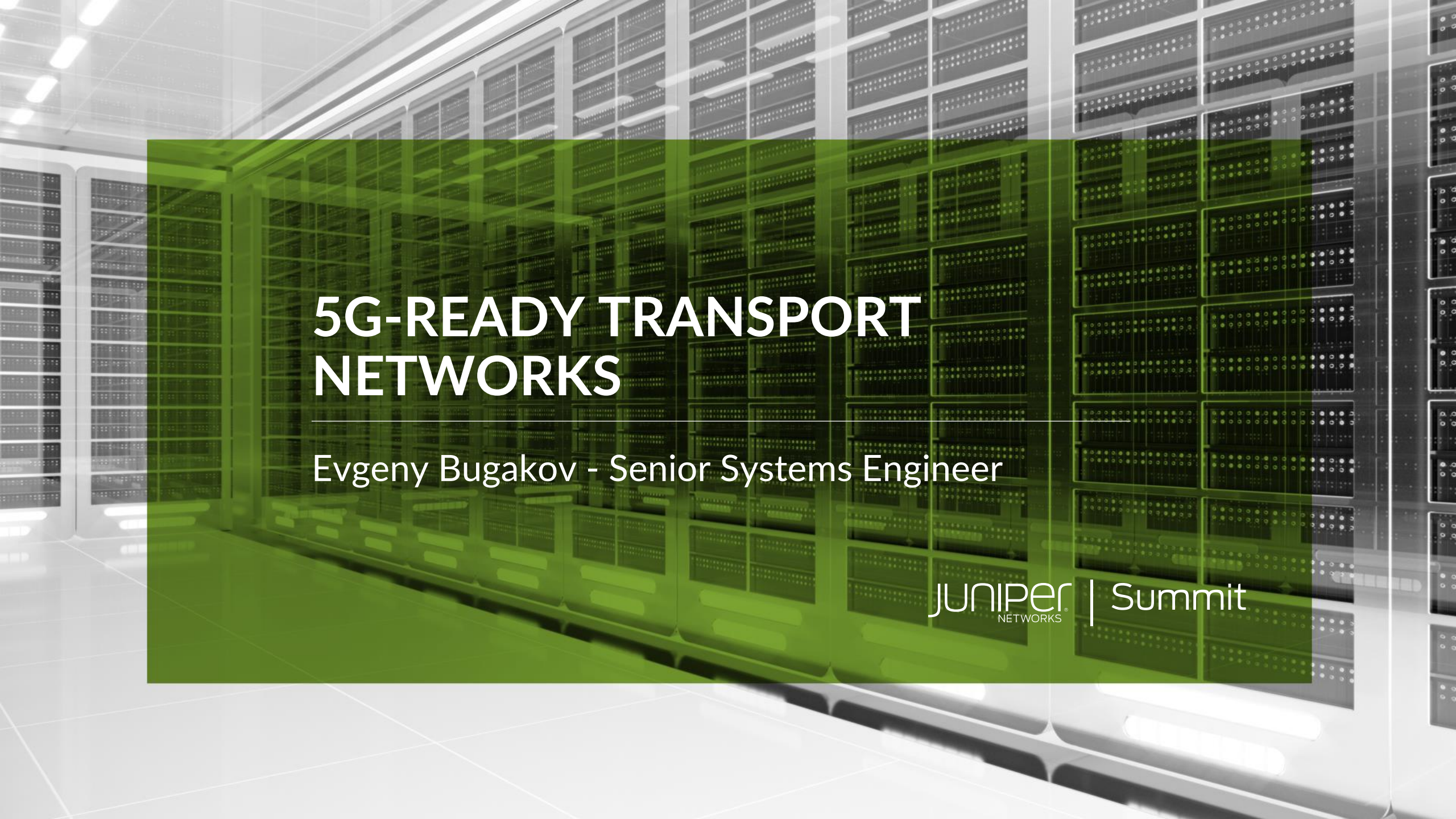


5G-READY TRANSPORT NETWORKS

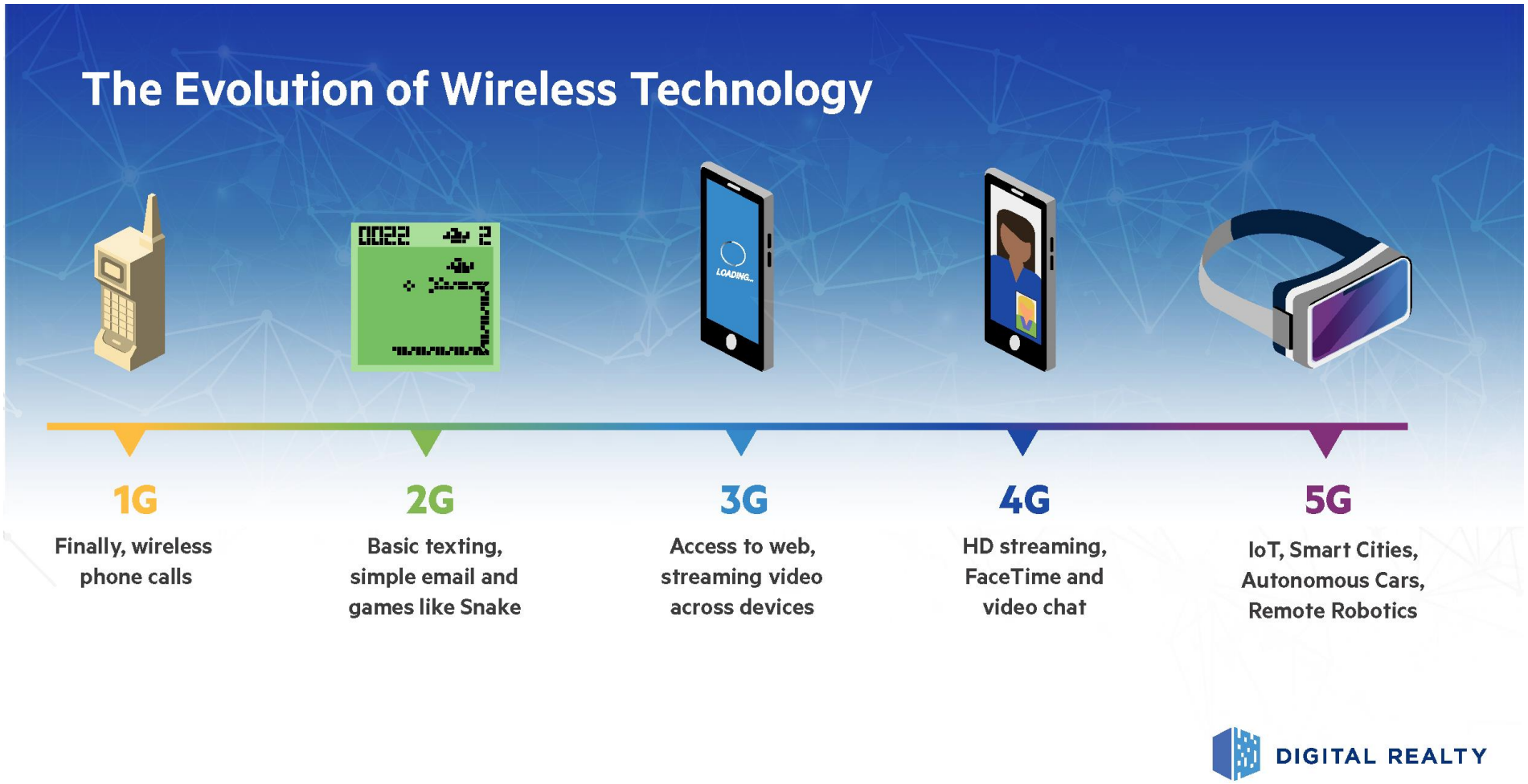
Evgeny Bugakov - Senior Systems Engineer

JUNIPER NETWORKS | Summit

LEGAL DISCLAIMER

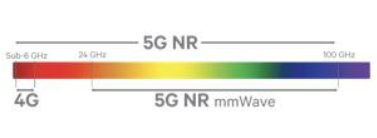
This product roadmap sets forth Juniper Networks' current intention and is subject to change at any time without notice. No purchases are contingent upon Juniper Networks delivering any feature or functionality depicted on this roadmap

WHAT IS 5G?



DIGITAL REALTY

5G TECHNOLOGY DRIVERS

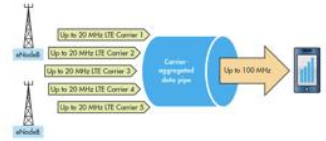


mmWave

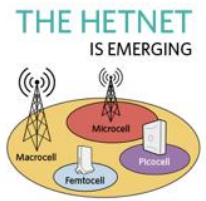
Massive MIMO

Peak Data Rates: 10Gbps

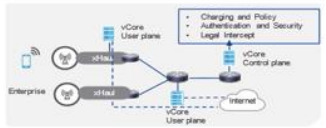
Beamforming



Carrier Aggregation

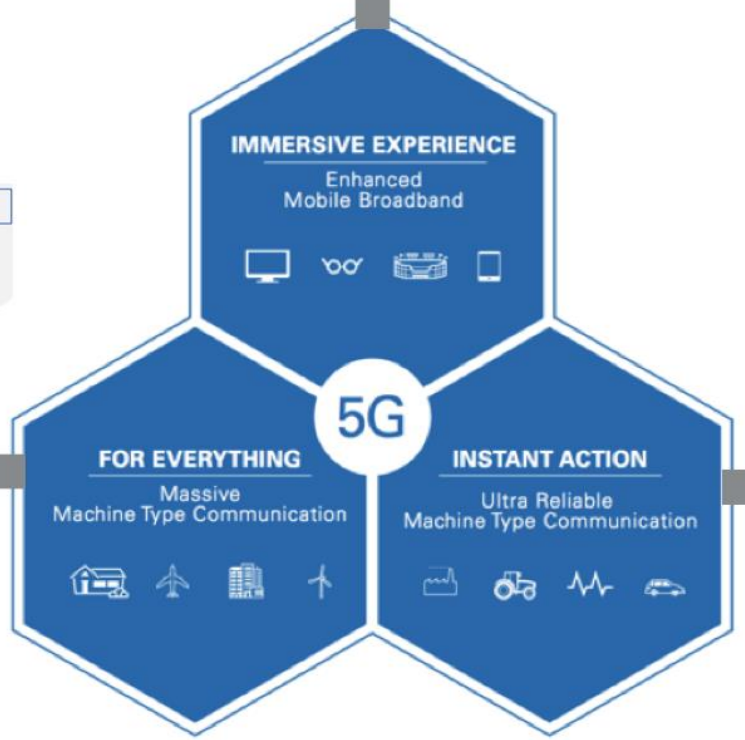


HetNet



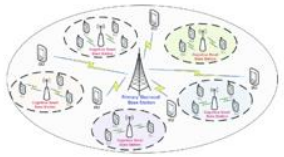
CUPS

MEC

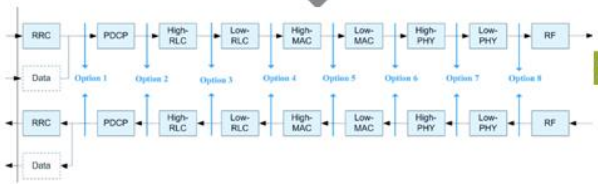


1 million connections/ km2

Low Latency: 1ms (radio)
Network: <10ms



Small Cell



RAN Split

5G IS HERE!

