JUNIPER NETWORKS

# JUNIPER DAY

16 октября 2018 | Москва

# Metro Access Evolution

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# AGENDA

For today

1. 5G evolution & Mobile backhaul
2. IP-Optical convergence
3. Metro Optimization with NorthStar

# SPEAKER INTRODUCTION

Evgeny Bugakov

6 years in Juniper
15+ years in telecom
JNCIE-SP

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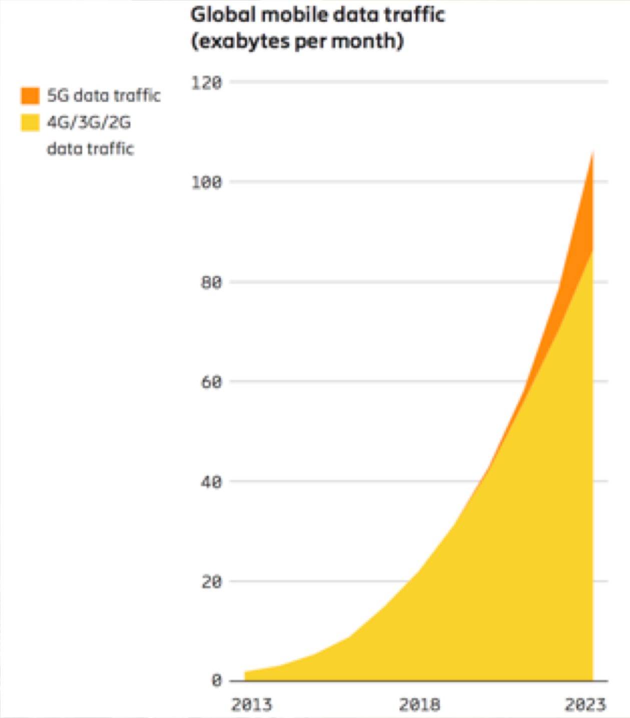
# 5G EVOLUTION

## Impact on the mobile backhaul network

# Metro/Access trends

Mobile is leading the way




**Mobile traffic is growing rapidly:**

- 46% CAGR over 2016-2021 (6.7x), compared to 24% CAGR (2.9x) for global IP traffic*.

**Increase in mobile traffic triggers mobile network capacity upgrades:**

- More wireless spectrum / additional frequency bands.
- More base stations, cell site densification with small cells.
- LTE-A deployments and carrier aggregation.

5G is much discussed, but still early days:

- Initial 5G trials this year
- 5G starts to contribute in earnest to traffic volume by 2021+

From: Ericsson Mobility Report, June 2018

* Cisco VNI, 2016-2021, September 2017

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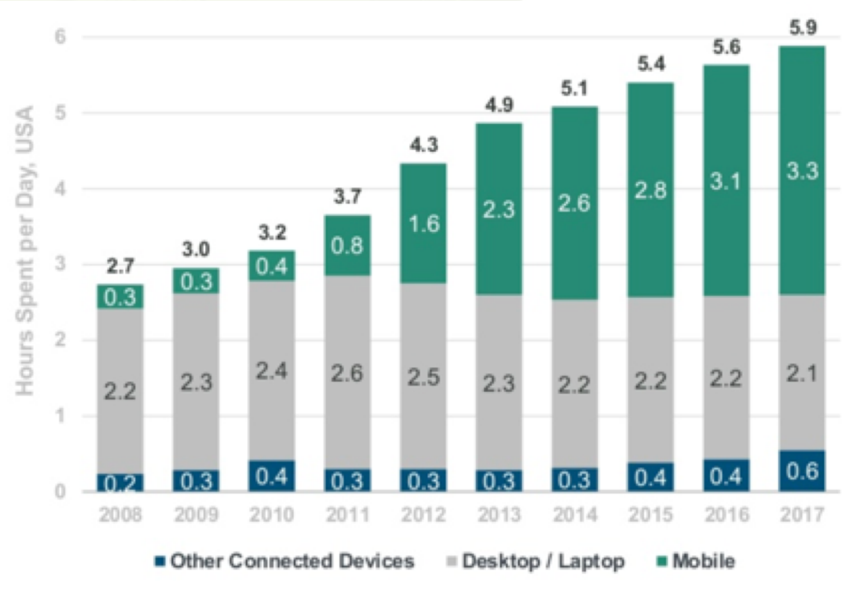
# MOBILE DATA TRAFFIC

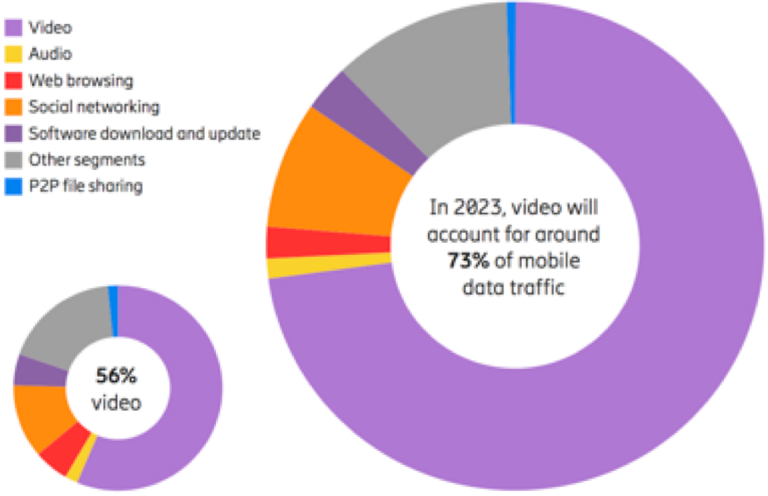
## What's driving the traffic growth?

We're getting addicting to the small screen.... watching ever more (and higher definition) video

**Daily hours spend with digital media per adult user**




**Mobile data traffic by application**



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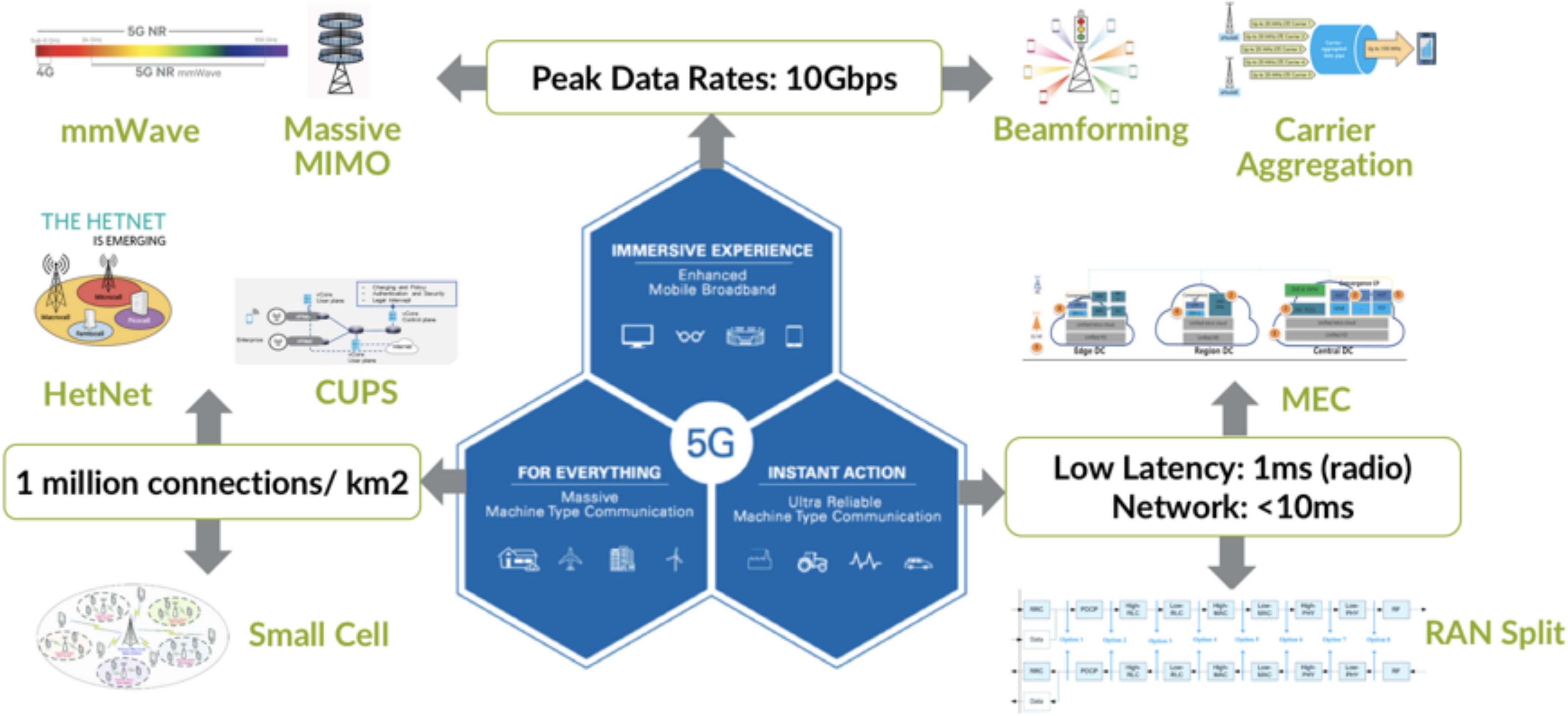
# 5G TECHNOLOGY DRIVERS



