400G TRANSPORT EXTENSION INTO MIDDLE-MILE NETWORKS

Why 400G?

Design Considerations

ACG RESEARCH

Experienced, in-depth research on ICT innovations and the transformations they create

Agenda

RICK TALBOT
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Introduction

EARL KENNEDY
Nokia: Business Development and Consulting Engineering Manager

Why 400G in the middle mile?

VINI SANTOS
Ciena: Routing and Switch Portfolio and Solutions Marketing

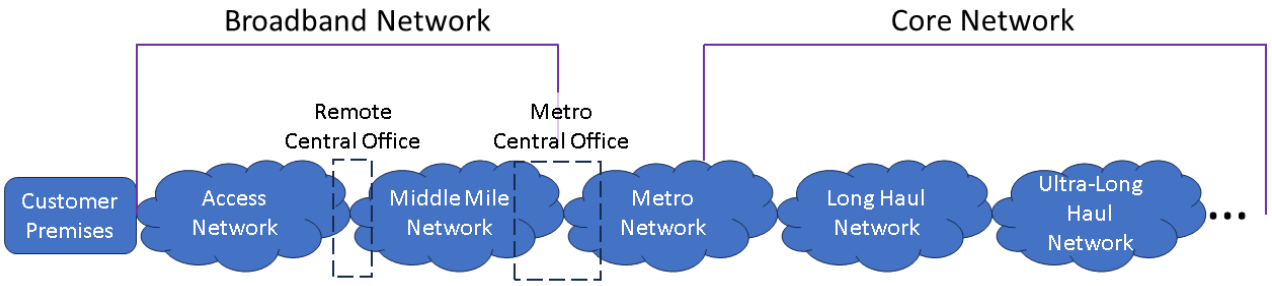
Evolution of the Middle Mile

TIM DOIRON
Infinera: Vice President, Solution Marketing

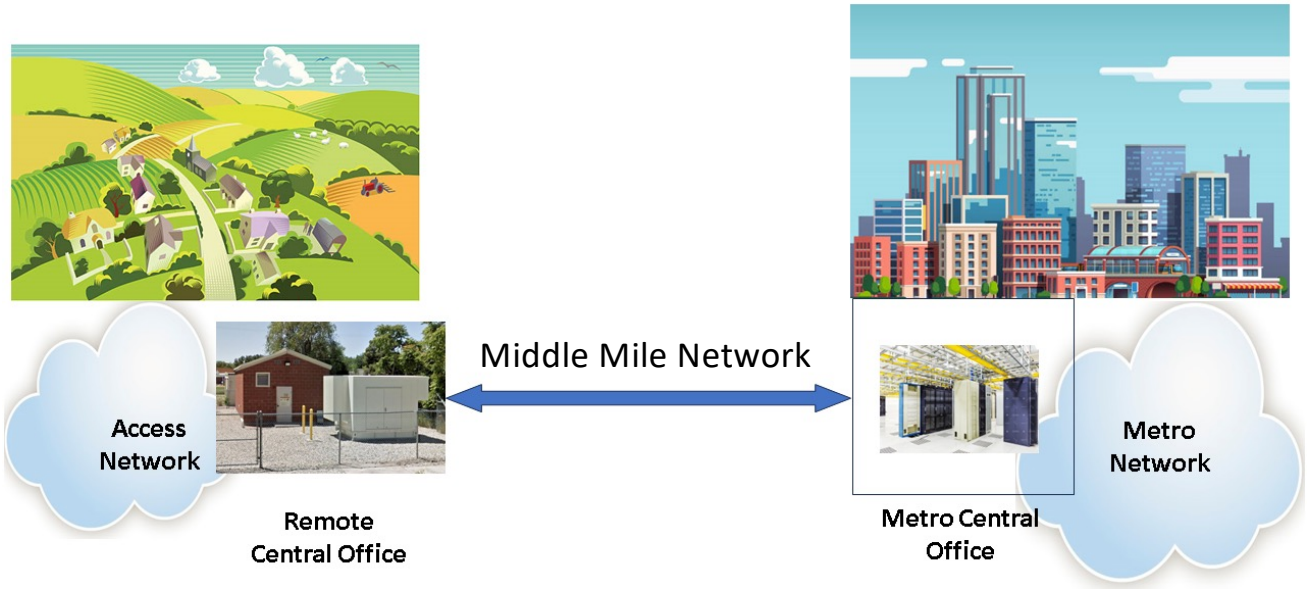
400G Coherent Optics and the Middle Mile

What is the Middle Mile Network?