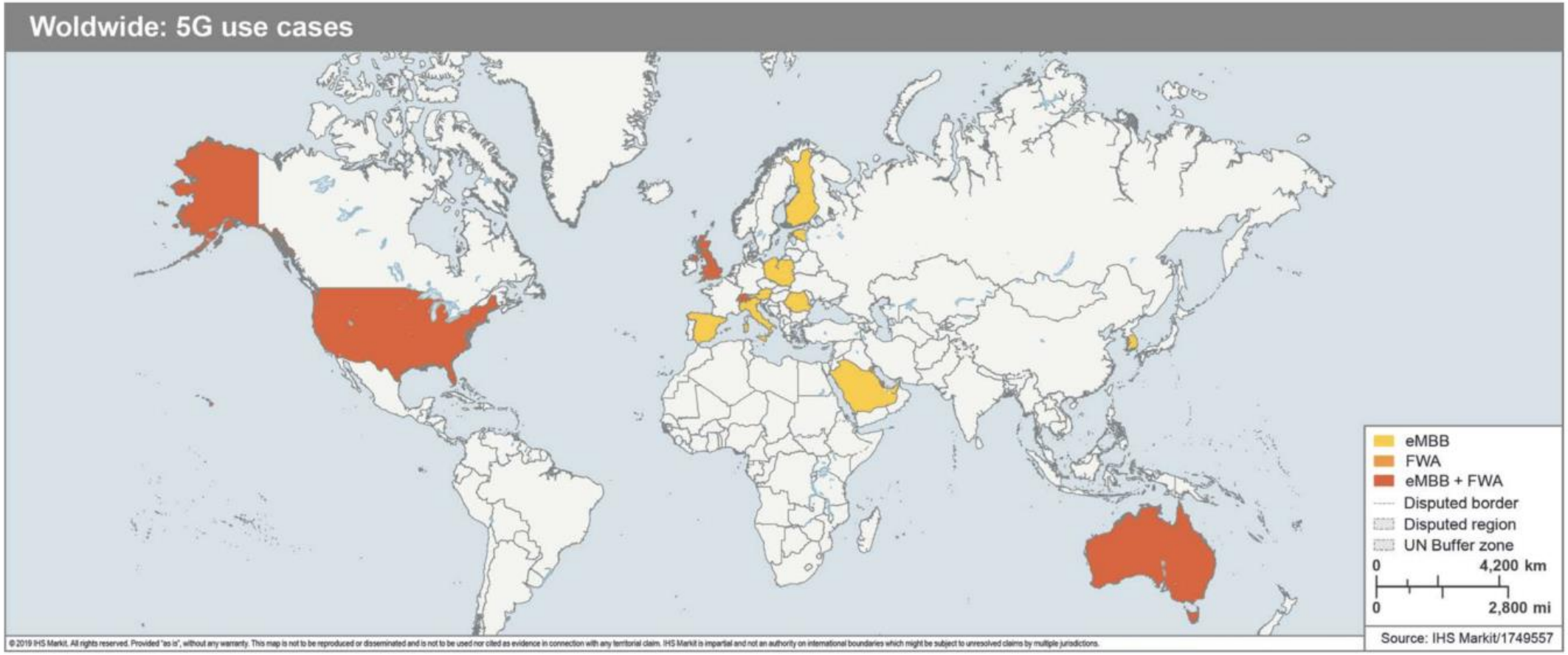
First 5G networks now live across Americas, EMEA and APAC:

- Still early days, mass nationwide roll-outs will still take several years.
- Mainly Mid bands in EMEA and APAC, High bands in Americas
- Worldwide 45%~65% coverage expected by 2024.

https://www.ericsson.com/en/5g, October 22nd, 2019

BUT WAIT A SECOND…

Enhanced mobile broadband and fixed wireless access are the primary use cases applied by operators so far



5G STANDARTIZATION PROCESS

RELEASE 15 – 5G first phase (commercial deployments)

5G non-standalone (Dec 2017) and 5G standalone definitions (Jun 2018)

Mainly focused on enhanced Mobile Broadband (eMBB) and fixed wireless

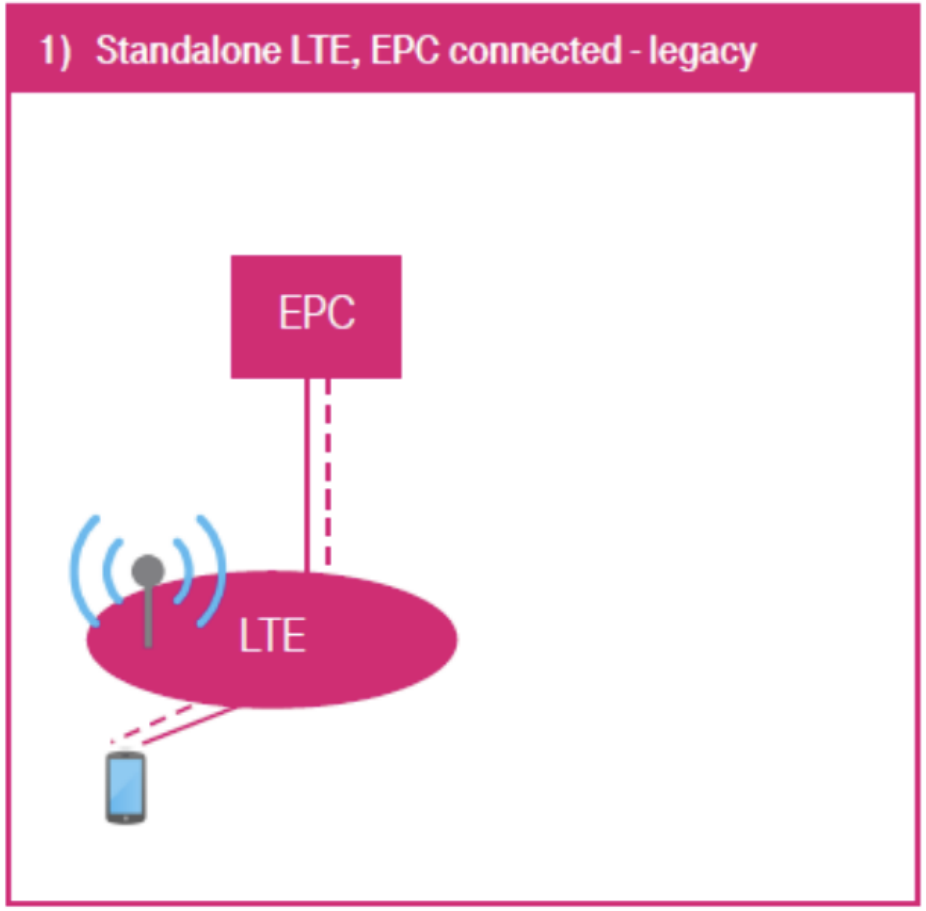
May perform on lower speed (on sub-6GHz bands) comparable to LTE Advanced Pro (LAA – Licensed Assisted Access, Rel 13) -> Gigabit Class LTE on 20MHZ of licensed spectrum + 5Ghz unlicensed part

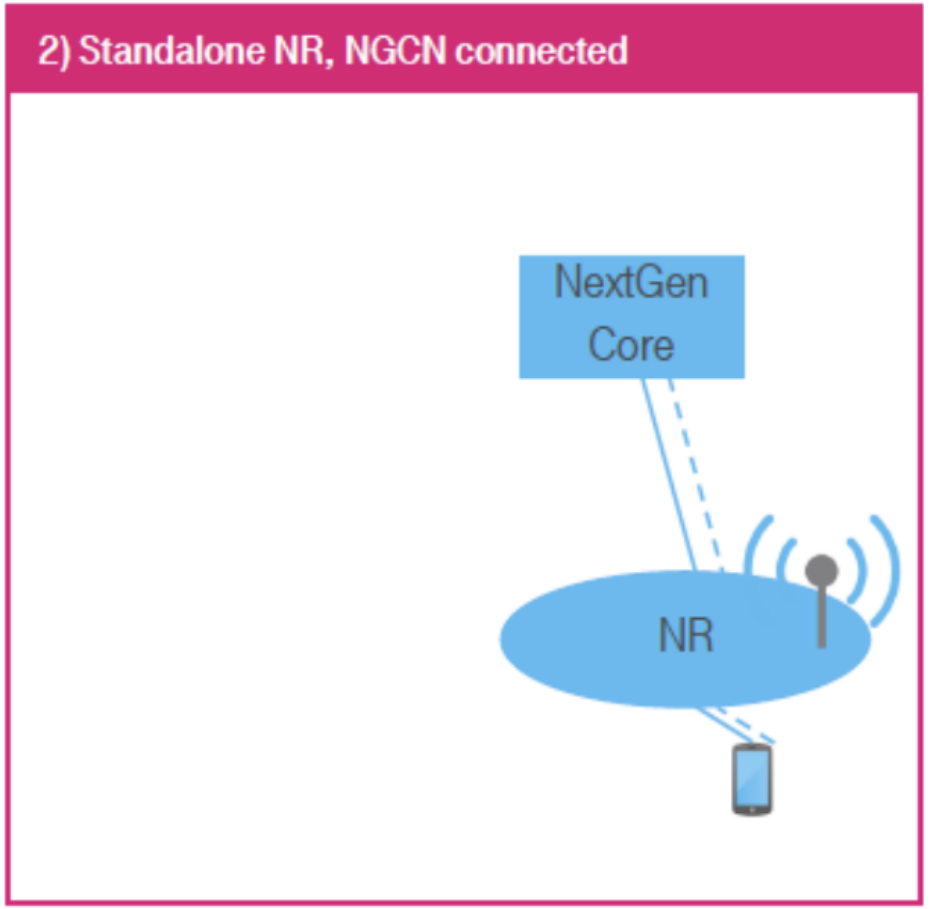
RELEASE 16 – 5G second phase (further evolution)