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# 5G STANDARTIZATION PROCESS

**RELEASE 15** – 5G first phase (commercial trials)

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

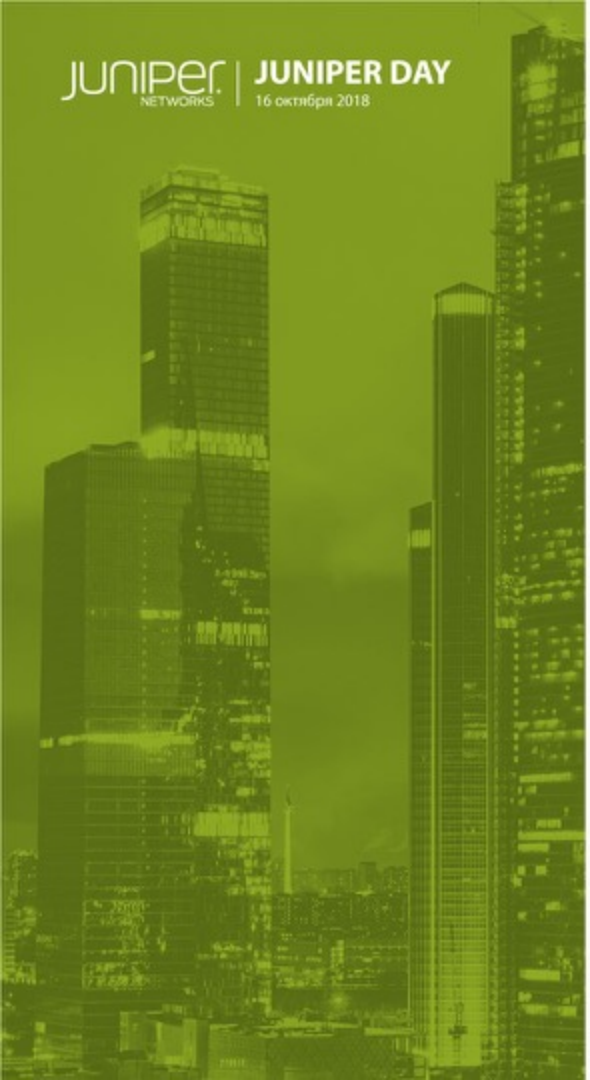
Mainly focused on enhanced Mobile Broadband (eMBB) and fixed wireless

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

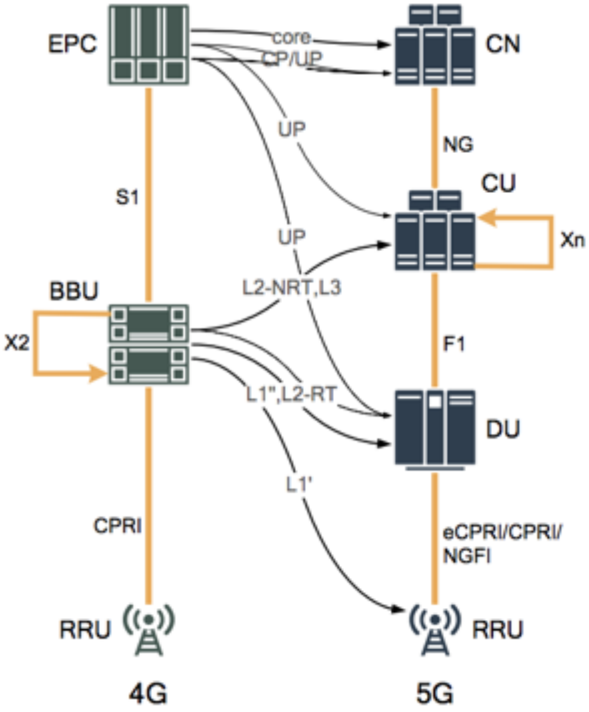
**RELEASE 16** – 5G second phase (further evolution)

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)