In the context of the end-to-end network

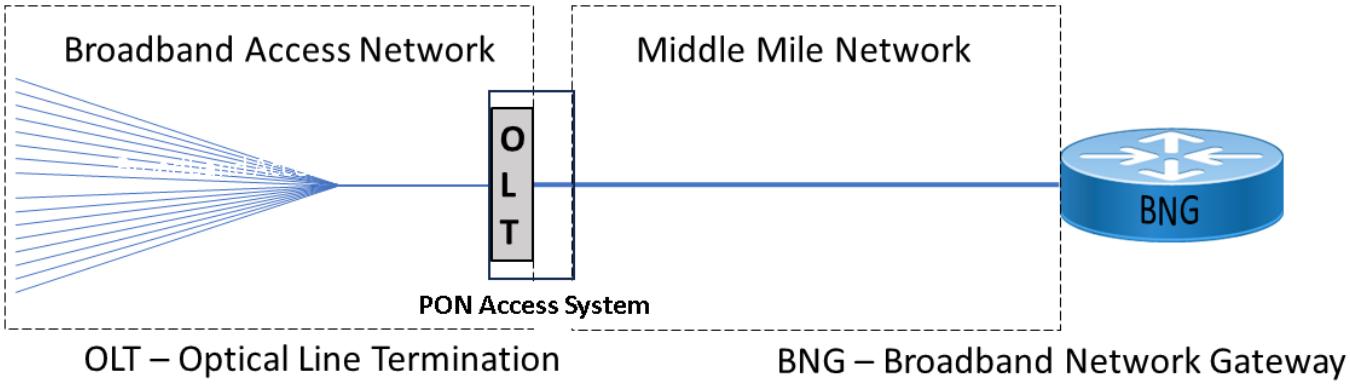


Middle Mile Network as Physical Backhaul

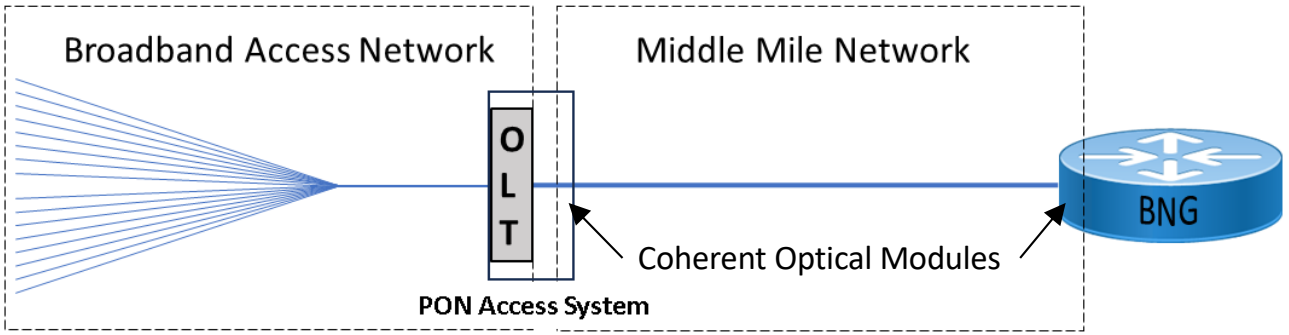


Middle Mile Network from a New Perspective

Current Segmentation



Segmentation from an IP Perspective



Why 400G in the middle mile?

Factors that influence middle mile network

1. The applications that drive bandwidth demand
2. Number of households in the service area
3. Business/enterprise service opportunities
4. Average usage rates (Off Peak and Peak)
5. Yearly growth rate
6. Broadband service penetration rate

The shift to new generation broadband

Aligned with WORLD BROADBAND ASSOCIATION

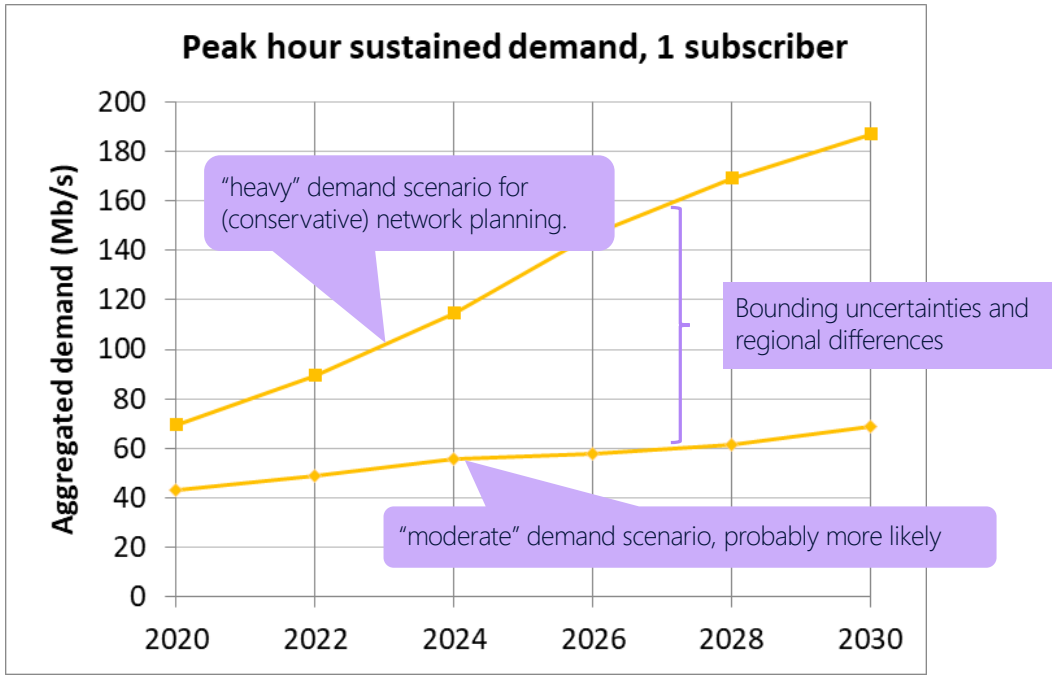
Voice	Internet	3play	4K, gaming	VR cloud, SME	Fiber for everything
Gen1	Gen2	Gen3	Gen4	Gen5	Gen6
• POTS, • NBB	• DSL	• VDSL	• GPON • Wi-Fi	• XGS-PON • Wi-Fi 6 • Automation	• 25G, 50G, 100G PON • Wi-Fi 7 • Autonomous • Network slicing • Sub ms latency