To be completed by the end of 2019

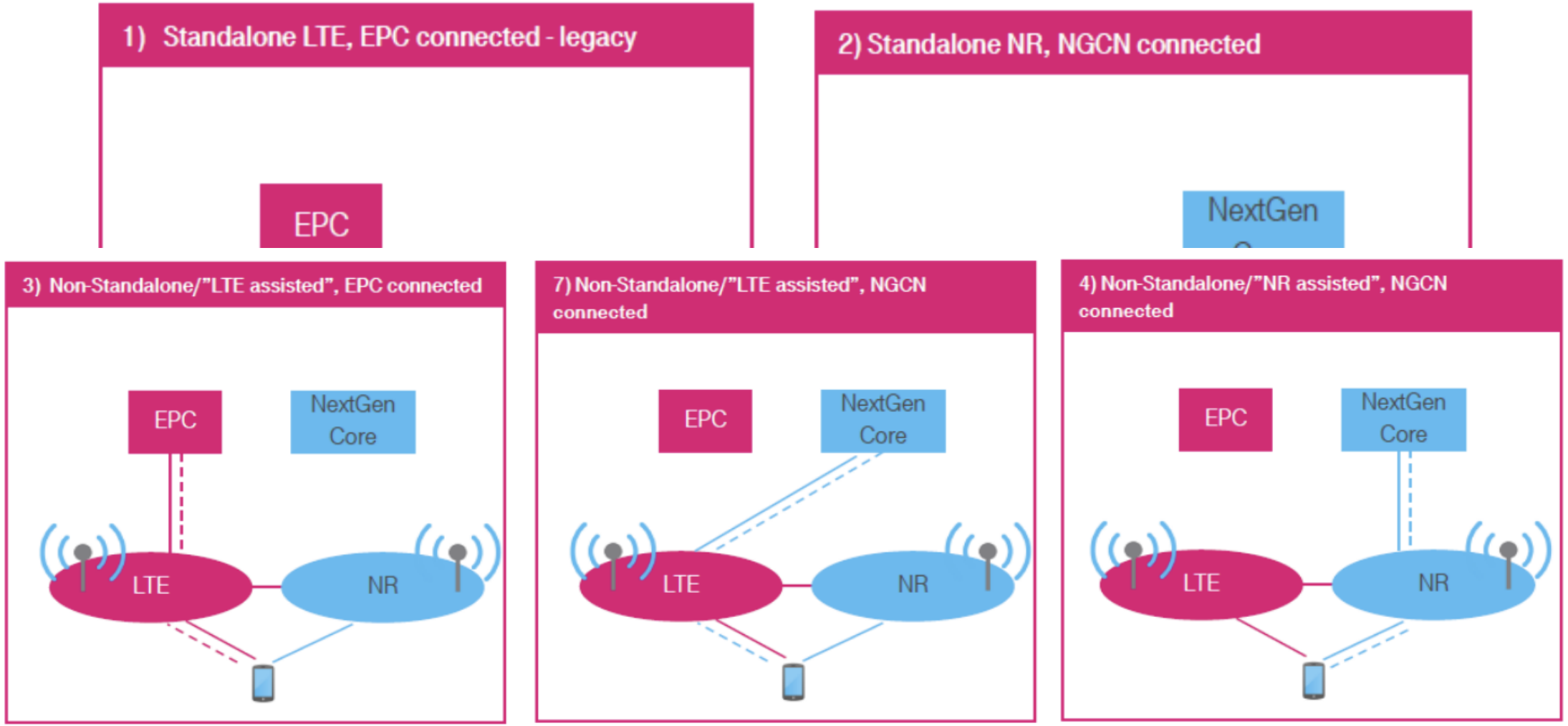
Focus on Ultra-Reliable Low-Latency Communications (URLLC, 1ms latency -> SD cars) and Massive Machine Type Communications (MMTC, 1m devices per km2 -> Industrial IOT)

TRANSITION TO 5G

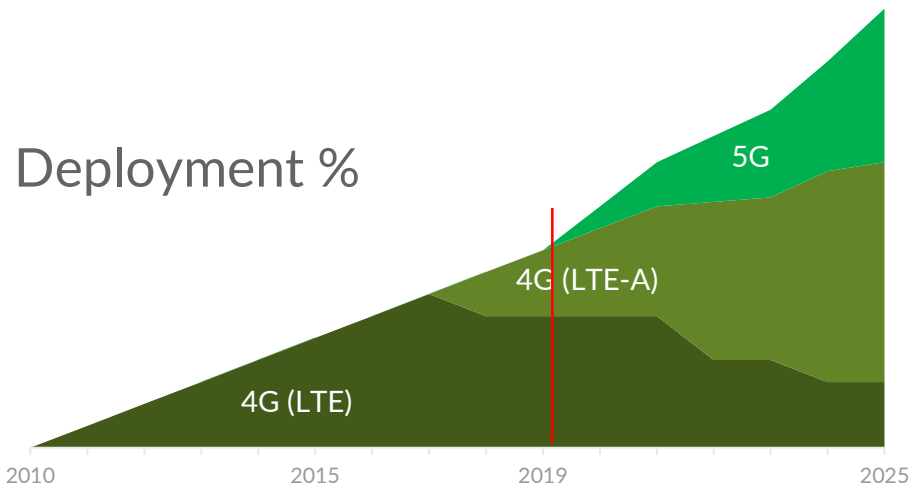




TRANSITION TO 5G



MOBILE TRENDS AND INVESTMENTS

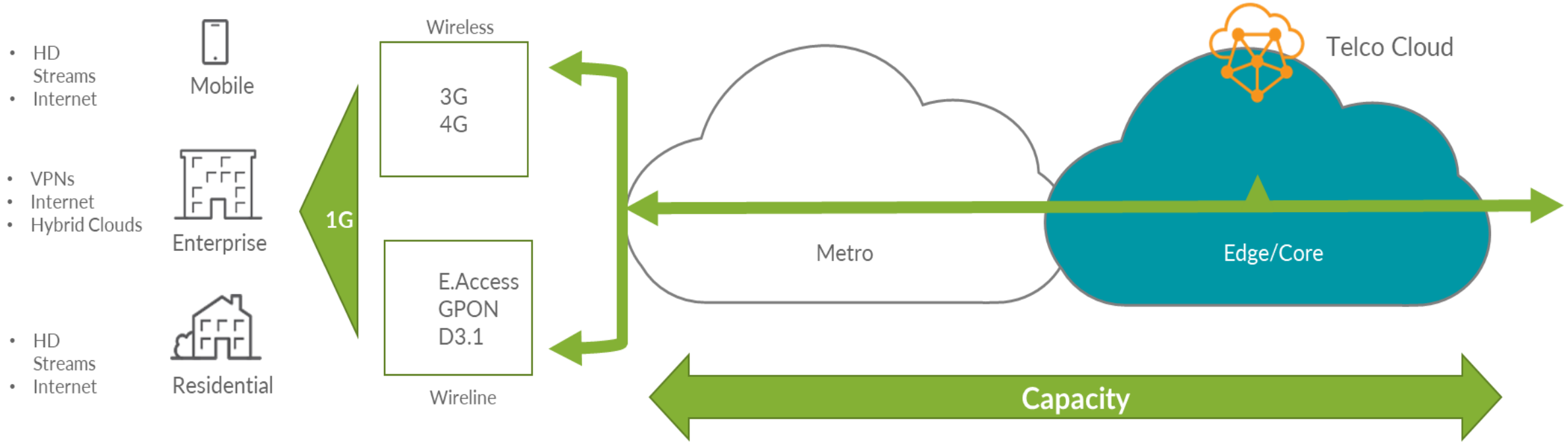


- LTE will continue to Grow.
- 5G will be a journey. Current focus on 5G is with NSA and looking for Enterprise Services and Industrial IOT.
- Operators focuses on Mobile Transport upgrades in Backhaul and architecture refresh to take the wave of 5G in future.
- Operators are evaluating Fronthaul solutions that is defined by 3GPP to take advantage of network reach, capacity and cost.
- Initial trails and rollout on 5G SA focused beyond 2020.
- We see new Vertical targeted services such as V2x, Massive IOT, Health Care beyond 2021.