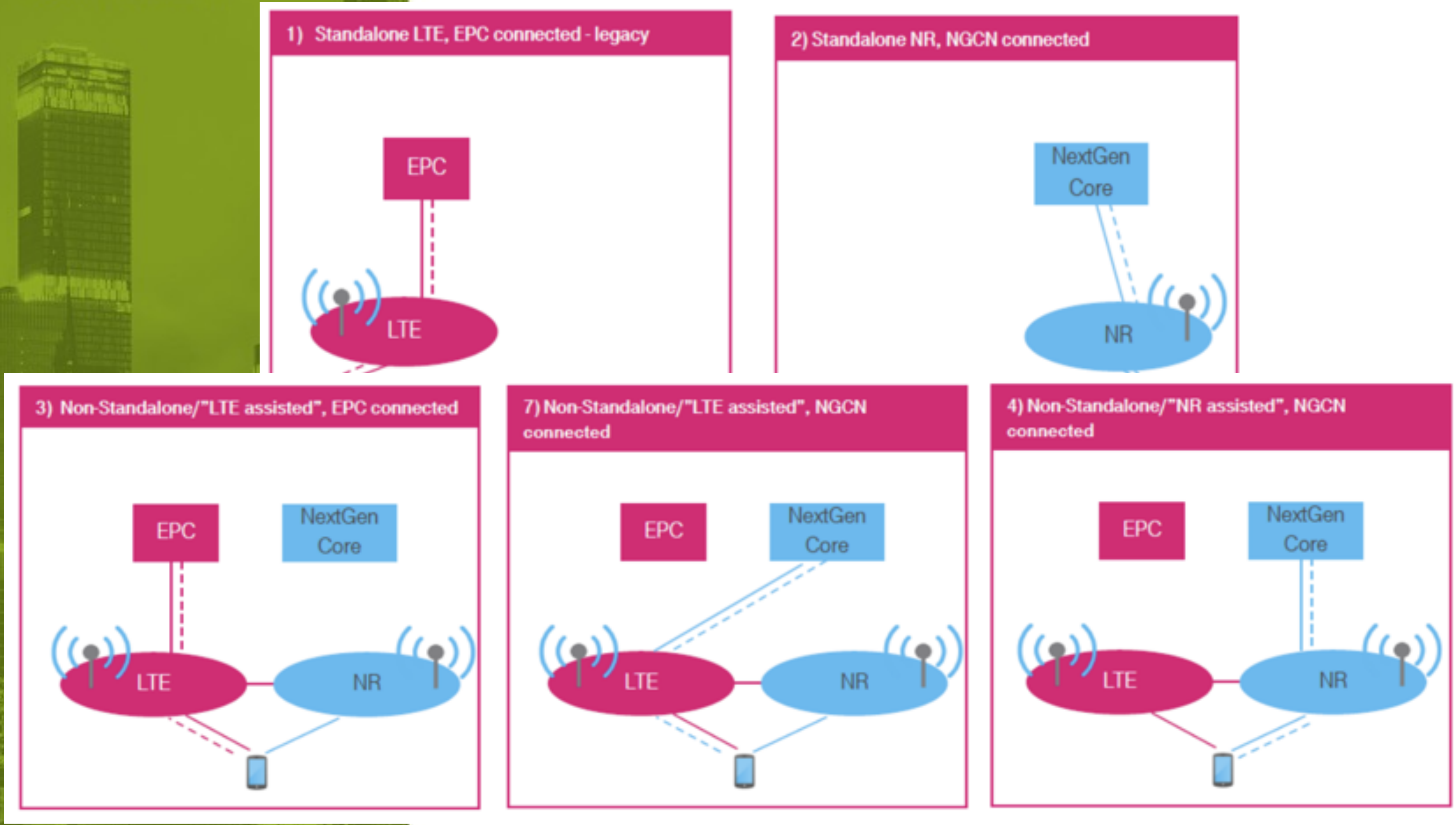



# TRANSITION TO 5G

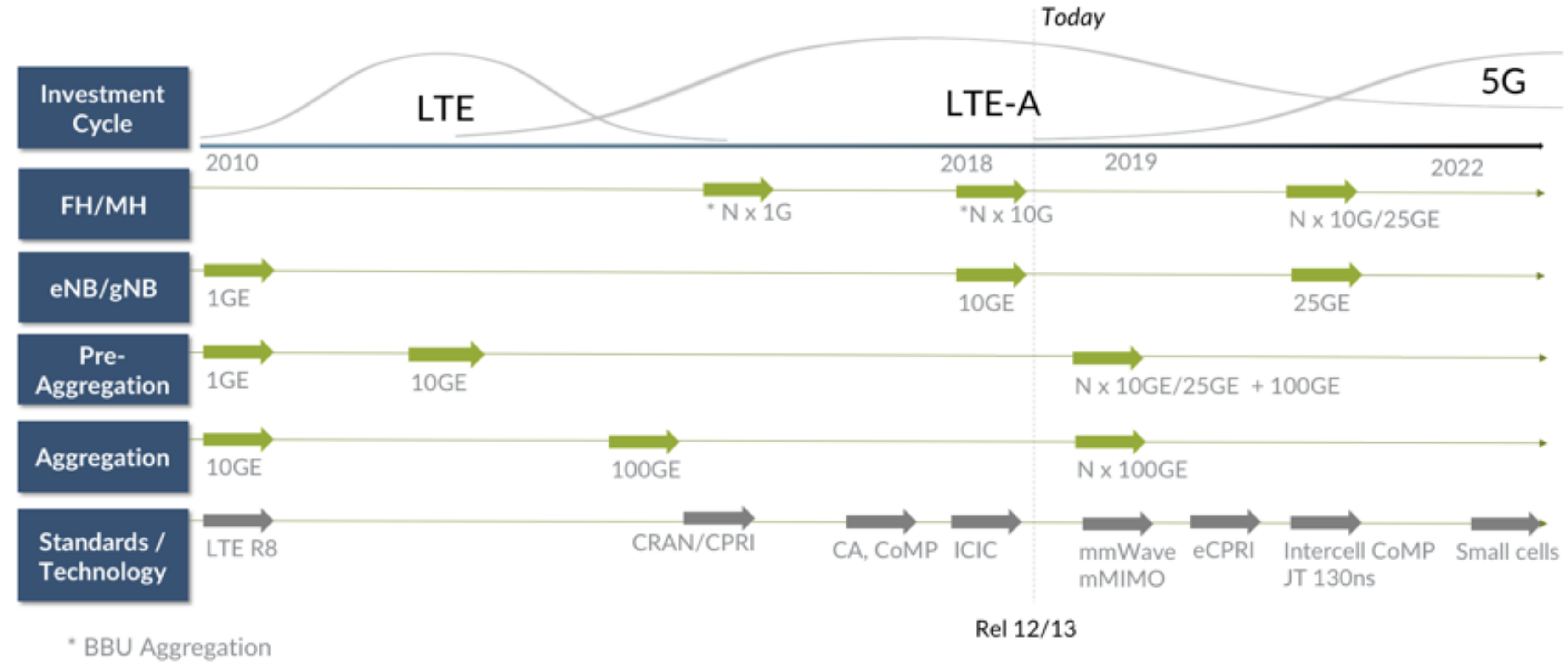


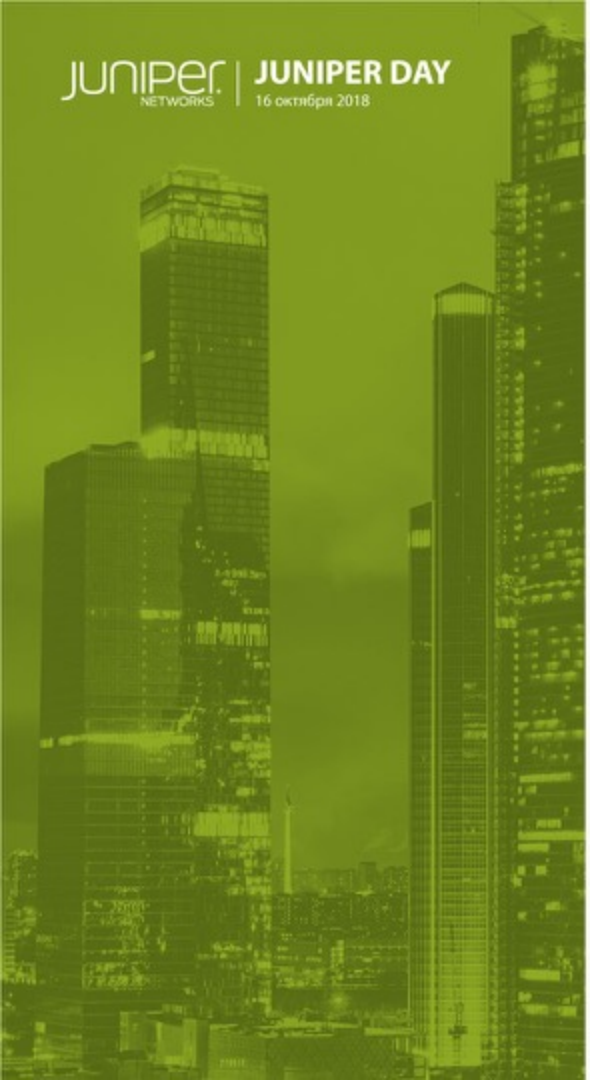

**Evolving from single-node in 4G to split function architecture in 5G**

# TRANSITION TO 5G



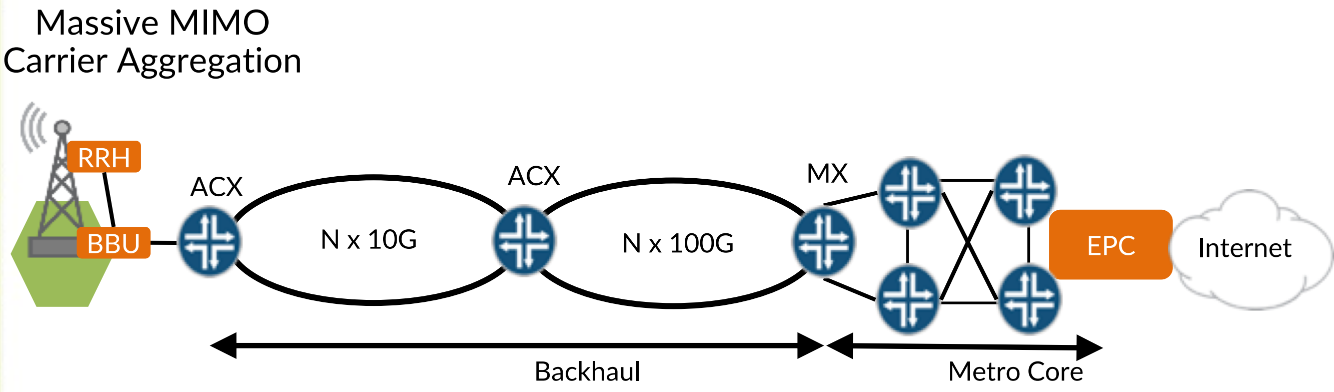
# MOBILE BACKHAUL INFLECTION POINT






# CSR architecture today

## 4G / LTE-A

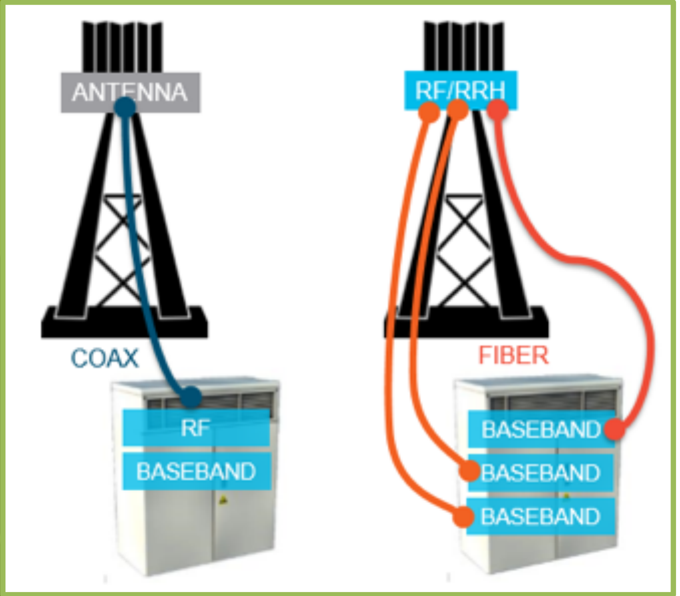



Most deployed CSR architecture for 4G / LTE-A today:

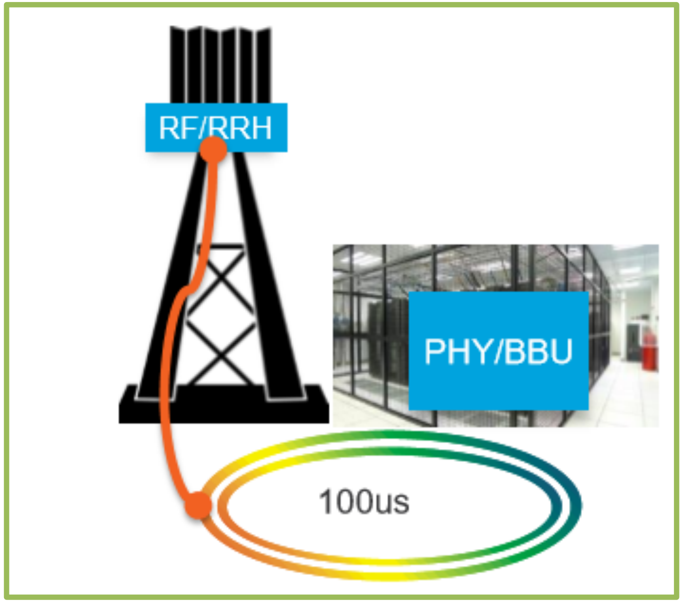
- Operators start to implement Massive MIMO and Carrier Aggregation for better spectrum efficiency to improve density and bandwidth. This requires CSR upgrades at Cell Sites from **1GE to 10GE**.
- **10GE CSR** typically deployed at single site or to aggregate multiple cell sites, depending on reach between sites.
- Requires hardened CSR with **3 … 8 x 10GE ports** (downlink & uplink).

# FRONTHAUL

## Evolution




BBU aggregation




- 4G introduced CPRI
- Reduce TCO and improved performance

- 100 us latency budget allows for BBU aggregation & centralization.
- Potential benefits from scale & efficiency, but needs low latency & high accuracy timing.

# NG Mobile Backhaul

## Evolution

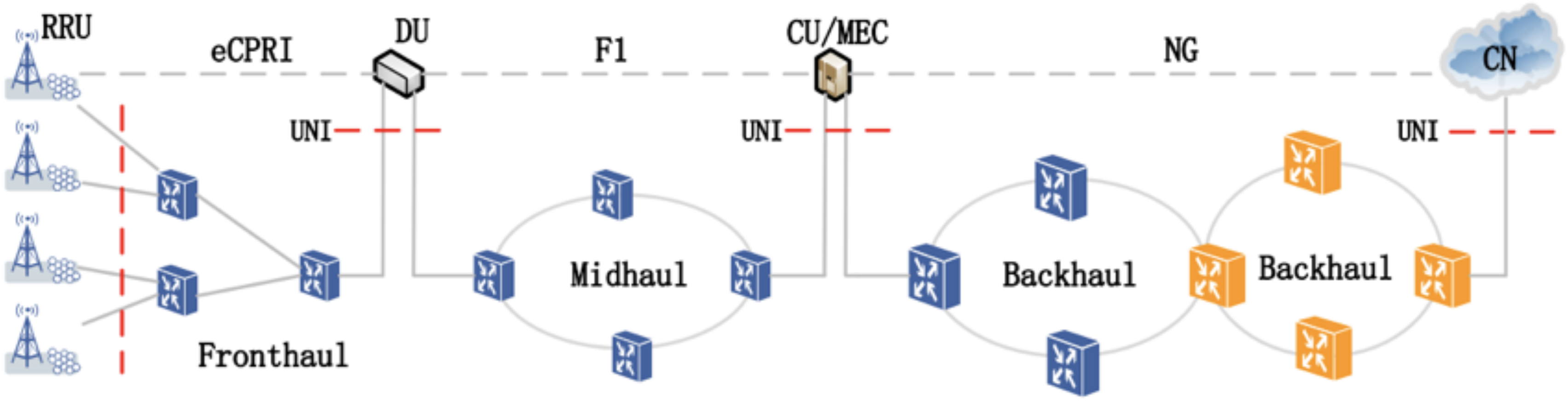


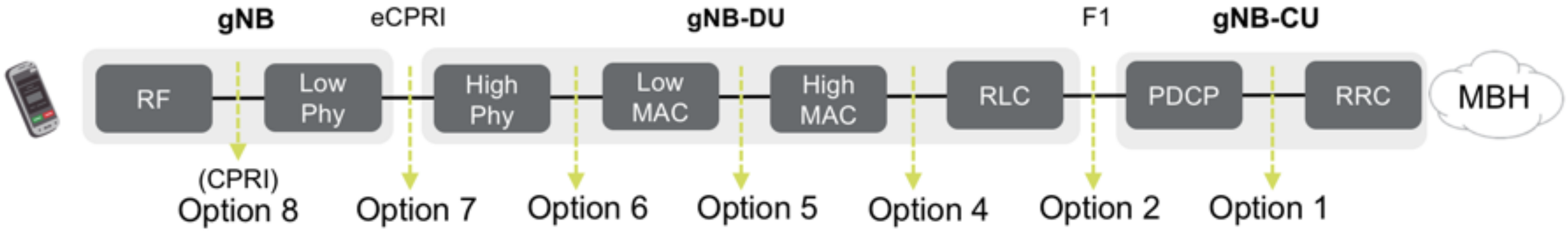

**Table 7-3 Network reach requirements**

| | |
|---|---|
| Fronthaul | 1~20km |
| Midhaul | 20~40km |
| Backhaul | 1~10km<br>Aggregation: 5-80km<br>Core: 20~300km |

L2 fronthaul evolution with eCPRI

- Maximum 100 us (microsecond) latency and 65 ns delay variation
- Ethernet Switch with RoE and TSN: typically 6 x 10/25GE + 2 x 100GE

# 5G RAN Functional Split (1/2)




**Current CPRI based approach cannot meet 5G bandwidth demands.**

- Split Option 8 (CPRI link per Antenna) will require 10x of capacity in FH for 5G Radio (100MHz, 8x8, 256QAM)
- Evolution to 64 x 64 Massive MIMO will be nearly impossible based on CPRI (Split 8).

**5G recommends Functional split architecture in RAN:**

- Achieve bandwidth optimization with introducing Ethernet/IP and hierarchical design in RAN.
- Ability to introduce virtualization (for increased scale and flexibility) and node slicing (for end-to-end service models) in RAN.

# 5G RAN Functional Split (2/2)

**5G RAN considers different architectures with split options 1 through 7:**

- Split at higher the layer requires less bandwidth, but with high latency.
  - Sufficient for services like Fixed Wireless Access to provide High Speed Internet.
- Split at lower the layer requires higher bandwidth, but provides low latency for
  - better RF gain for supporting technologies such as CoMP and Carrier Aggregation.

**Split Options 2 and 7 are most often considered model for meeting bandwidth and latency design in 5G FH:**

- Option 7: To meet RF Gain (Ex: Carrier Aggregation, CoMP) and bandwidth reduction compared to CPRI.
- Option 2: To meet bandwidth reduction with PDCP aggregation and approach to vRAN.