Broadband subscriber demand

Estimates for off peak and peak demand

Rural broadband networks need to support increasing traffic and bandwidth:

- Average household bandwidth of 13 Mbps in 2021
- Average household bandwidth of 20.1 Mbps in 2025
- Rural area served with an average of 20,000 households
- Service providers' penetration rate growing from 25% to 60%
- This drives the requirement for a 200 Gbps by 2022 and 400 Gbps middle-mile ring by 2025



Middle-Mile Networks Capacity Requirements for Fixed Broadband
Peter Fetterolf, Ph.D for ACG Research

A view into bandwidth demand, market penetration and growth

BroadbandUSA Community Report

Colorado (FIPS 08)

FCC Form 477 Terrestrial Speeds

Jan - Jun 2021

10,000 Max Advertised Download (Mbps)	**10,000** Max Advertised Upload (Mbps)
50 Median Advertised Download (Mbps)	**15** Median Advertised Upload (Mbps)
1% Pop. % below 25/3	**9%** Pop. % Below 100/20
116 Broadband Providers	**11** Transmission Technologies

Speed Test Results

Jan - Jun 2021

89 Ookla Median Download (Mbps)	**12** Ookla Median Upload (Mbps)
206,275 Number of Ookla Devices	
44 M-Lab Median Download (Mbps)	**10** M-Lab Median Upload (Mbps)

American Community Survey Key Facts

2015-2019

5,610,349 Total Population

$72,331 Median Household Income

37 Median Age

HOUSEHOLD INTERNET CONNECTION

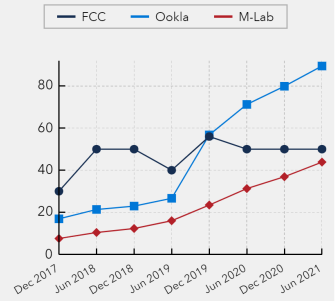
2,148,994 Total Households	**88%** With Broadband of Any Type	**9%** No Internet Access	**6%** Households that Have No Computer, Smartphone, or Tablet

Internet Cost

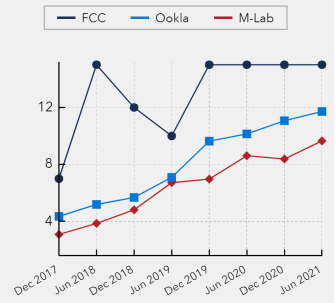
Jan - Jun 2021

$39.78 Average Minimum Monthly

Median Download Speed (Mbps)



Median Upload Speed (Mbps)



Speed data from FCC Form 477, Ookla, and M-Lab speed tests compare fixed broadband speeds only.

Source: 2015-2019 American Community Survey 5-year (ACS), 2017-2021 FCC Form 477, 2017-2021 Ookla, 2017-2018 Bureau of Labor Statistics Consumer Expenditure Surveys, BroadbandNow, M-Lab