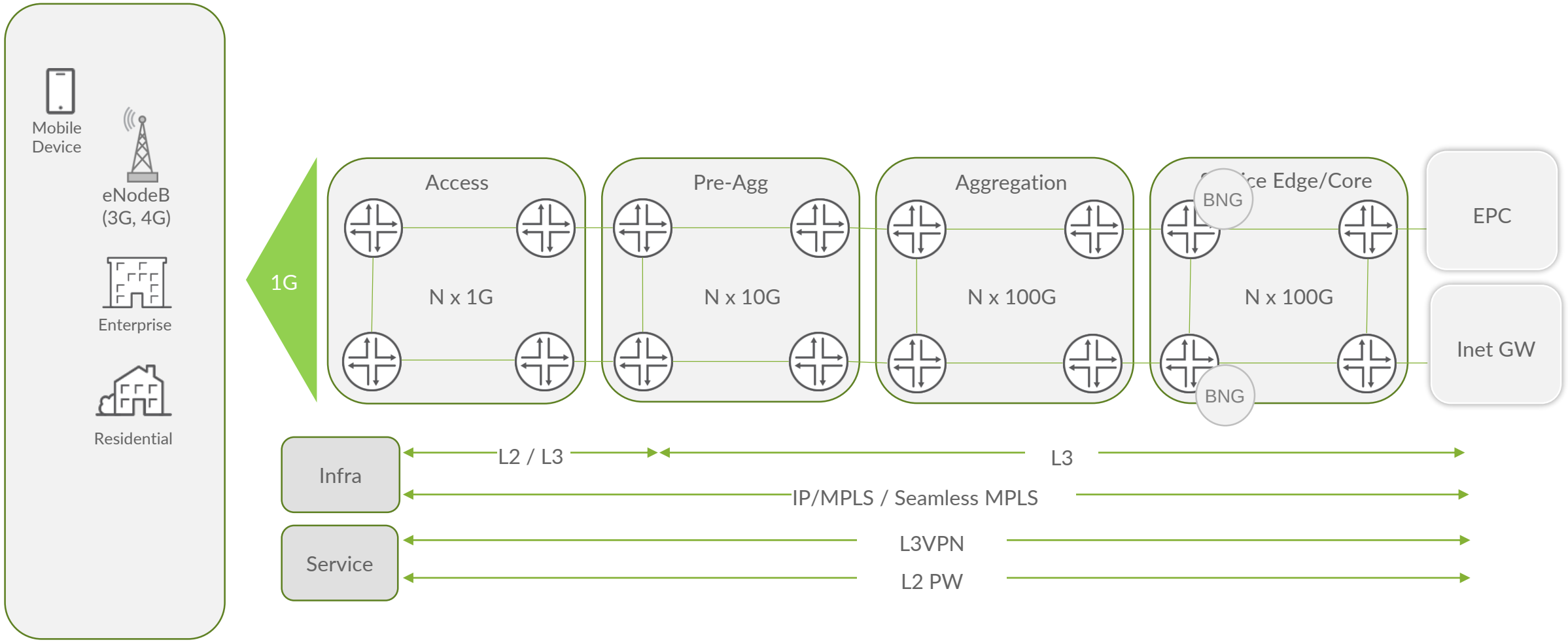
Source: IHS Markit, ACG

MOBILE BACKHAUL EVOLUTION

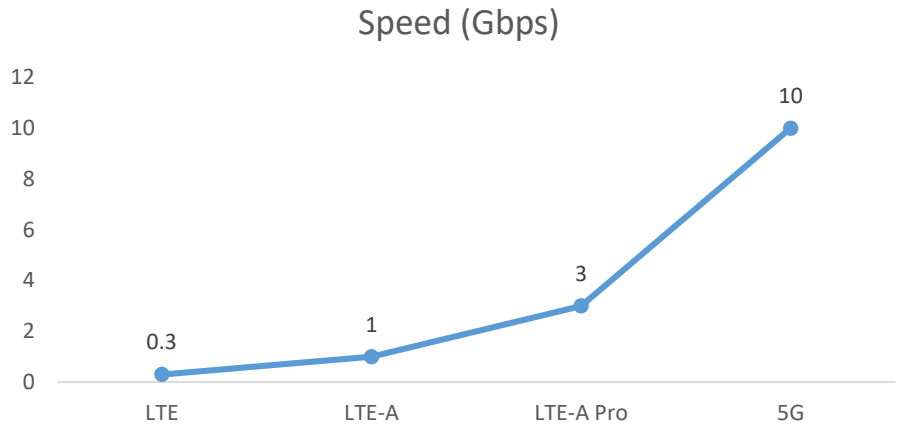
TODAY'S METRO NETWORK

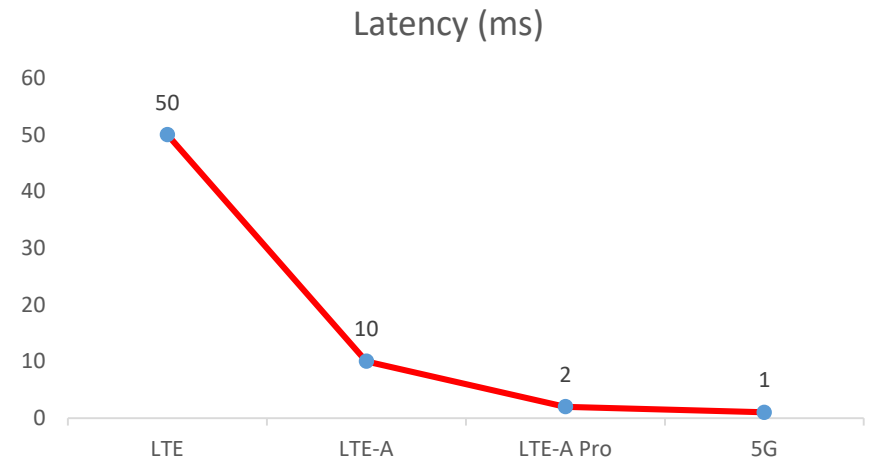


METRO-E AND LTE MOBILE TRANSPORT - TODAY



RADIO DRIVES TRANSPORT

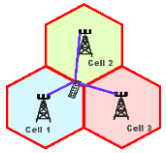




		LTE	LTE-A	LTE-A Pro	5G
Capacity	QAM	64	256	256	256
	Channel BW	20MHz	20Mhz	20Mhz	500Mhz
	Carriers	1	5	32	16
	Antenna (MIMO)	4	8	32	64 to 256

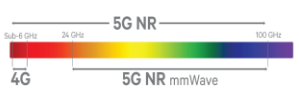
Efficiency & Coverage


Beamforming

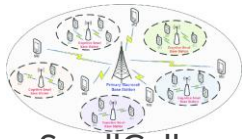


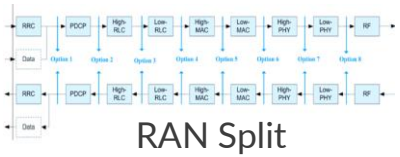
CoMP


Micro DC

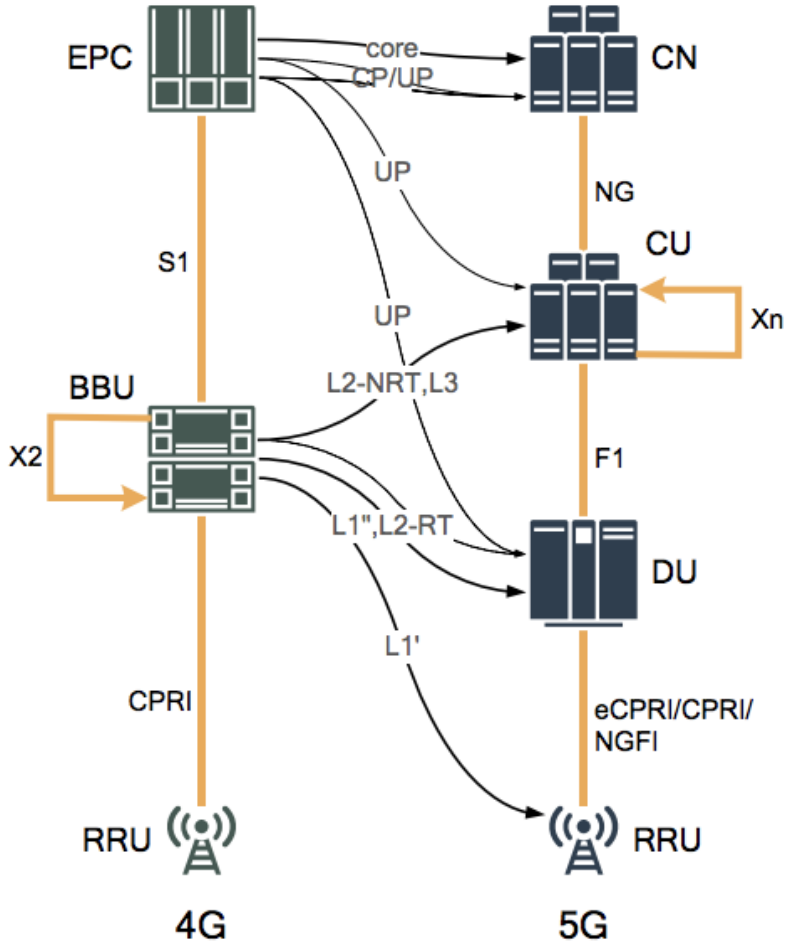


mmWave


SmallCell

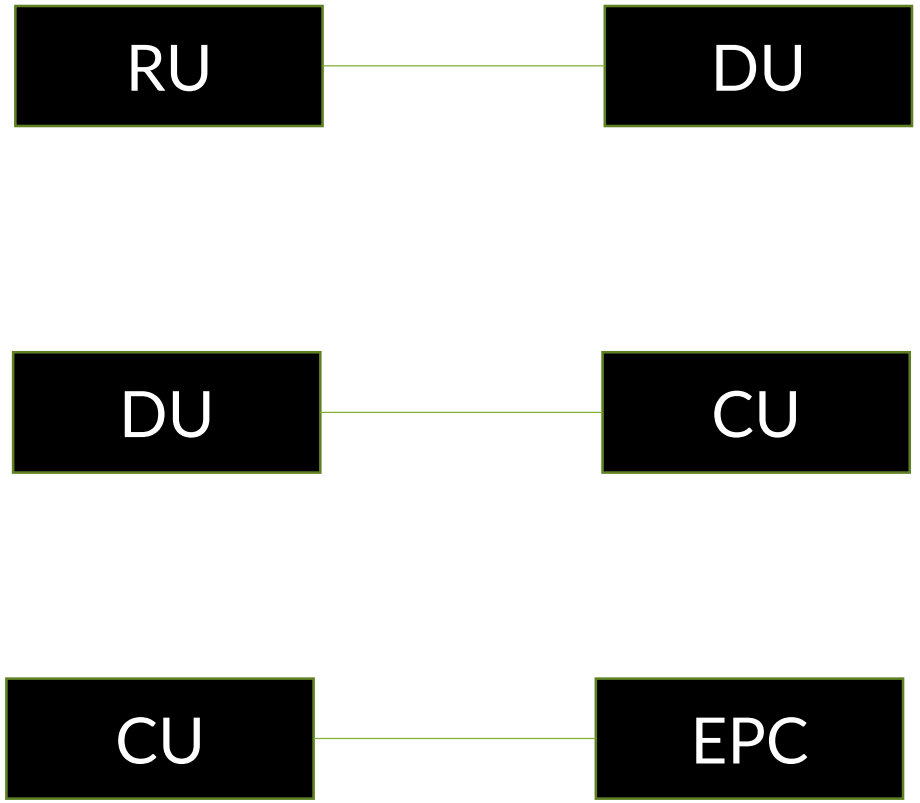

RAN Split

BASE STATIONS EVOLUTION



Evolving from single-node in 4G to split function architecture in 5G

5G RAN DESIGN OPTIONS/REQUIREMENTS

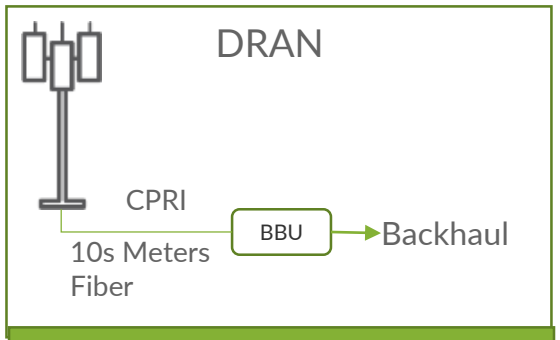


- Fronthaul @ 150us
- Low Latency Ethernet with TSN Profile
- WDM Passive and Active
- Dark Fiber