# 5G RAN Functional Split (2/2)

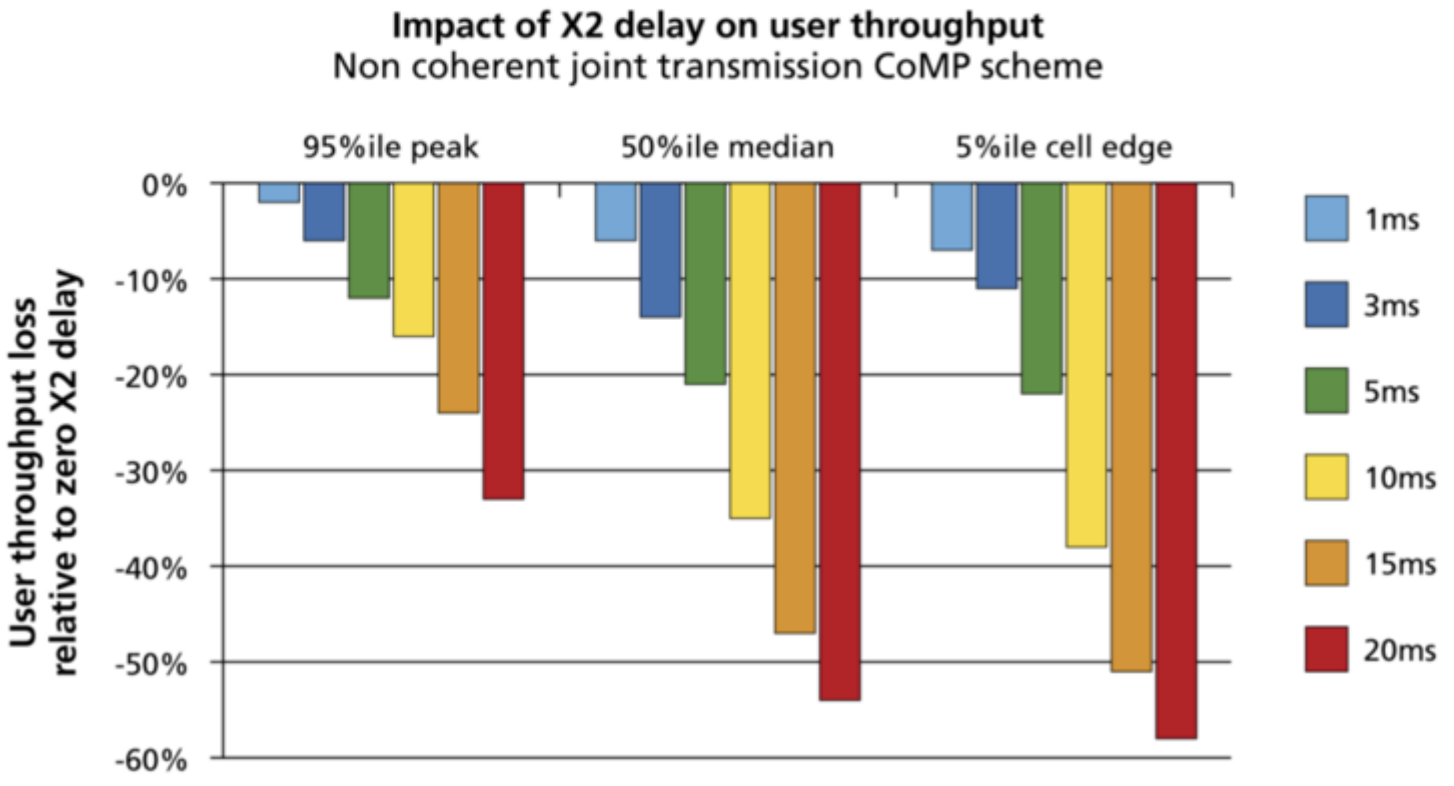
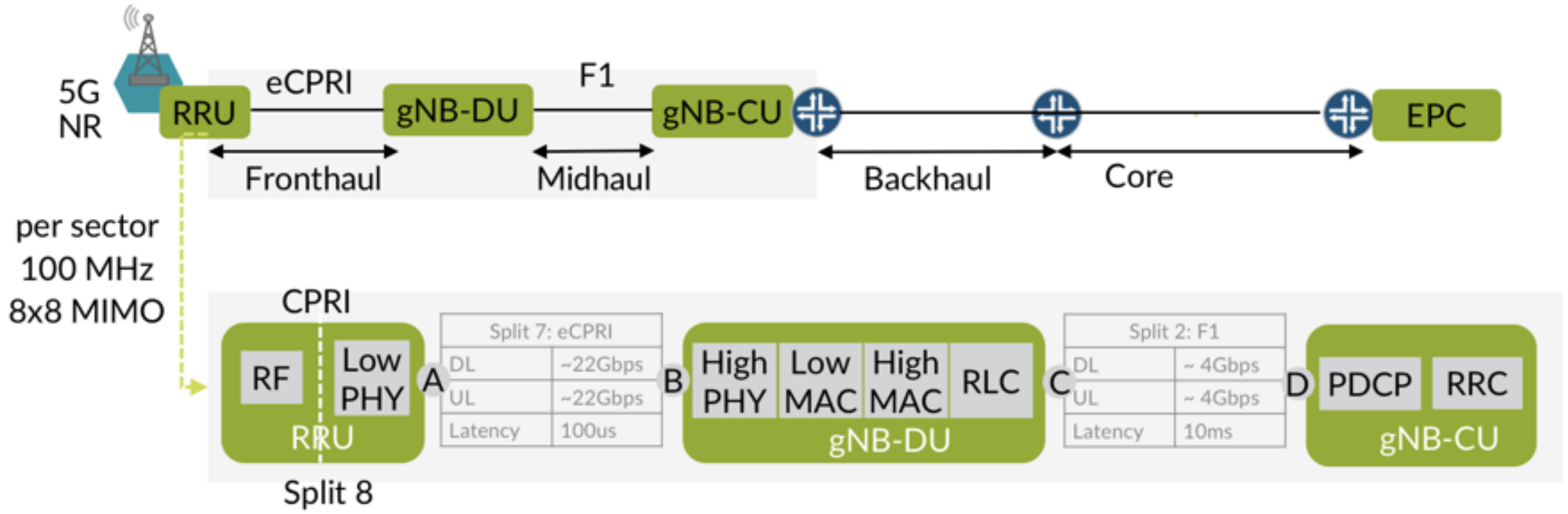



**Figure 4 Impact of X2 delay on user throughput with CoMP scheme. 3km/h users assumed. Source Qualcomm [11]**

# 5G FRONTHAUL & BACKHAUL




| Node Type | (A) FH Access | (B) FH Aggregation | (C) MH Access | (D) MH Aggregation |
|---|---|---|---|---|
| Total # of RRU | 3 x RRU* | 18 x RRU (6 x sites) | 18 x RRU | 144 x RRU (48 sites) |
| No. of Interface | 6 x 25GE + 2 x 100G | 12 x 100GE | 4 x 100GE | 16 x 100GE |

* 3 x RRU per site

# ACX PORTFOLIO OVERVIEW

| ACX500 | ACX1K/4K | ACX5008 | ACX5424 | MX204<br>ACX5448 | MX10K3<br>ACX5800 |
|---|---|---|---|---|---|
| Small Cell NID | 2G/3G/LTE CSR | LTE-A CSR | 5G CSR, E-RAN, Pre-Aggregation | Aggregation | Aggregation |
| 2*10GE + 4*GE/2.5GE | 2*10GE + 4*GE RJ45 + 4*GE / 2.5GE | 8*10GE + 8*GE + 4*GE RJ45 | 24*10GE + 4*100GE / 8*25GE | 48*10GE + 4*100GE<br>44*10GE + 6*100GE w/macsec<br>36*10GE + 2*100GE + 2*200G DCO | Up to 12*100GE + 144*10GE |
| Wall/Pole mount | 1RU, ½ 19 Inch Fanless | 1RU, 19 Inch, 250mm | 1 RU, 19 Inch, 320 mm | 1 RU, 19 Inch 600mm | 5RU, 19 Inch 455 mm |
| IP65 | -40C to 65C | -40C to 65C | -40C to 65C | 0 to 50C | 5°C to 55°C |