Middle-Mile
Bandwidth Traffic Analyzer

Middle Mile BW Requriements

125 Gb/s

Year 1

Middle Mile BW Requriements

366 Gb/s

Year 5

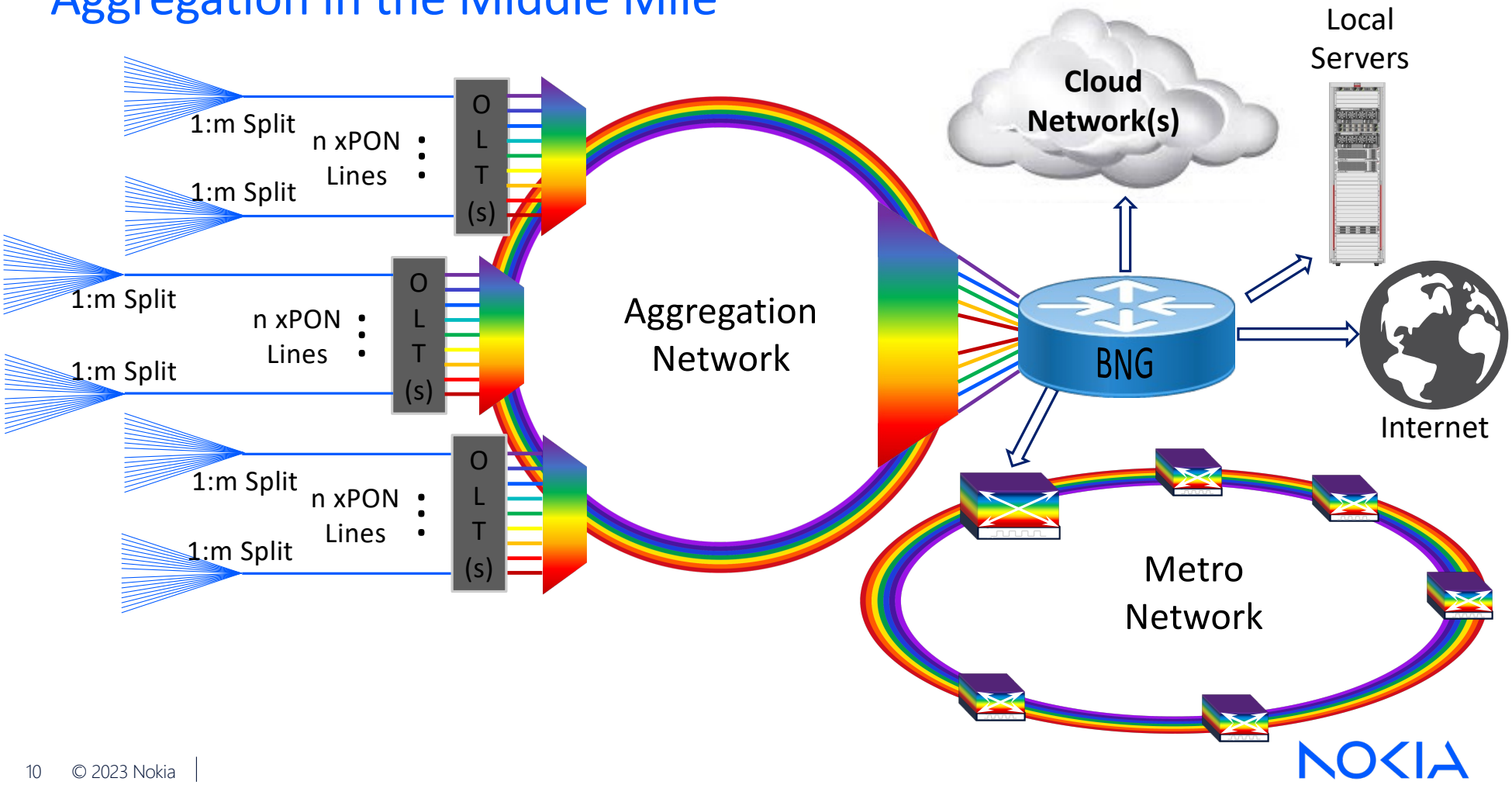
Service Area	
Households	20,000
Businesses	200

Broadband Service Penetration Rate	
Households	
Yr 1	25%
Yr 2	35%
Yr 3	45%
Yr 4	55%
Yr 5	60%
Businesses	
Yr 1	5%
Yr 2	15%
Yr 3	20%
Yr 4	25%
Yr 5	30%

Average Usage Rates (Mb/s)	
Households	
Peak Times (4 - 9 PM)	25
Off Peak	16
Yearly Usage Growth Rate	5%
Businesses	20

Service Subscription Levels	
Households	
50 Mb/s Tier	65%
100 Mb/s Tier	30%
500 Mb/s Tier	5%
Businesses	
100 Mb/s Tier	100%