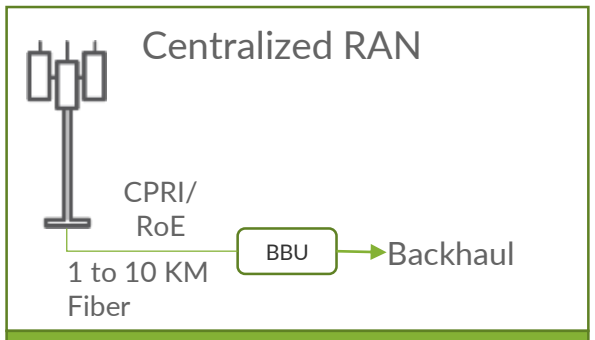
- Midhaul @ 5ms
- Ethernet/IP
- WDM
- OTN

- Backhaul @ 10ms
- Carrier Ethernet

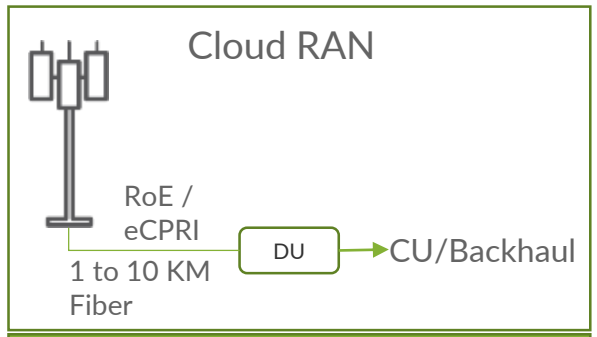
CRAN DEPLOYMENT OPTIONS



- Co-located with Tower
- Fiber
- 10s of meters
- Most deployed (90%)



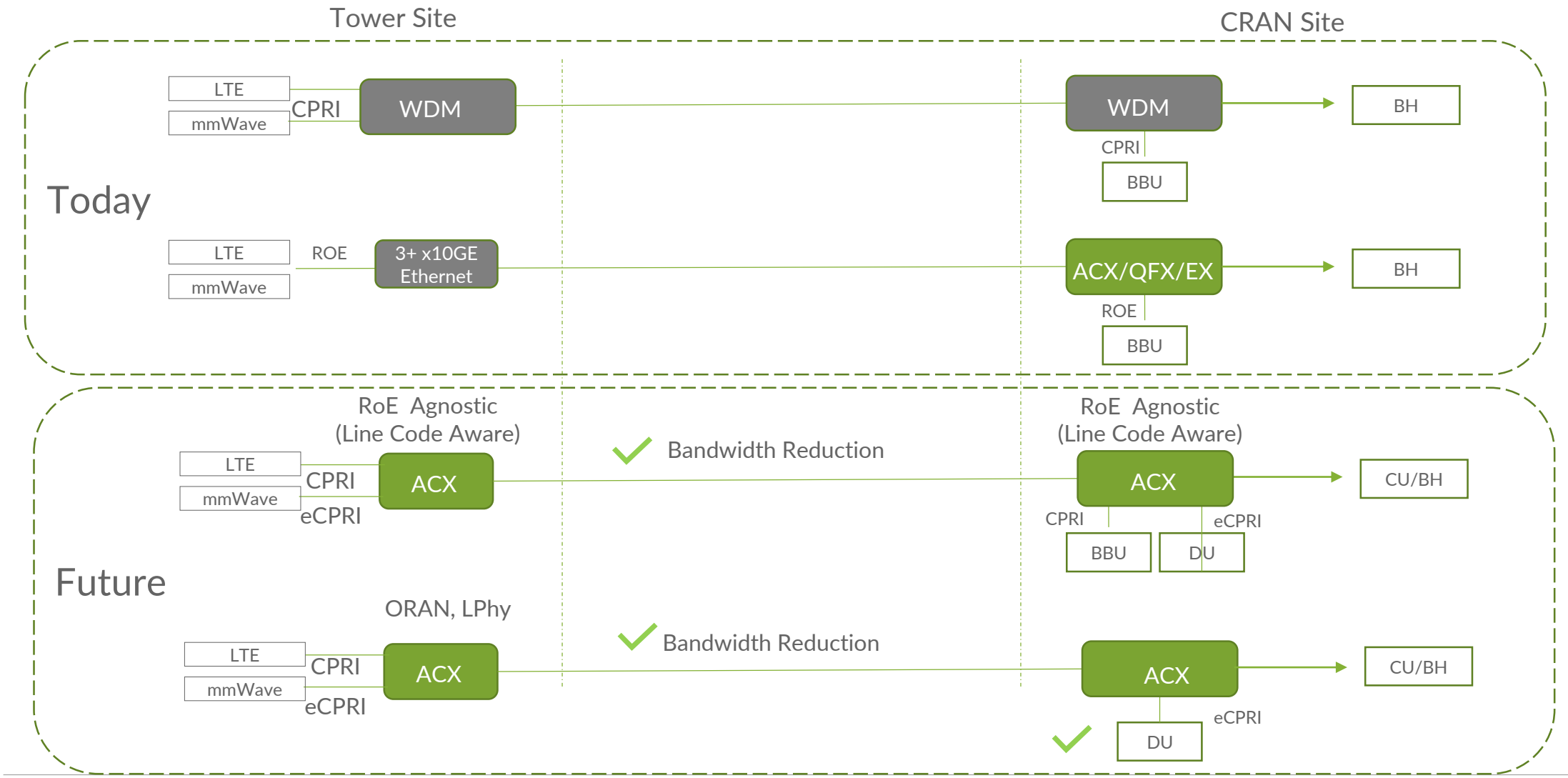
- BBU Pooling
- Fiber / WDM.
- 1 – 10 KM
- Few deployments (10%)
- Opportunistic OpEx Reduction



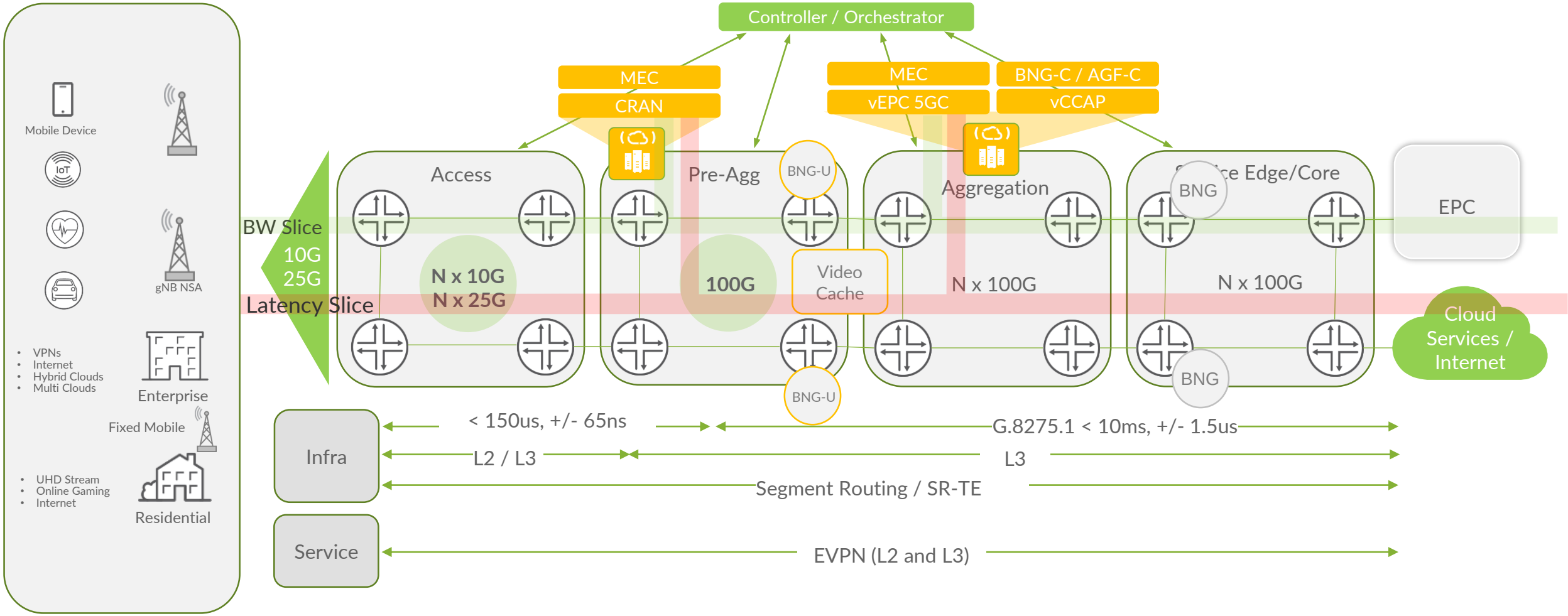
- DU Pooling
- Ethernet / Fiber / WDM.
- 1 – 10 KM
- Converged 4G/5G Fronthaul
- Bandwidth Reduction
- Long term

FRONTHAUL SOLUTIONS

Juniper solution



LTE-A/5G NSA MOBILE TRANSPORT - TODAY



JUNIPER SOLUTIONS IN 5G

Coverage

✓**Transport**
- Metro Fabric
- Fronthaul
- FMC/FWA
- Highly Scalable Edge/Core

✓**Virtualization**
- Edge Cloud/Telco Cloud/MultiCloud
- SDWAN

✓**Security**
- Mobile/IOT Security
- Edge Cloud Security
- Internet/Roaming Security.
- DDoS Protection (JNPR+Corero)

Capability

✓**Service Differentiation**
- Network Slicing

✓**Timing Synchronization**
- Tight TAE budget
- Strict High Availability

✓**Automation**
- ZTD
- Telemetry/Netconf/YANG
- Healthbot
- Network Management

Capacity

✓ **Platform (Transport)**
- Temperature Hardened High Capacity (300G+) access and Xhaul Aggregation (2.4T+) solution.
- Interface type support for 25GE, 100GE in Access.
- Support for 400GE uplinks.
- Low Latency switching for Fronthaul.
- Highly Scaling Timing support.
- Scalable Backhaul Architecture,
- Highly Scalable Edge features.
- Scale-up/Scale-out Core

✓**Data Center**
- ToR/EoR Metro Aggregation.
- Scale-up/Scale-out DC Fabric.