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# ACX PORTFOLIO EVOLUTION

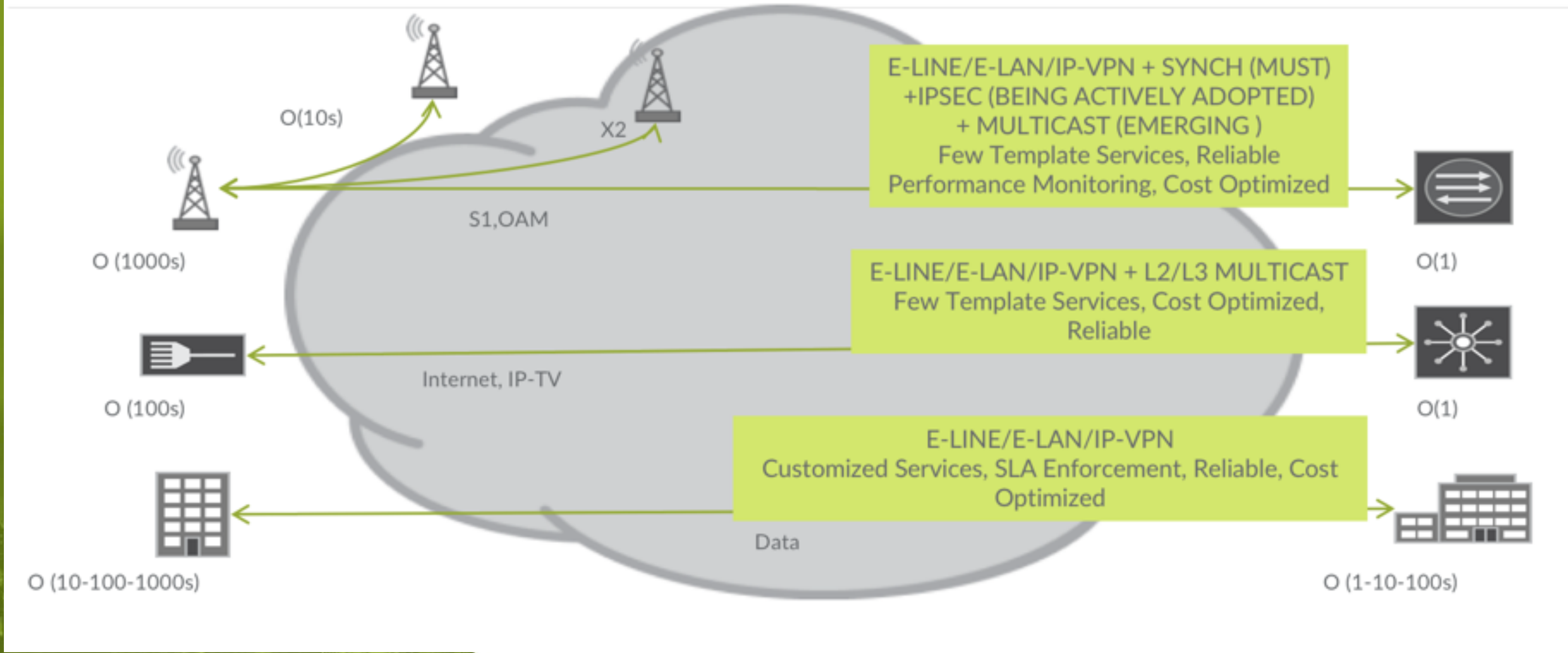




| TUMI 1 | TUMI 2 | Manhattan 1 | Manhattan 2 | R6273 |
|---|---|---|---|---|
| 5G FH, MH, Small Cell | 5G FH, MH | 5G Anyhaul & E-RAN Aggregation | 5G Aggregation | 5G Anyhaul & E-RAN Aggregation |
| 12*10/25GE + 2 *100GE | 12*10/25GE + 4 *100GE | 48*10/25GE + 12*100GE | 36*100GE | Up to 14*100GE and 56*10/25GE |
| Wall/Pole mount | 1 RU, 19 Inch, < 300mm | 2RU, ½ 19 Inch | 1RU | 3 RU, 19 Inch, 250 mm |
| IP65 | -40C to 65C | 0C to 50C | 0C to 50C | -40C to 65C |

# Metro Ethernet

## An universal Access Network Infrastructure



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# IP-OPTICAL CONVERGENCE

## In the Metro-Access

# JUNIPER'S PACKET-OPTICAL STRATEGY

Towards truly integrated end-to-end architectures

**Convergence between transport and IP network layers is finally happening:**

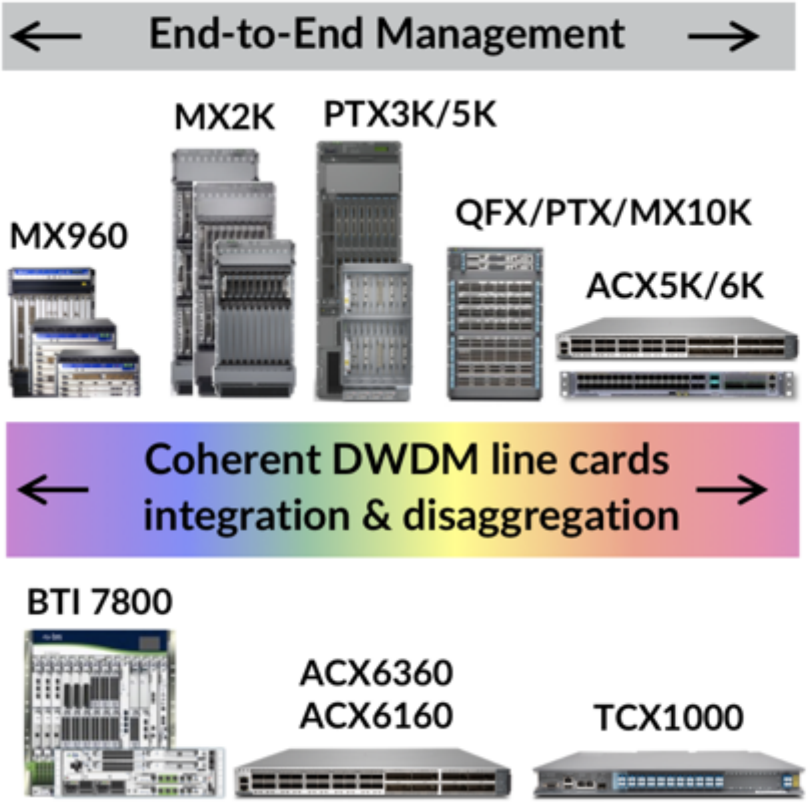
- Focus on Metro/DCI optical transport.

**Industry moving towards open optical ecosystem:**

- Driven by focus on network disaggregation and interoperable solutions.
- Transceivers are de-coupled from line system.

**Juniper's differentiators:**

- Junos RPD routing stack: integration from L0 to L3 (not only L0 to L2).
- Multi-layer management & control.



# Coherent DWDM pluggables

## The next frontier

**100G/200G DWDM deployment in metro (<600 km) is now widespread:**

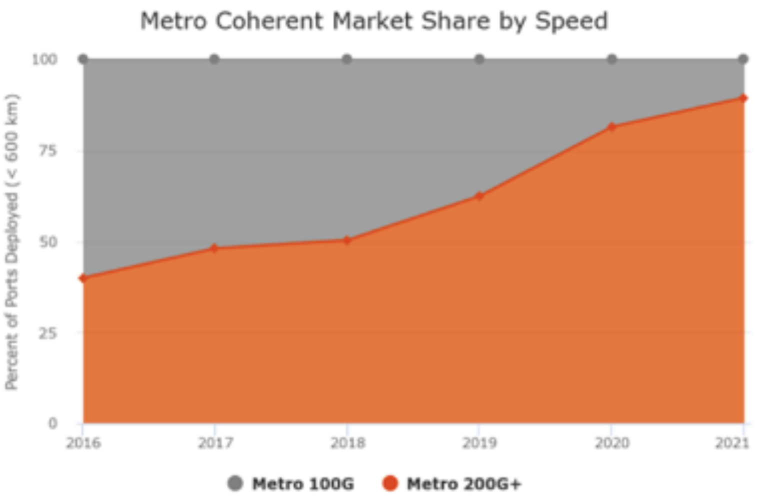
- 100GE services, but often 200G wavelengths to reduce cost per bit.
- 200G wavelengths have approx. half the cost per bit compared to 100G – but at strongly reduced maximum reach.
- 400G wavelengths will start to become relevant in 2019, but generally still using 100GE QSFP28 clients.