Aggregation in the Middle Mile

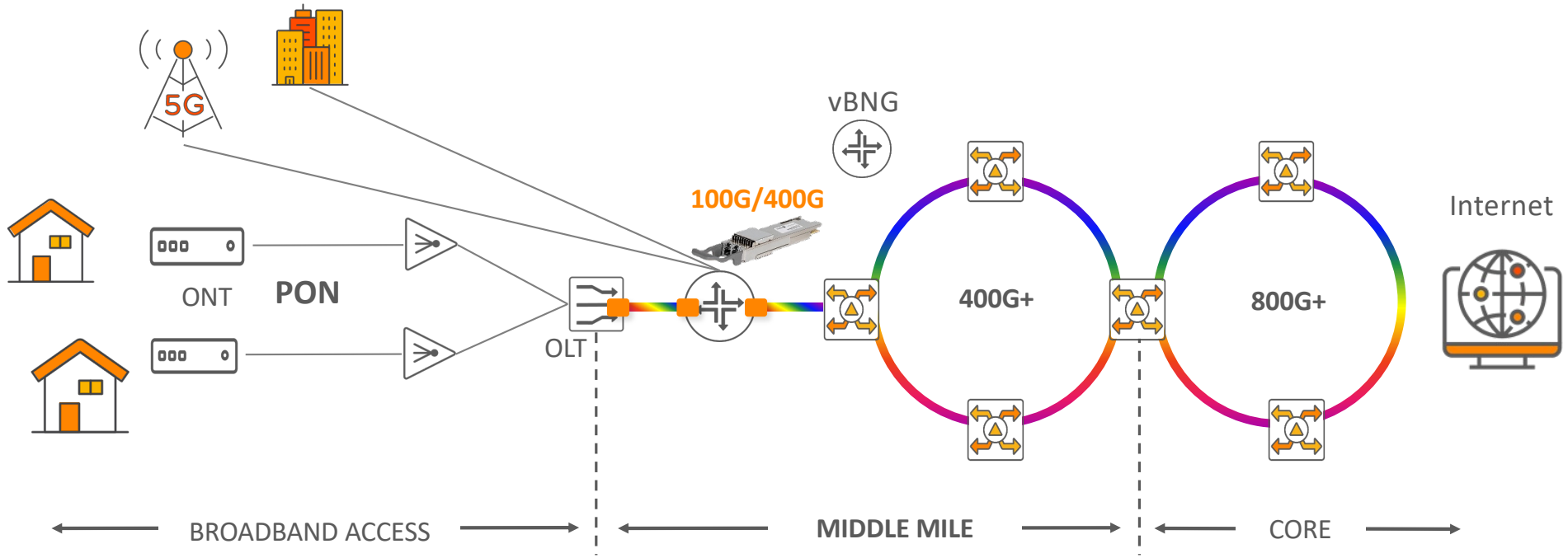


400G Coherent Optics and the Middle Mile

Tim Doiron, VP Solution Marketing

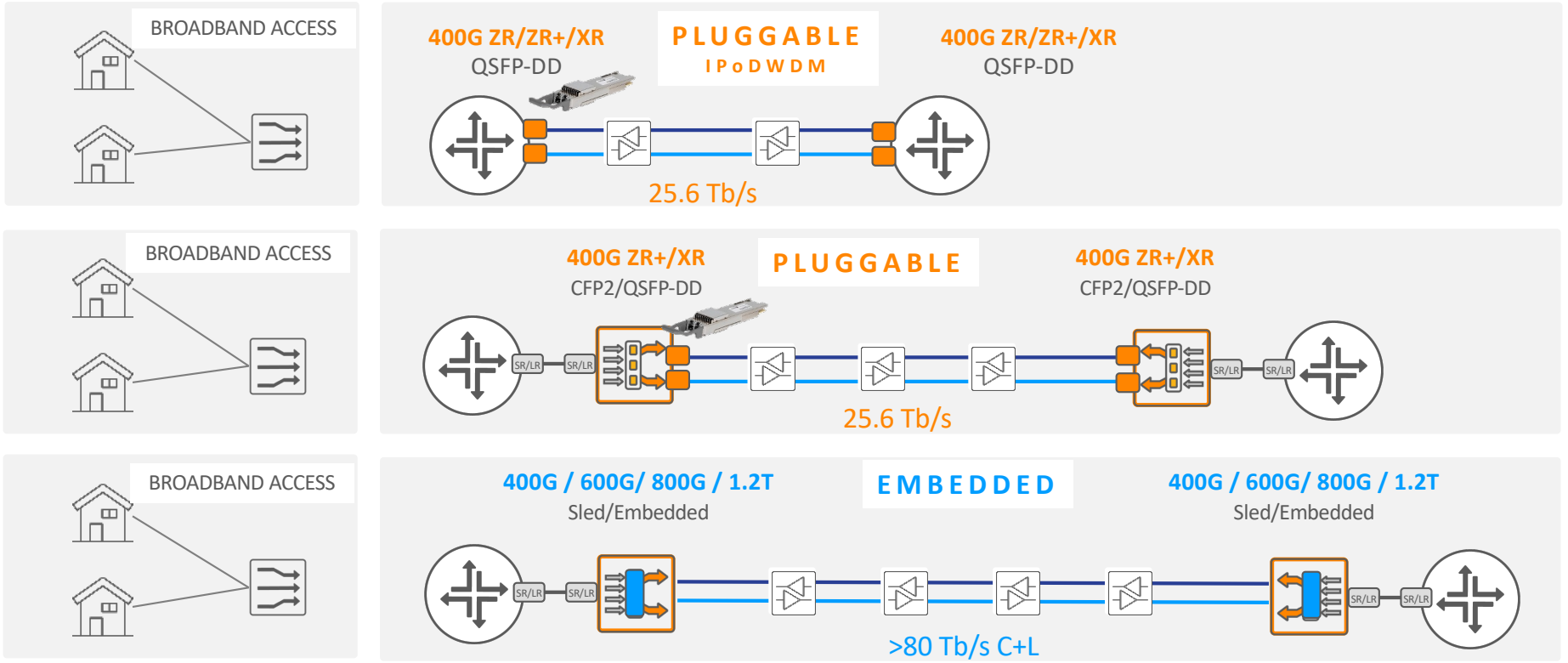
August 7, 2023

The Broadband Network and the Middle Mile



Optical transport connects broadband access to the Core/Internet via the Middle Mile

Embedded or Pluggables? In Optical Gear or Routers? Yes!



Reduce Power, Space with Pluggables, Reduce Cost/Bit/Km with Embedded

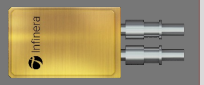
Modular, Building Block Design Strategy

ANALOG OPTICS

MADE IN THE USA — OPTICAL SEMICONDUCTORS

- MODULATOR
- TIAs
- LASER
- DRIVERS
- PHOTO DETECTORS
- RX PASSIVE

TROSA



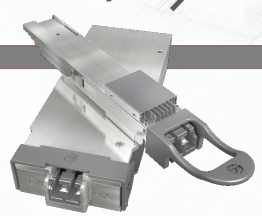