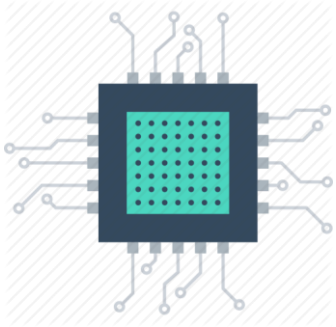
✓**Security**
- Service Provider Managed Service Enterprise Security Solution at scale.

FLEXIBILITY FOR SP INFRASTRUCTURE TRANSFORMATION

Juniper: Leadership Without Technology Religion

Flexible Silicon Options

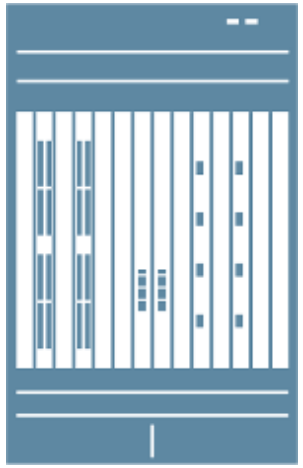
or



Custom Silicon
Penta
Triton

Merchant Silicon
Qumran 2
Jericho 2

Flexible Junos Options

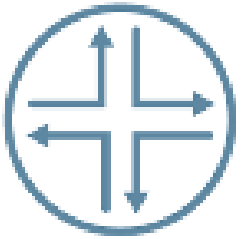


Integrated HW + SW

or

Standalone Junos SW

+

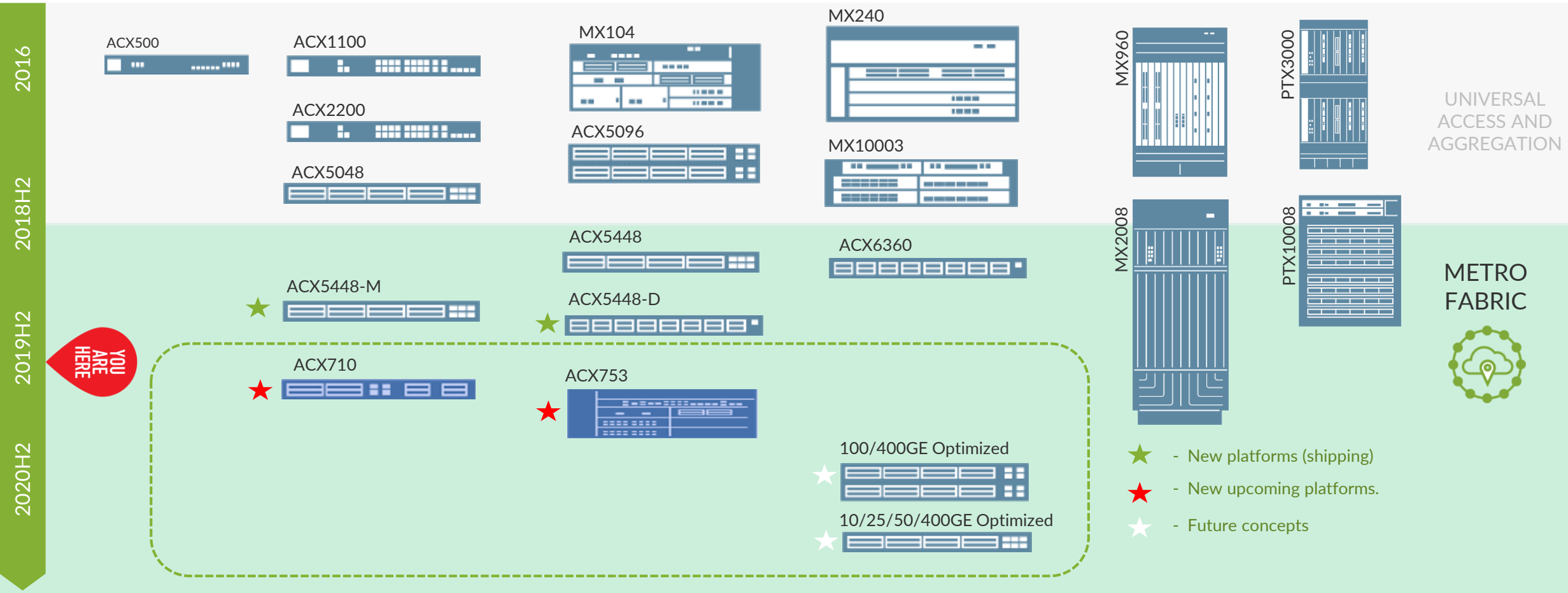


3rd-Party White Box HW

CONVERGED METRO ETHERENT PORTFOLIO

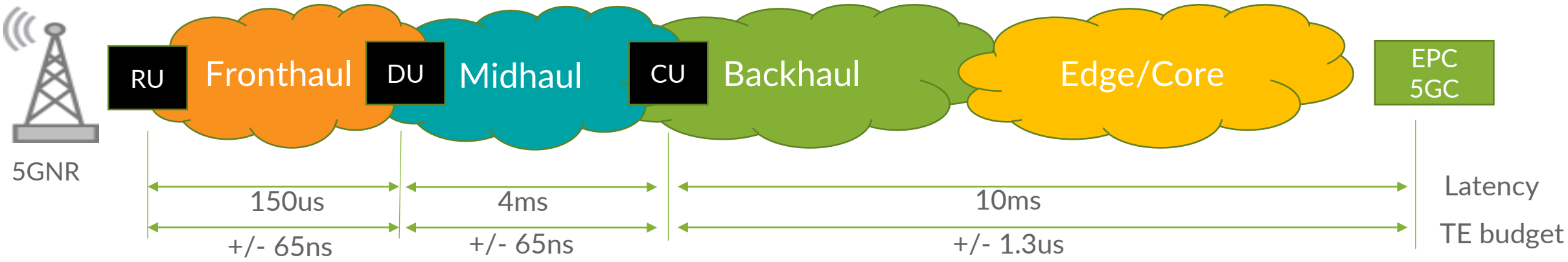
JUNOS, ZTD, Automation, Telemetry, Analytics, Multilayer Control & FCAPS

SR-MPLS (SRo4, SRo6), Flex-Algo, PCEP, BGP-LS, eODN, IPVPN/EVPN



TIMING & SYNC

SYNCHRONIZATION & TIMING BECOMES CRITICAL



5G TDD demands Strict Timing

- +/- 1.5us
- Strict Hold-over timing (In Hours)

Stringent Timing in New architectures

- Fronthaul - +/- 130ns (Required for CA, CoMP,etc.,)

Following specifications are critical for 5G Timing

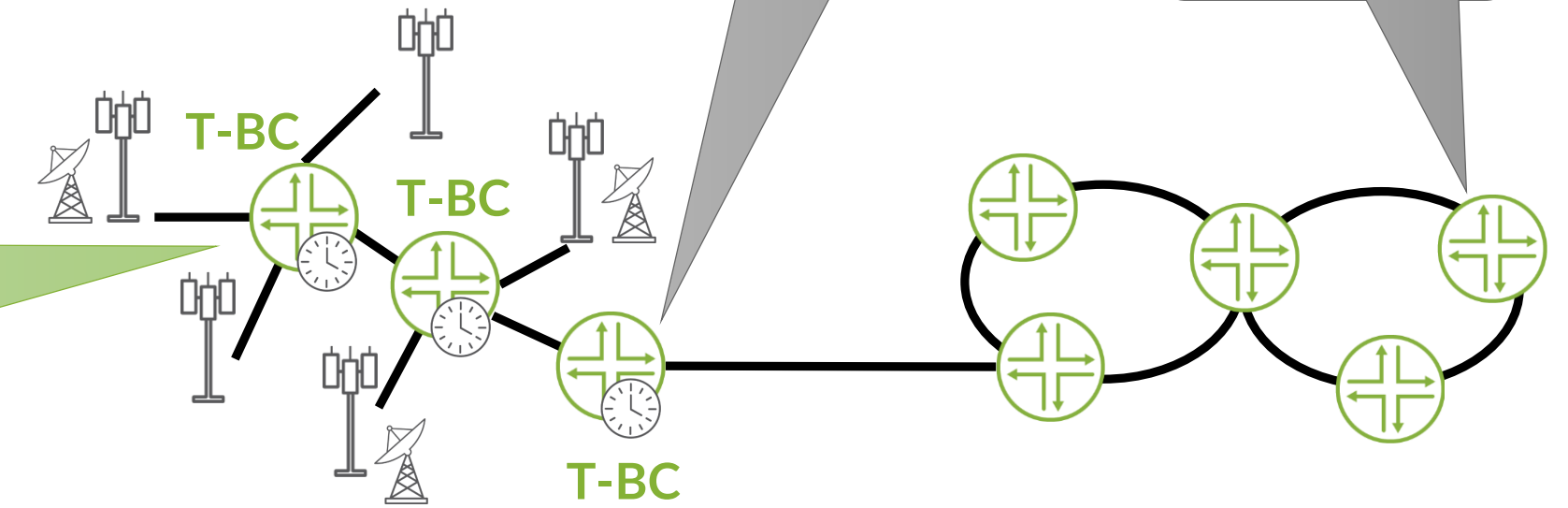
- Class B or C Devices
- PTP and SyncE Support
- G.8275.1 and G.8275.2 Telecom Profile

OPTION 1: FTS & DISTRIBUTED GRANDMASTERS

PTP Telecom profile: G.8275.1

- GNSS on all, or at least multiple, cell site in a metro area.
- G.8275.1 FTS with T-BC in all backhaul nodes within the metro area for redundancy
- No timing requirement in the core, but still vulnerable to GNSS jamming of an entire region.