**100G+ for metro-access (< 80 km) is now starting to become relevant:**

- This drives the need for very cost effective, short reach DWDM solutions → DWDM pluggables.
- Market will develop over the next 2 -3 years.

100G

200G




Cignal AI, 2H16 Optical Application Report, May 2017

# 100G DWDM pluggables today

## 100G/200G CFP2-DCO

**100G QSPF28 clients support only up to 40 km:**

- 100G ER4-Lite allows for 18 dB loss budget with FEC.
- 80 km reach requires at least 23 dB loss budget, which is not feasible with 25G NRZ signaling and direct-detection.
- Coherent DWDM transceivers can easily meet this, but are still too high power consumption to fit into QSFP28 form factor.

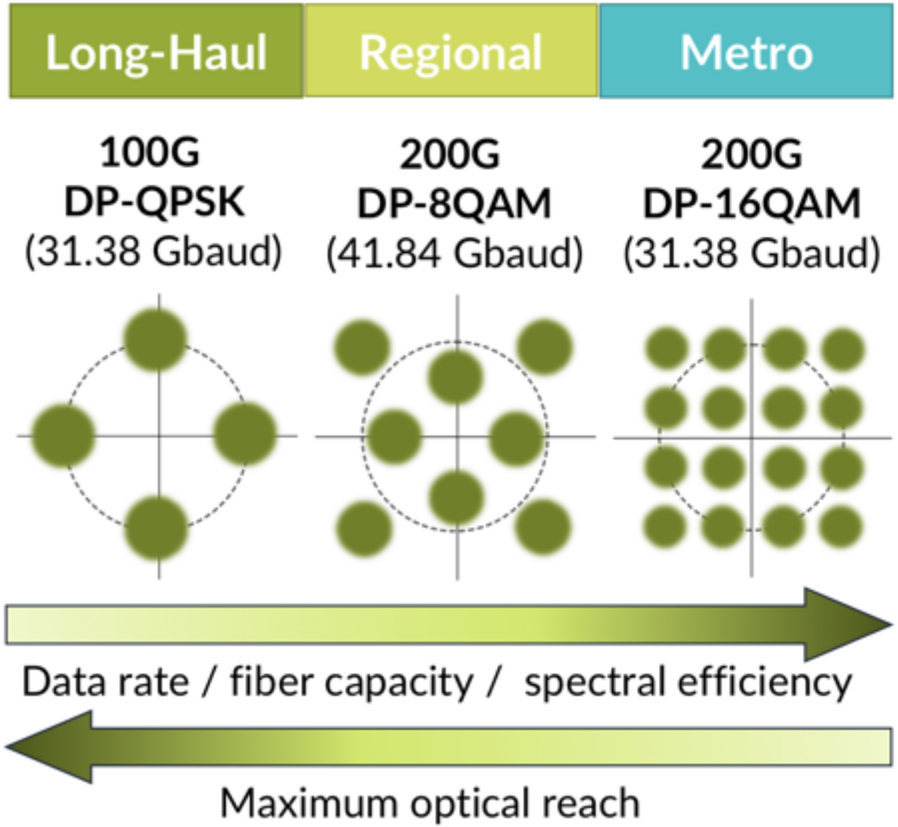
**CFP2 allows for full coherent detection and digital signal processing in a pluggable form factor:**

- Power consumption <19W feasible in CFP2 form factor.
- Fully tunable across the C-band with up to 96 x 100G/200G per fiber (and even 128 x 100G/200G with 37.5 GHz flex-grid).
- Unamplified dark fiber links up to 140 km (33 dB loss budget).
- Amplified DWDM transport links up to 2500 km.

https://acacia-inc.com/product/cfp2-dco/

# 100G DWDM pluggables today

## 100G/200G CFP2-DCO




| | |
|---|---|
| Maximum reach | Up to 1000 km (@200G) |
| Modulation | 1 λ x 100G/200G |
| Wavelength grid | 37.5/50/100 GHz |
| Power consumption | < 19 W |
| Tx power / lane | -10 to +1 dBm (tunable) |
| Rx power / lane | -26 to +3 dBm (@200G) |
| OSNR requirement | 19.5 dB (@200G) |
| CD tolerance | +/- 26,000 ps/nm |

# OPTICAL INTERFACED BEYOND 40 KM TODAY

100G/200G pluggable DWDM interfaces for ZR and short-reach DCI

100G/200G CFP2-DCO

MPC5/6 for MX and FPC2/3 for PTX

ACX6360 with 20 x QSF28 and 8 x CFP2-DCO slots

## 100G / 200G coherent DWDM CFP2-DCO

- Pluggable coherent DWDM interfaces, used for both ZR and DWDM applications
- Fully tunable across the C-band (up to 96 x 100G)
- Up to 2500 km transmission over DWDM line systems
- Up to 140 km transmission over dark fiber

# ACX6360

Platform

**1RU compact packet-optical transport platform:**

- 3.6 Tbps non-blocking PFE with 2.0B packet/s and 100 us buffer for micro bursts
- Pluggable client interfaces: 20 x 100G QSFP28
- Pluggable line interfaces: 8 x 100G/200G CFP2-DCO (DP-QPSK/DP-8QAM/DP-16QAM)
- MACsec with AES256 encryption supported on client and line-side for secure transport
- 685 mm deep, < 756.5 W power consumption

QSFP28 client-side ports　　CFP2-DCO line-side ports

# ACX6360

## Software features & scaling

| Features | |
|---|---|
| **Features @ FRS** | **Features Post-FRS (t.b.c.)** |
| Protocols<br>BGP, ISIS, MPLS, RSVP, LDP | L2 COS |
| ZTP | LLDP |
| Port Mirroring | MC-LAG |
| 256AES MACsec | Multicast – PIM-SM/SSM |
| JTI Optical/OTN sensors | IGMP, MSDP, PIM |
| LDP Synchronization | sFlow |
| BGP-LS | FBF |
| LAG / LACP | GRE |
| FRR (link and node) | 6PE |
| Virtual router (VRF-lite) | P2MP |
| Filters – Port ACLs (ingress), Routed ACLs (ingress/egress) | Filters – Port ACLs (egress), VLAN ACLs (ingress/egress) |
| L3 QOS – classification (DSCP only), rewrite, queuing | |

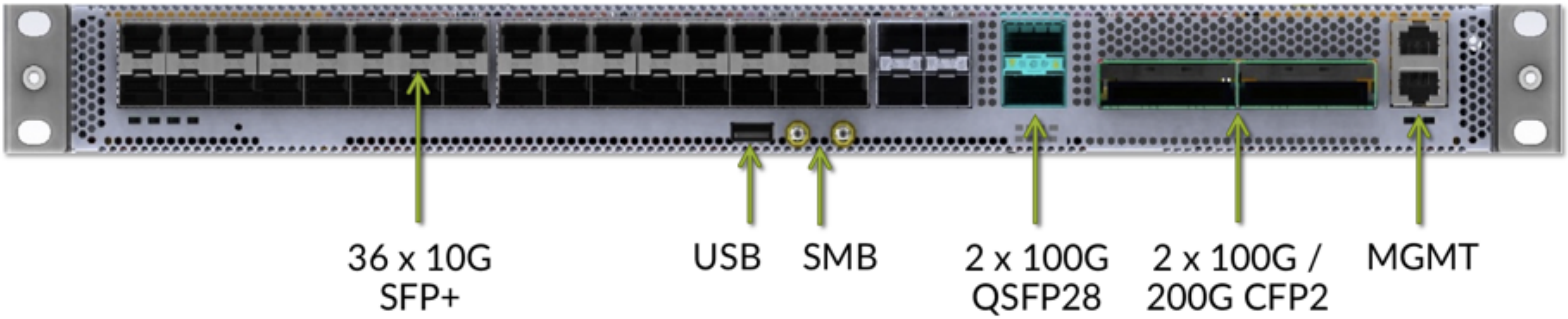
| Scale | |
|---|---|
| | **Scale @ FRS** |
| Ports per AE | 64 |
| AE interfaces per system | 128 |
| ECMP paths per system | 32 |
| IFLs per PFE/system | 60K |
| VoQs | 384K |
| IPv4 / IPv6 FIB capacity | 480K |
| RIB capacity | 5M |
| Filters MPLS label stack | No Limit |
| Max imposed / pop / swap labels | 8 |
| Max ingress / transit / egress LSPs | 48K/128K/48K |