DIGITAL SIGNAL PROCESSING

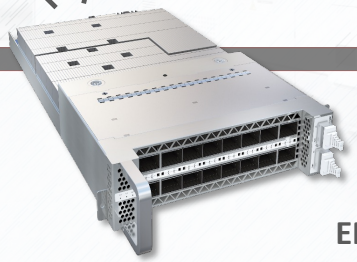
DSP

- ADVANCED ALGORITHMS
- DSP DESIGN CENTER

TROSA = Transmit Receive Optical Subassembly

ADVANCED PACKAGING





PLUGGABLES
CFP-2, QSFP-DD

EMBEDDED
(Sled Based)

COST EFFECTIVELY BUILD MORE COHERENT OPTICAL ENGINES FOR MORE APPLICATIONS

Building a Better Coherent DWDM Pluggable

PERFORMANCE

1

Maximize capacity-reach

PROGRAMMABILITY

2

Adapt to diverse environments like single-fiber working

MANAGEABILITY

3

Host-independent management, dual management

Categories

400ZR	400G ZR+	400G XR
OIF-Defined	OpenROADM, OpenZR+, More	Open XR Forum
Ethernet only	P2P	P2P, P2MP, SFW
400G only	100G-400G	25G-400G
40km – 120km	500km+	1,000 km+