Distributed grandmasters at (some of the) sites in the metro or backhaul network.



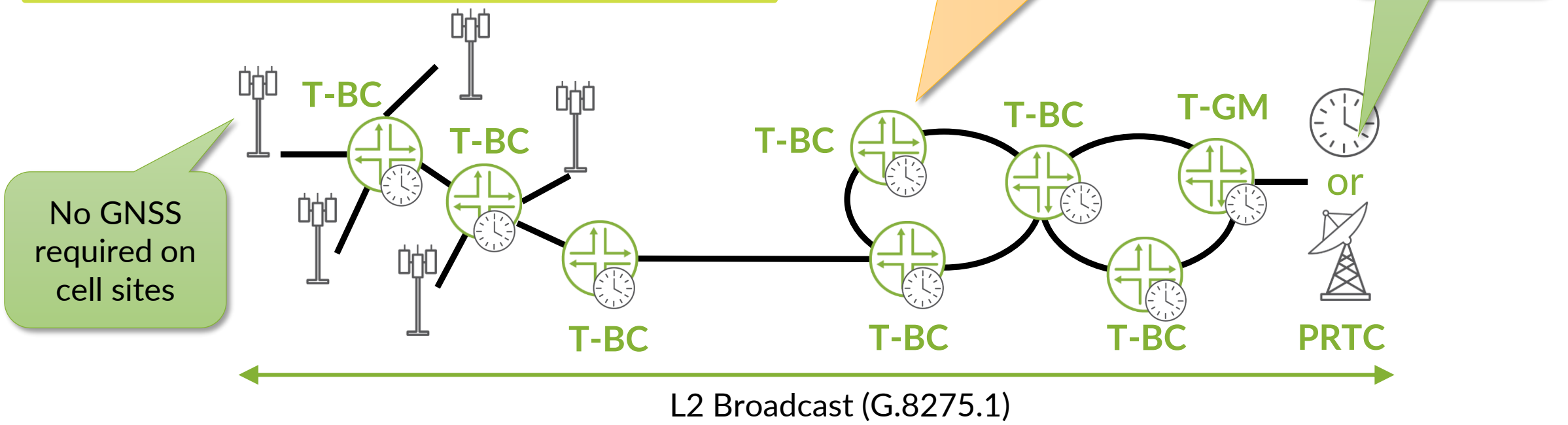
OPTION 2: FTS & CENTRALIZED GRANDMASTERS

PTP Telecom profile: G.8275.1

- Centralized GNSS on core or main PE sites
- G.8275.1 FTS with T-BC in all nodes along the sync chain, generally including core nodes
- No need to deploy GNSS on the cell sites, saving cost and operational complexity and inherent protection against GNSS jamming

Every node in Sync distribution path needs to support boundary (T-BC) clock
– no exceptions!

Centralized Grandmaster



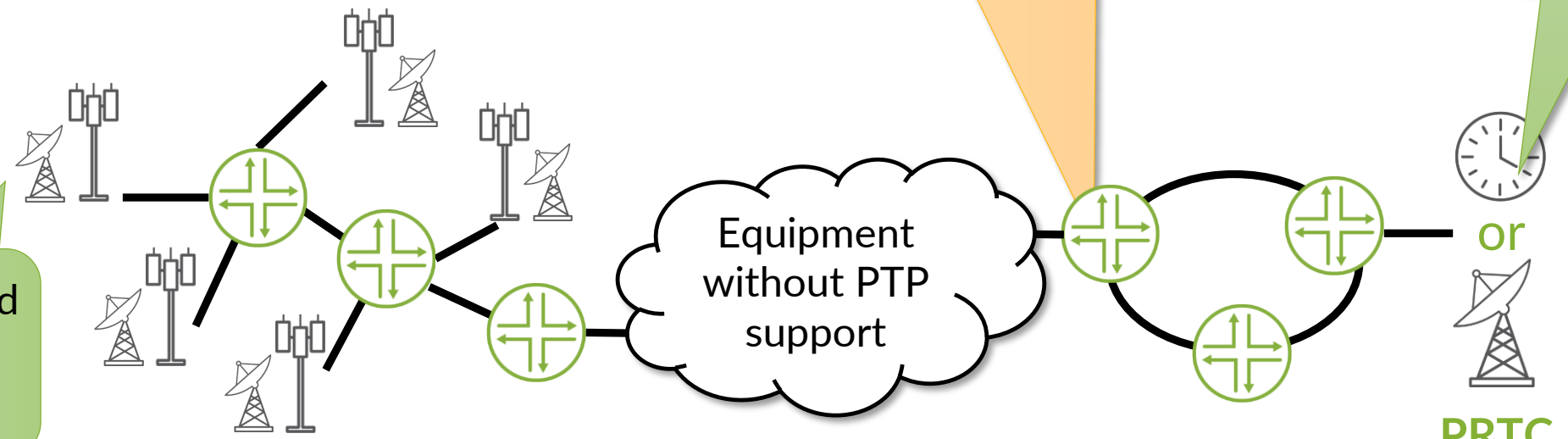
OPTION 3: ASSISTED PARTIAL TIMING SUPPORT

PTP Telecom profile: G.8275.2

- GNSS on all cell sites
- G.8275.2 A-PTS in the backhaul nodes to provide for GNSS redundancy and hold-over
- Part of the network can be PTP unaware, e.g. for leased lines or brownfield deployments with older platforms

PTP provides better hold-over incase of GNSS failure, but is generally not used as the primary reference clock

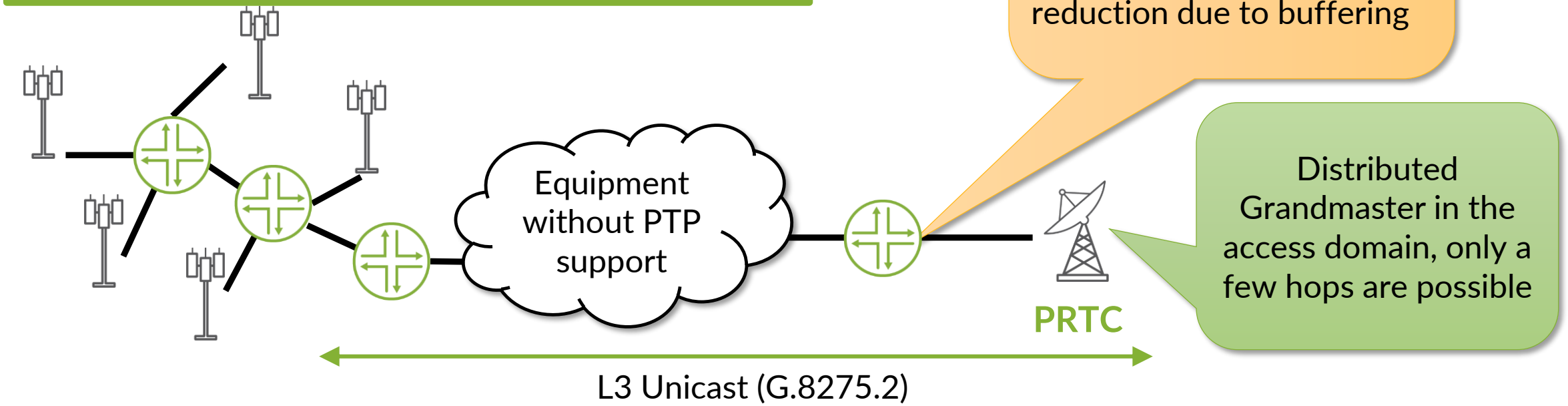
Centralized Grandmaster



OPTION 4: PARTIAL TIMING SUPPORT (PTS)

PTP Telecom profile: G.8275.2

- No GNSS in the access domain
- G.8275.2 PTS in the backhaul nodes
- Part of the network can be PTP unaware, e.g. for leased lines or brownfield deployments
- Only very few hops possible with acceptable sync performance



CONCLUSIONS

Different architecture choices for timing & synchronization

There's not a single "right" way to do sync, depends on customer preferences and installed base

Options	Pros & Cons
GNSS deployed at every cell site	▪ High cost & complexity, but best accuracy and stability. ▪ GNSS might not always be available (e.g. jamming / spoofing)?
PTP Full Timing Support	▪ Low cost & complexity as only few Grandmasters are requited ▪ G.8275.1 support required in every node
Assisted Partial Time Support	▪ Same cost and complexity as GNNS at every cell site ▪ Can be appropriate solution for GNSS failure / unavailability
Pure Partial Time Support	▪ Lowest cost, very little requirements on the network ▪ Major challenges with accuracy and stability, only possible for a small number of hops – if at all

Juniper "5G sync" recommendation is (1) Hybrid PTP + Sync-E, (2) G.8275.1 Telecom profile with T-BC in all nodes, and (3) PHY/MAC timestamping on all interfaces

THE JUNIPER ADVANTAGE

In house timing stack-servo

- High flexibility
- Full control

Accuracy and performance

- Tested and deployed

Interface flexibility

- 1GE-100GE support
- Full range of optics

Increased timing clients

- 512 clients supported on ACX
- HW support on MX

THE JUNIPER ADVANTAGE

Advanced timing hardware

- Better holdover performance, jitter/wander compliance, Stratus 3, OCXO, PHY/MAC timestamping, Advanced PLLs

