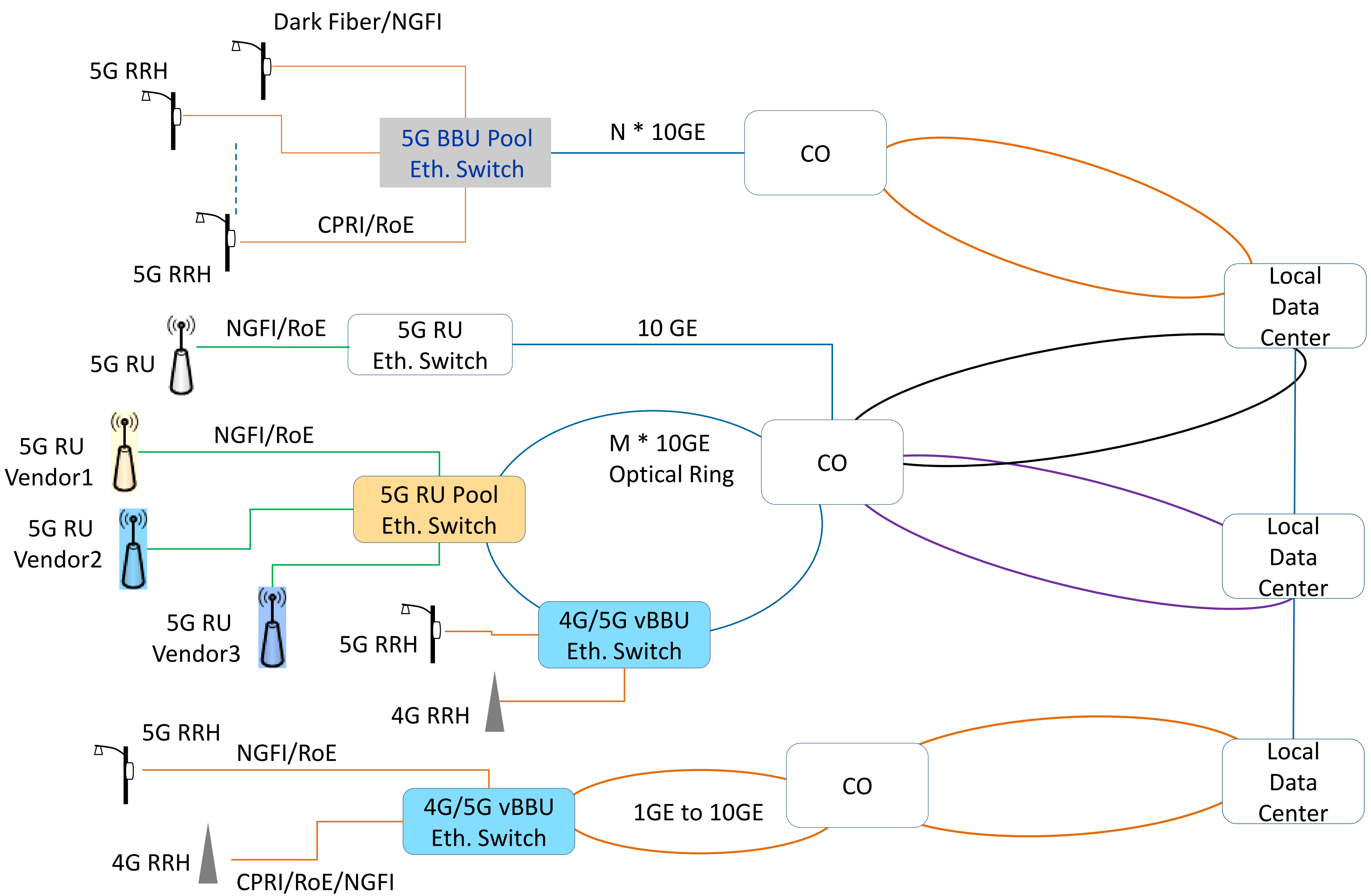
5G Fronthaul BW Estimates

Parameter	Units	LTE Baseline (UL)	5G Case 1	5G Case 2	5G Case 3
Bandwidth	MHz	20	100	100	100
OFDM Sym per sub frame	#	14	14	14	14
Subframe duration	ms	1	0.2	0.2	0.2
FFT Size	#	2048	2048	2048	2048
# of subcarriers	#	1200	1200	1200	1200
# of BS antenna elements/sector	#	8	8	8	16
# of streams (layers)	#	4	4	4	8
Bits/Sample	bit per sample	8	8	8	8
Mod Order	bits per symbol	8	6	6	8
Max TB Size	bits	75375	66392	66392	66392
# of carrier aggregation	#	2	4	8	8
Overhead of front haul protocol	%	25%	25%	25%	25%
		Fronthaul BW			
Split Type	**Units**	**LTE Baseline (UL)**	**5G Case 1**	**5G Case 2**	**5G Case 3**
PDCP - RLC	Gbps	0.7	6.0	12.0	23.9
MAC – PHY / MAC Hi-MAC Low	Gbps	0.8	6.6	13.3	26.6
PHY Bit - PHY Sym	Gbps	1.3	10.1	20.2	53.8
PHY Pre - PHY IFFT	Gbps	5.4	53.8	107.5	215.0
PHY - RF	Gbps	9.2	91.8	183.5	367.0