P2P = Point-to-Point
P2MP = Point-to-Multipoint
SFW = Single-Fiber Working


Infinera
Thank You

Mountain Connect

400G TRANSPORT EXTENSION INTO MIDDLE-MILE NETWORKS

Vini Santos
Solution Marketing

August 2023

Evolving and New Residential Broadband Requirements

More bandwidth

Lower latency

Better Symmetry

High Availability

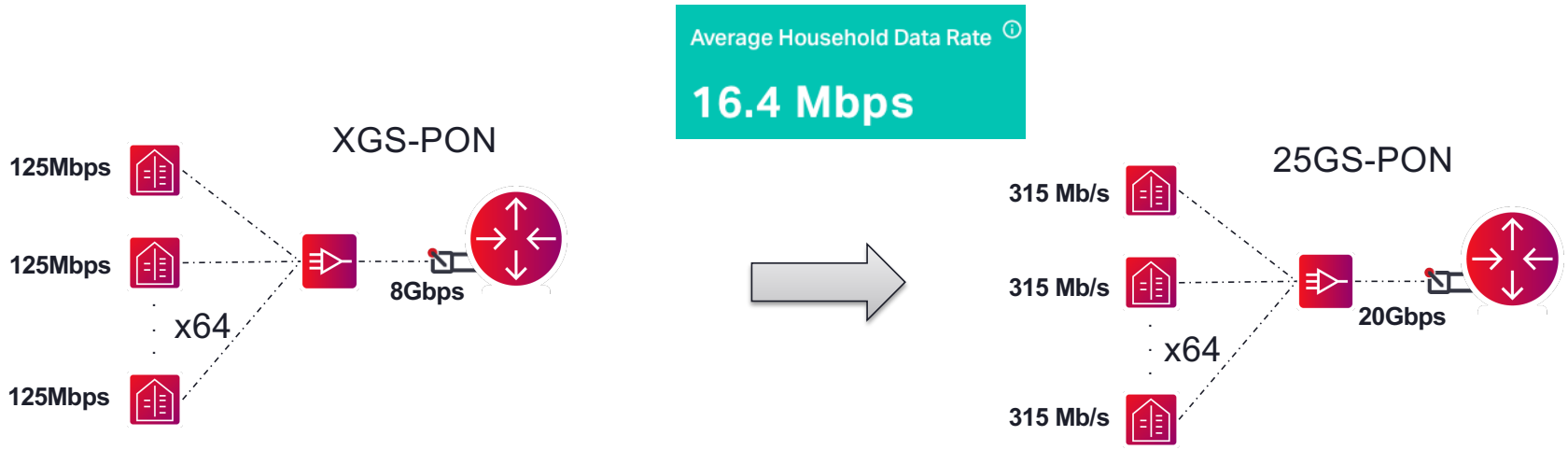
Great QoE

Sustainability

Ubiquity

Affordability

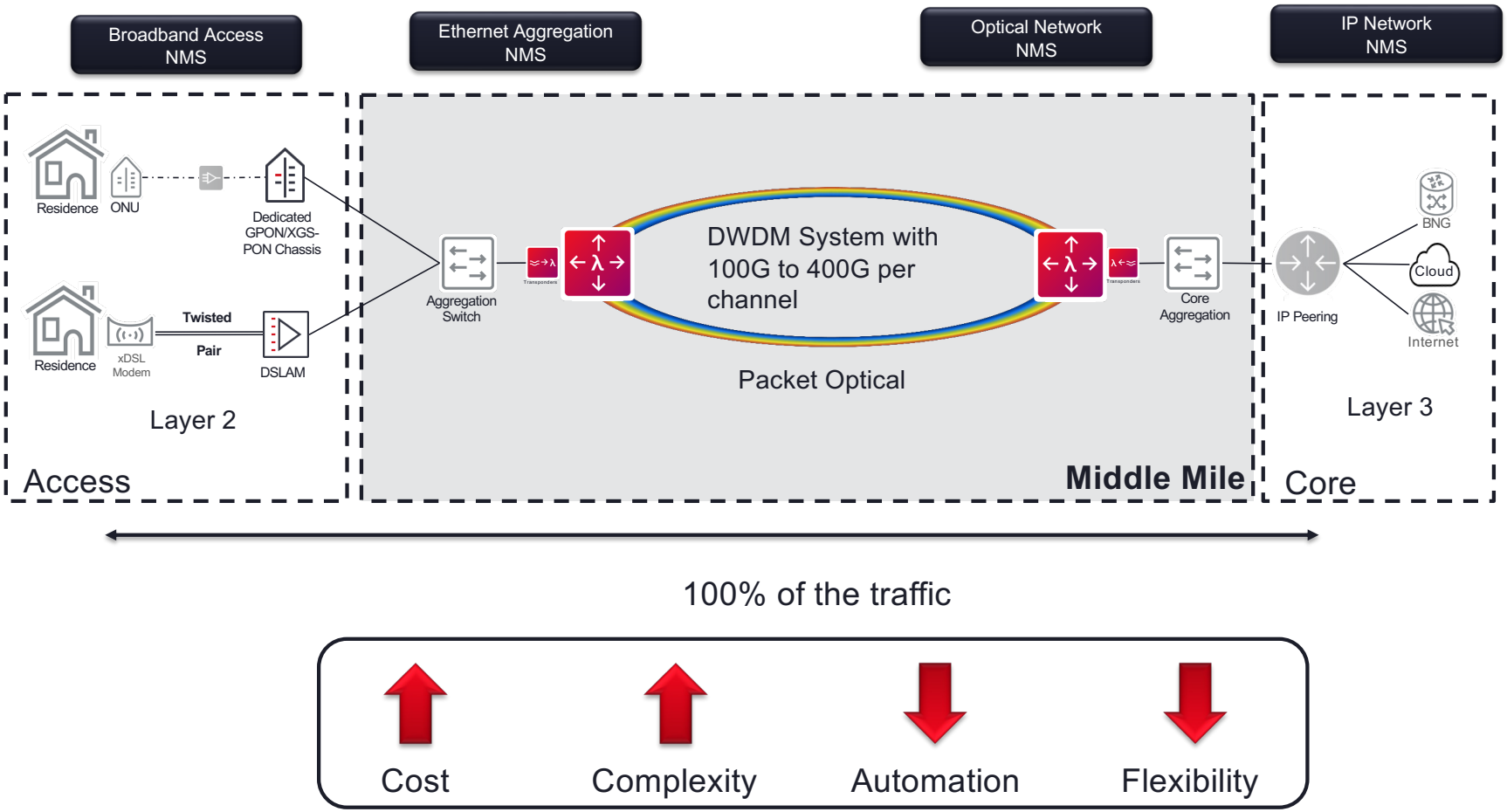
The challenges are moving from the access to the Middle-Mile