Multiple encapsulations

- Ethernet (VLAN tags), IPv4, IRB, IPv6

Multiple timing profiles

- ITU-T, IEEE, IETF and SMPTE possible

Hybrid mode support

- Enhanced stability, High accuracy, Extended holdover
- PTPoE, IPv4, IPv6

AUTOMATION

AUTOMATION IN JUNOS BASED NETWORK JUNIPER OPEN SOLUTION

ON BOX AUTOMATION TOOLS

JUNOS

OFF BOX AUTOMATION TOOLS

AUTOINSTAL., PYTHON, SLAX

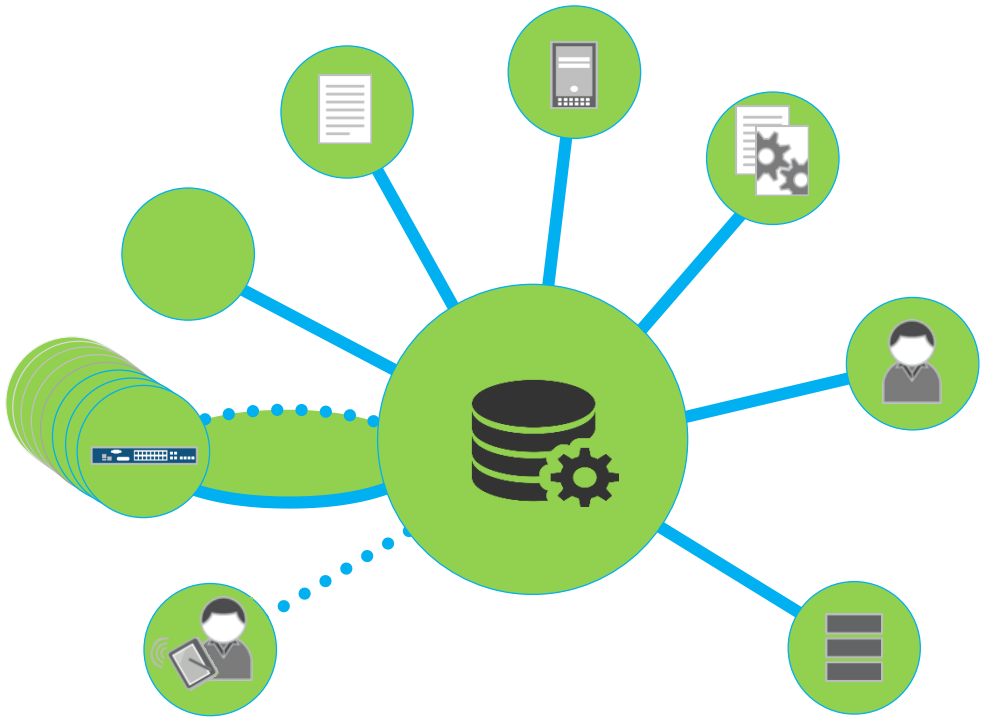
YANG, JSON, XML

YANG, OPENCONFIG

NETCONF, REST, CLI

JET API

TELEMETRY SENSORS
SNMP, STREAMING, gRPC



PYTHON, RUBY

ANSIBLE, JinJa2

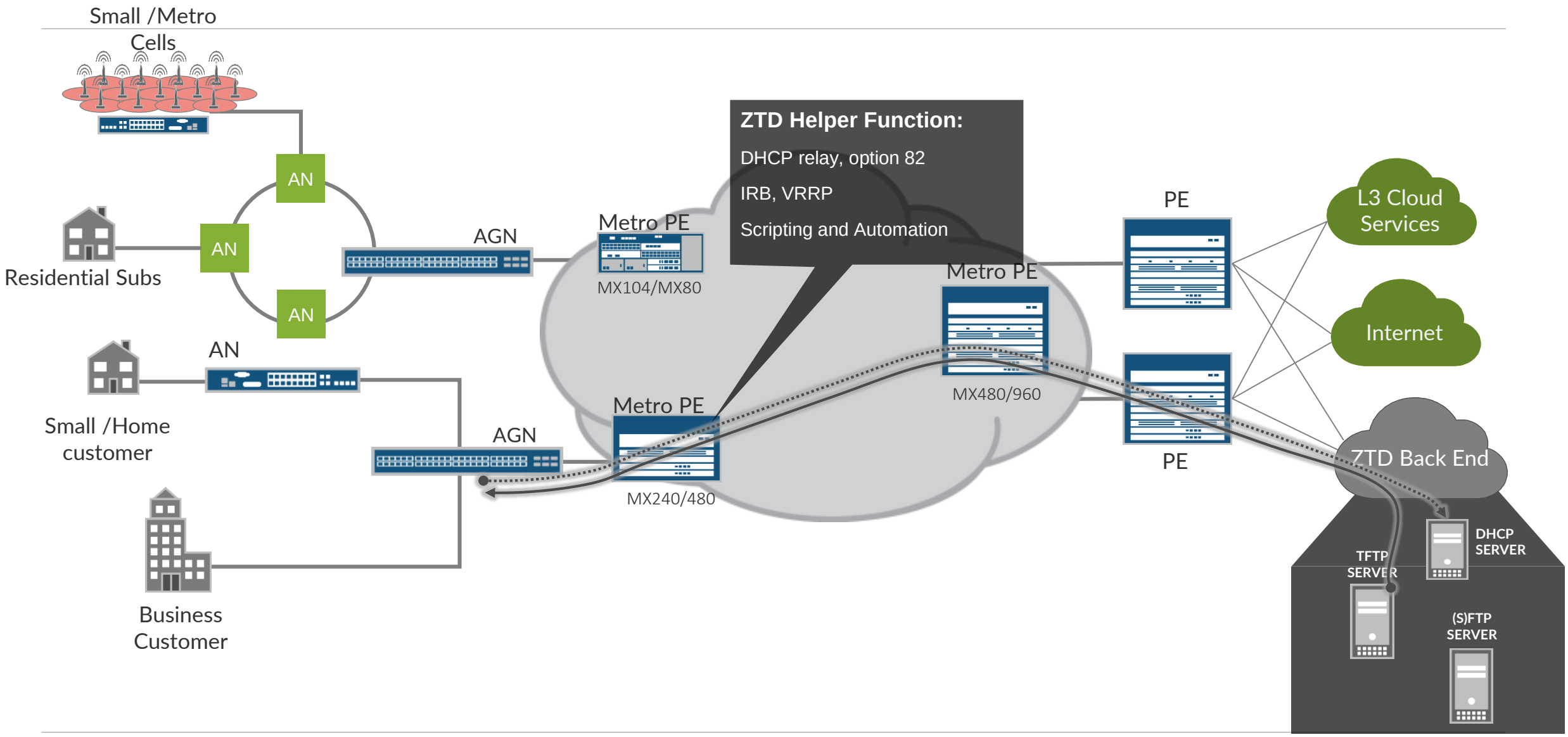
Junos Space CSD/CPP

Flex

OPEN SOURCE PROJECTS

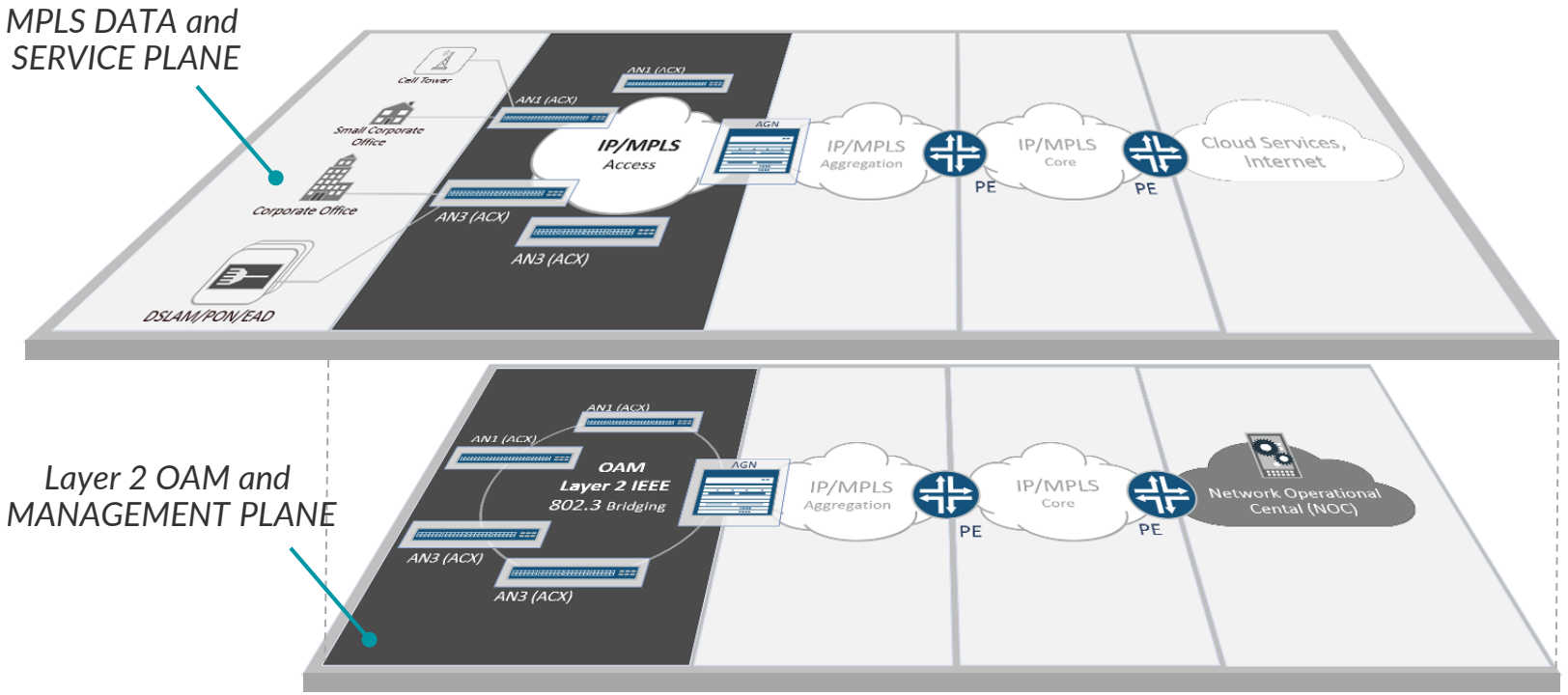
Healthbot, AppFormix

ZTD IN A&A INFRASTRUCTURE



ZTD USE CASE WITH MPLS IN THE ACCESS

Decoupling MPLS Data from ZTD Management (OAM) Plane



ZTD Management Plane is required to provide L2 connectivity between any newly connected node and AGN. There two options:

- ✓ Use a dedicated VLAN shared across access ring (IEEE802.3 bridging)
- ✓ Enable Layer 2 service on top of the provisioned MPLS infrastructure

[Zero Touch Deployment in Access and Aggregation Design and Implementation Guide]

QUESTIONS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