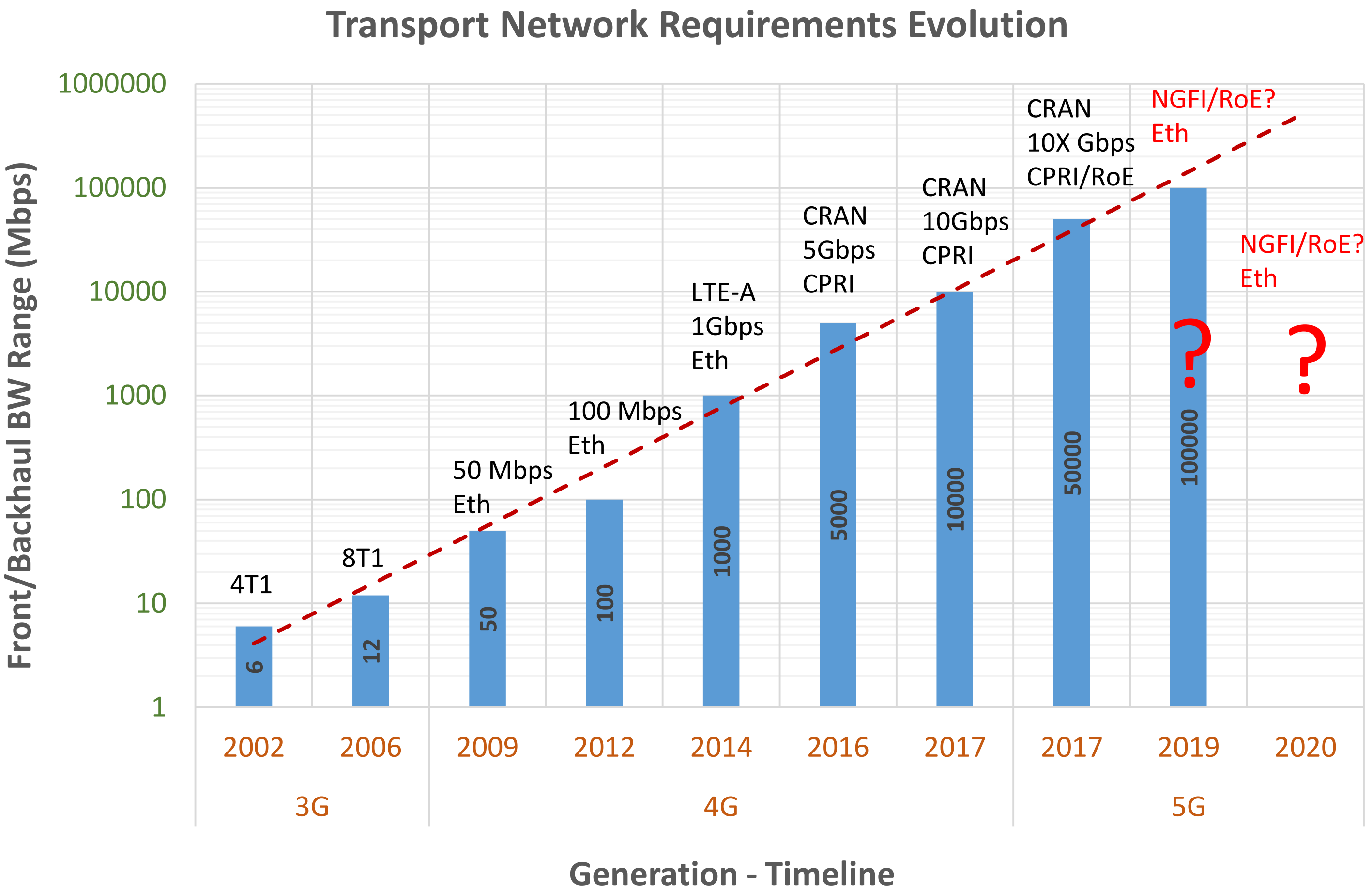
FH BW Comparison – RAN Split Options



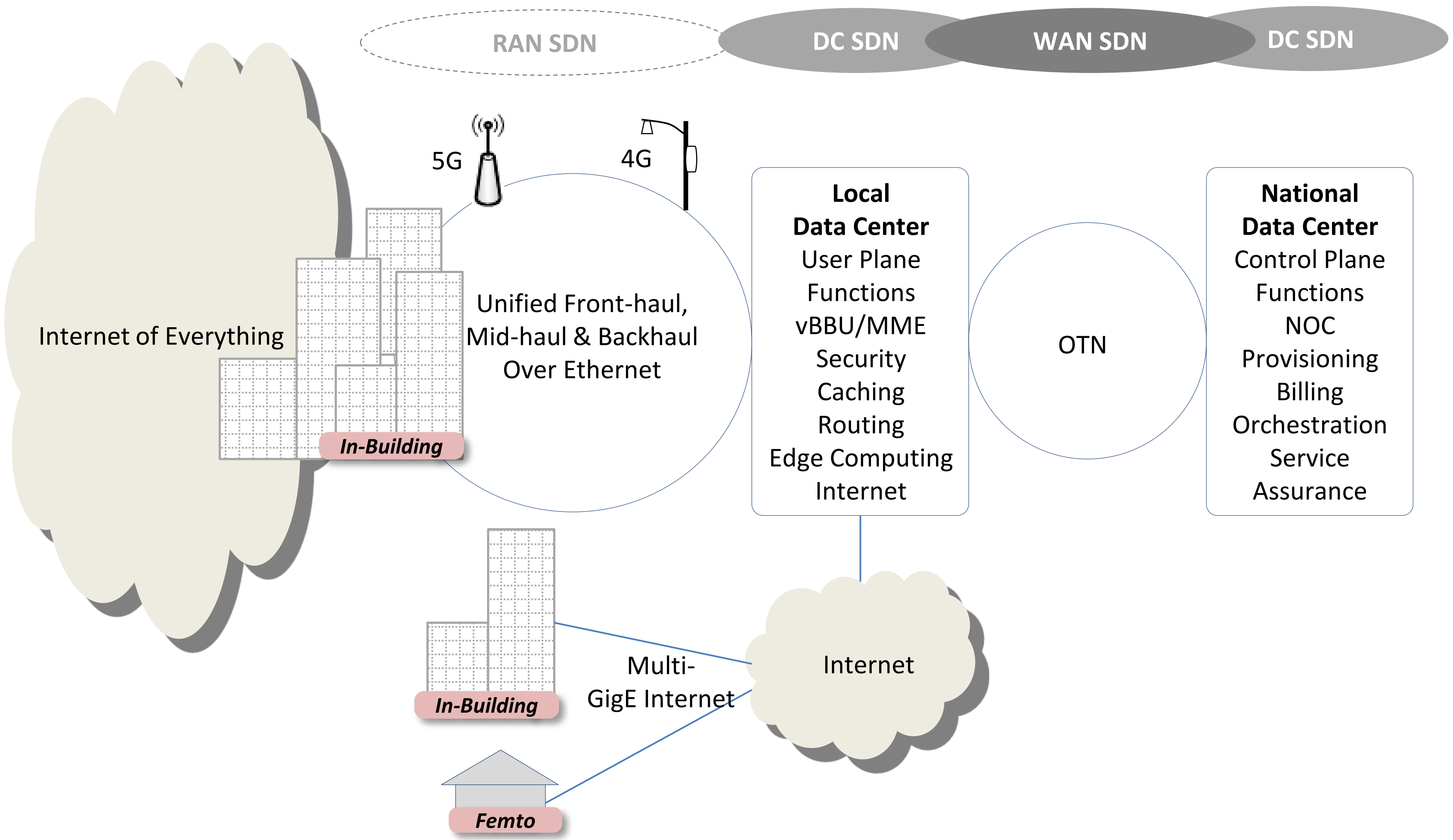
4G/5G Fronthaul/Backhaul Architecture Options



Trajectory of Change



Future Mobile/Access Network



New Opportunities/Challenges

- **Unified front-haul, mid-haul and backhaul**
  - Move away from CPRI (technical and ecosystem limitations)
  - Ethernet could be the unifier
  - Enable fronthaul resilience
- **Optimized RAN Split: Desired Features**
  - Reduced FH Bandwidth
  - Low complexity interface
  - Low cost off-the shelf Remote Units
  - Centralization gains
  - At least one high and one lower layer split
- **Challenges**
  - Tradeoffs: Timeline-Flexibility, Cent. Gains–Bandwidth
  - Standardized Interfaces: Vendor Interoperability
  - Ecosystem: Partners needed for equipment, compute, networking, and end-to-end testbeds/PoC