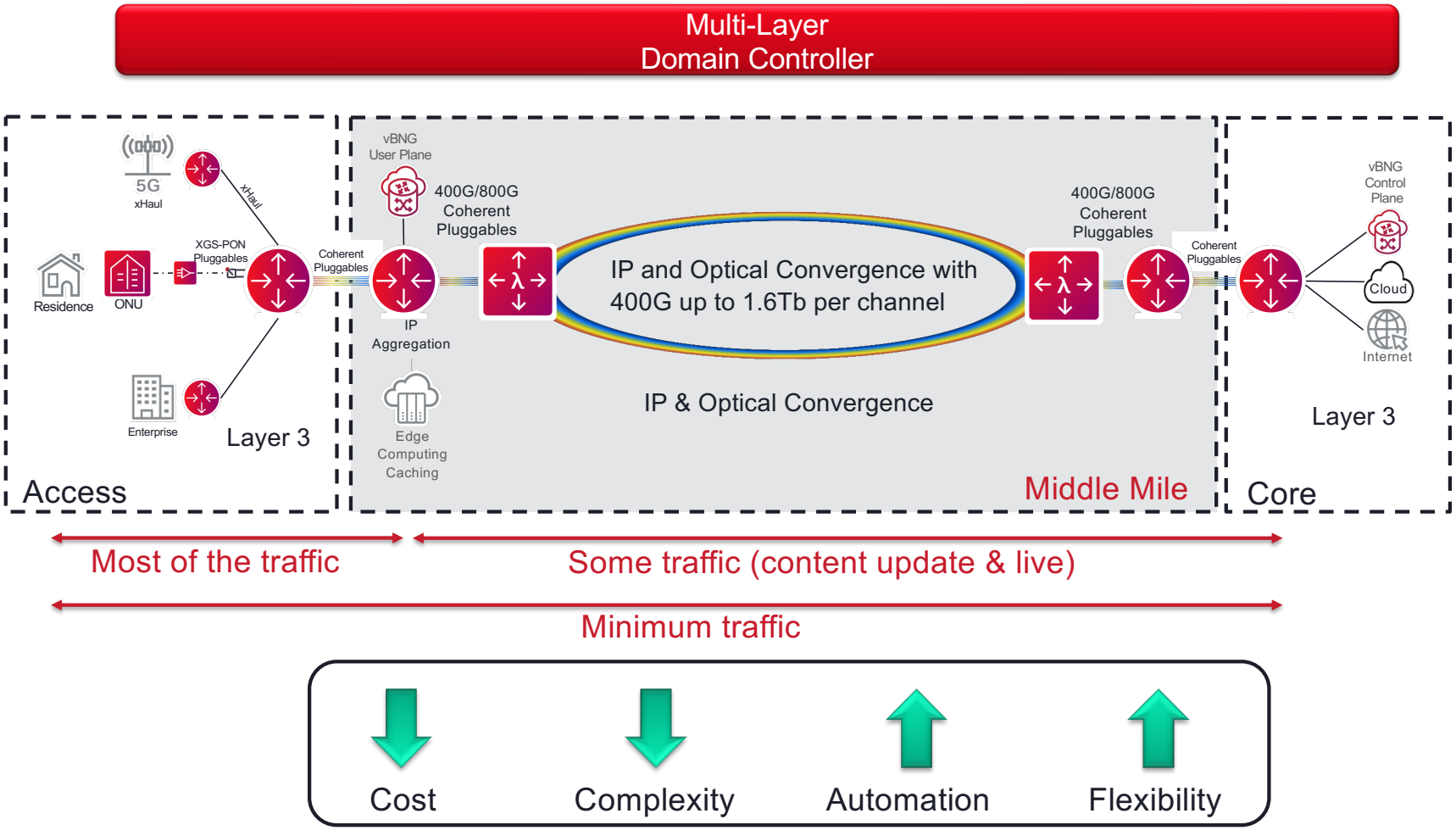
With service provider deploying XGS-PON with an easy evolution to 25GS-PON the access will be able to support the existing and future application for years

What about the Middle Mille?

Legacy Middle Mile



Evolution of the Middle Mille



Key Considerations for Middle Mile

- Adding IP intelligence to the access enabling local breakout
- Adopting the virtualization and disaggregation of the BNG with CUPS (Control and User Plane Separation) model, moving the user plane to the edge.
- Utilization of 400G Coherent Pluggable in routers for scalability, cost efficiency and flexibility. An open line system may be needed for amplification and fiber capacity expansion
- Adoption of a more modern and optimized IP stack (SR) to accommodate the need for more and smaller IP nodes without multiplying complexity
- Adoption of a single multi-layer domain controller from the access to the core to reduce the operational complexity and cost while optimizing the network resources and reliability