# ACX5448-D

100G/200G DWDM uplinks

## IP-optical integration in the metro-access:

- Same hardware platform (PFE, RE, etc...) as ACX5448.
- 36 x 1GE/10GE, 2 x 100G QSFP28 and 2 x 100G/200G CFP2-DCO
- Software switchable between QSFP28, CFP2 ports & TCAM (for high/medium FIB scale)




**Integrated 100G/200G coherent DWDM CFP2-DCO interfaces enable IP-Optical integration in the metro-access domain**

# COHERENT DWDM PLUGGABLES TOMORROW

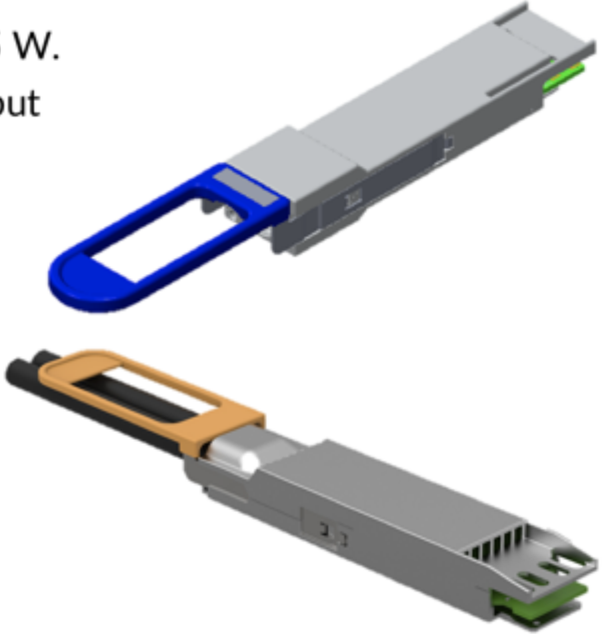
for the QSFP ecosystem

## QSFP28 is today the universal form factor of choice :

- QSFP28 ports are generally designed for a power consumption < 4~5 W.
- Coherent technology scales down in footprint and power over time, but it will still take many years to meet this target.

## QSFP-DD is the next-generation universal form factor:

- Designed to support 200G / 400G pluggable optics, which have much higher power consumption (< 12~14W).
- Innovation in coherent DWDM technology is now focused on 400G DWDM small form factor pluggables → 400G DCI market.
- The same pluggables will also support 300G / 200G / 100G modes to address access, metro and regional markets.



**Differentiation between client and line interfaces will largely disappear once the form factors become identical and you can mix-and-match on the same line card**

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# METRO OPTIMIZATION

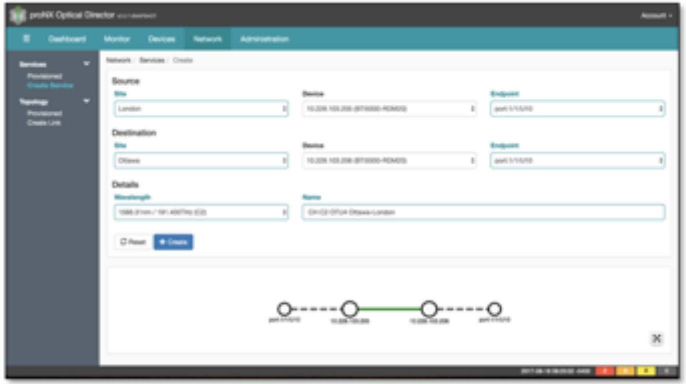
## and automation with NorthStar

# Multilayer optimization

## ProNX Optical Director & NorthStar

### NorthStar Controller

### proNX Optical Director



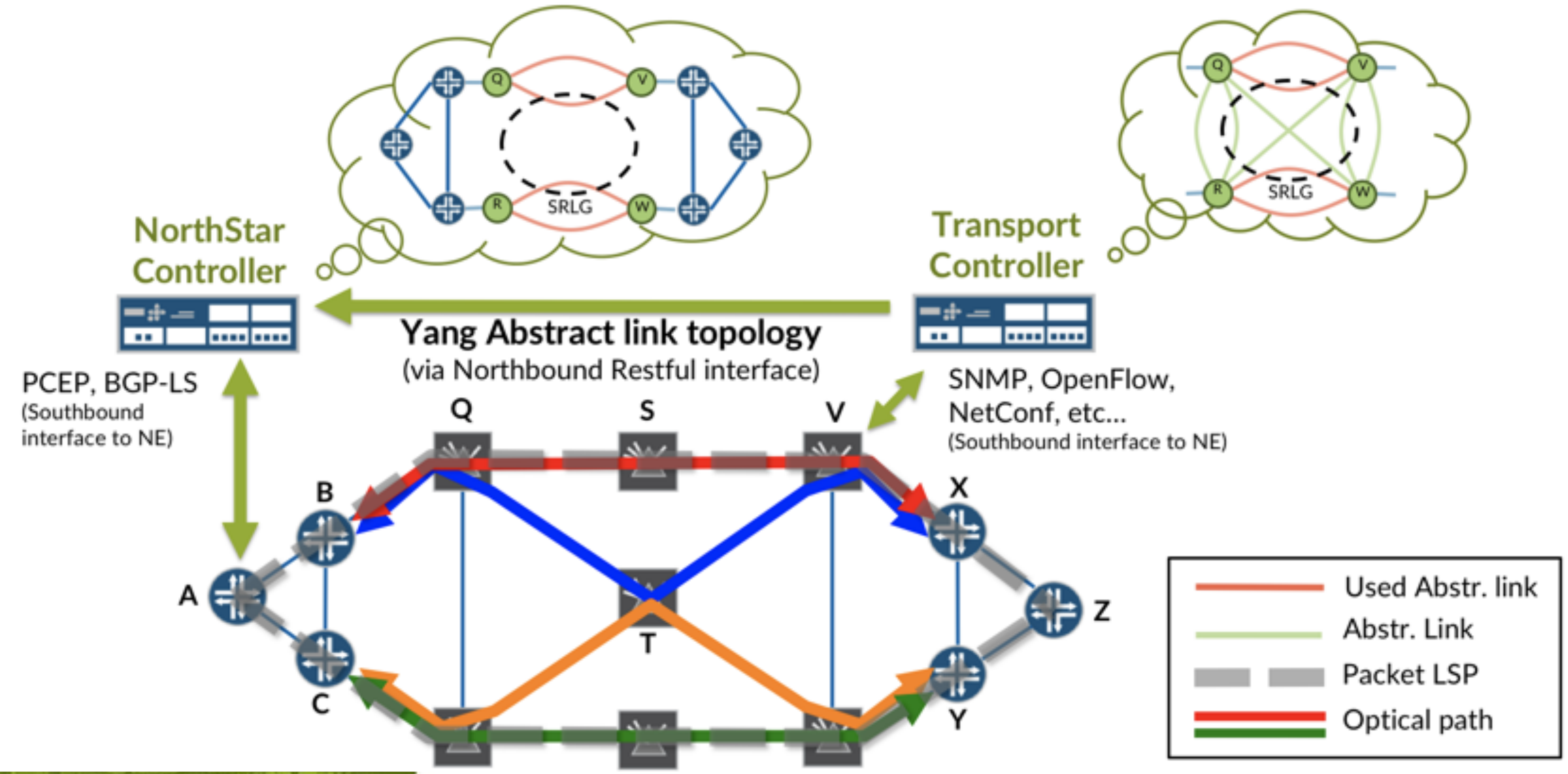
REST/
RESTCONF

Topology
Exchange

- Technology-agnostic YANG data model based on draft-ietf-teas-yang-te-topo-05.
- Dynamic learning of abstracted node & link topology through REST/RESTCONF interface
- TE metric, SRLG, protection, and delay attribute exchange with dynamic LSP re-optimization to ensure LSP constraints are met.
- Proven end-to-end Juniper solution, as well as with 3rd party transport controllers.

# NORTHSTAR MULTI-LAYER OPTIMIZATION

Controller-to-controller coordination between transport and IP/MPLS layers



# Q&A session

# THANK YOU FOR YOUR TIME

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