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TECH FORUM 23

Why you need a new middle mile

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Drivers for Broadband Network Transformation

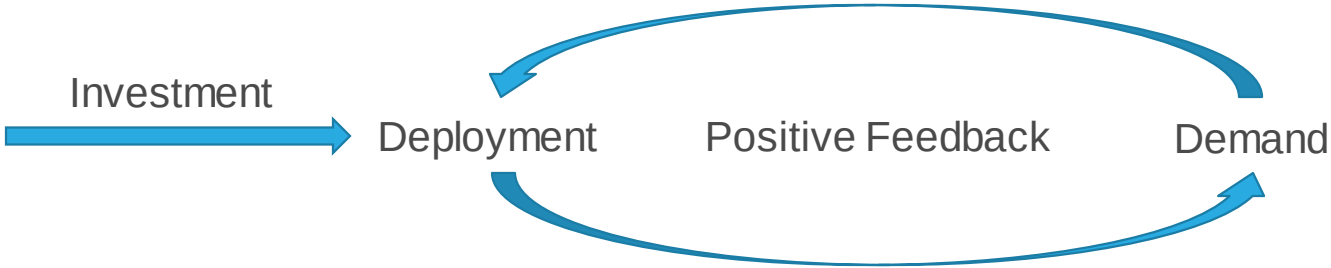
Massive Investment

- Federal Subsidies
  - Almost $100 Billion
  - Required Match 15% to 50%

- Private Investment
  - Billions of Dollars

Unprecedented Demand

- COVID opened consumers' eyes to online content & transactions.
- Demand formerly gated by available capacity
- Manifest Destiny



Requirements for Broadband Services

- To Qualify for Federal Subsidies:
  - **Capacity/(Scalability):** Reliable broadband service with speeds no less than 100/20 Mbps
  - **Latency:** 95% of latency measurements below 100 ms round trip time
  - **Reliability:** Outages not to exceed, on average, 48 hours over a 365-day period
  - **Affordability**:
    - Offer at least one low-cost broadband service option
    - Participate in the Affordable Connectivity Program (ACP)
    - No data usage caps for subscribers.
- Additional Commercial/Competitive Requirements:
  - **Symmetric Capability**: Currently available FTTH solutions easily provide symmetric 100 Gb/s service.
  - **100 Gb/s service**: The average FTTH subscribed speed exceeds 100 Mb/s.
  - **Gigabit Services**: Most FTTH service providers offer service speeds just short of 1 Gb/s (Based on GPON).
  - **Expanding Apps**


→ 25 Mb/s (Per Device)


→ 25 Mb/s


Depends


→ 225 Mb/s

The Middle Mile from a Federal Government Perspective

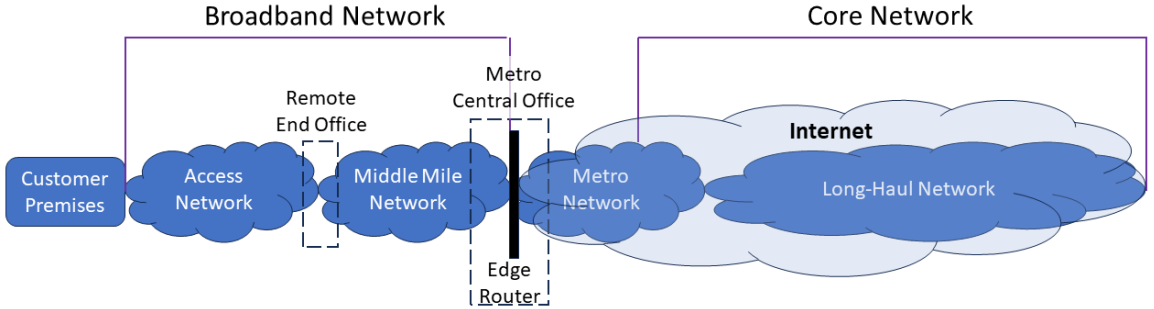
Infrastructure Investment and Jobs Act (the Act): Authorizes and funds the BEAD and Middle Mile funding programs.

- **Definition**
  - Any broadband infrastructure that does not connect directly to an end-user location
  - The Infrastructure Act (which authorizes and funds BEAD) lists a multitude of infrastructure types that are included in this definition.
  - (Implied) Any broadband infrastructure that connects directly to an end-user location is **Broadband Access**
- **Purpose**
  - Reduce the cost of connecting unserved and underserved areas to the backbone of the internet.
  - Promote broadband connection resiliency via alternative network connection paths that can be designed to prevent single points of failure.
- **Requirements**
  - Support overall broadband requirements - Capacity, Latency, Reliability and Affordability
  - Geographic Diversity
  - Permit other broadband service providers to interconnect with middle-mile network facilities on a just, reasonable, and nondiscriminatory basis.

The Middle Mile Network

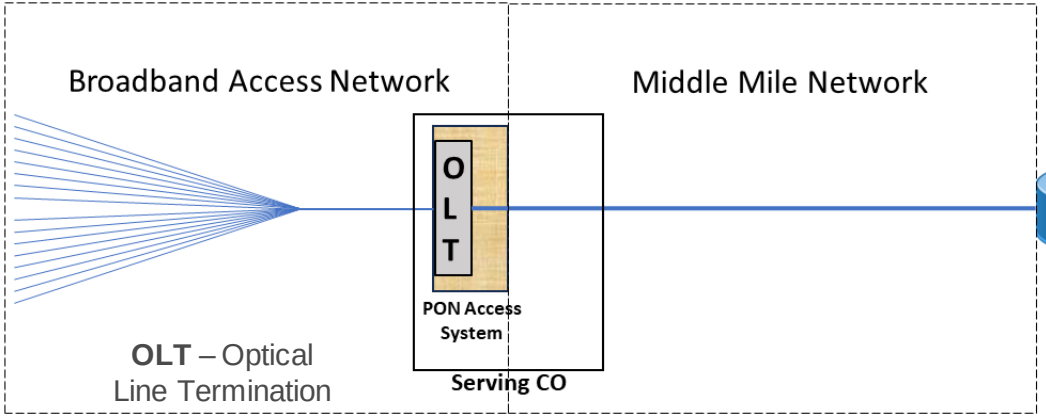
Middle Mile Network as Physical Backhaul

In the Context of the End-to-End Network



Middle Mile Network Technical Perspectives

Middle Mile Network as a Transport Network

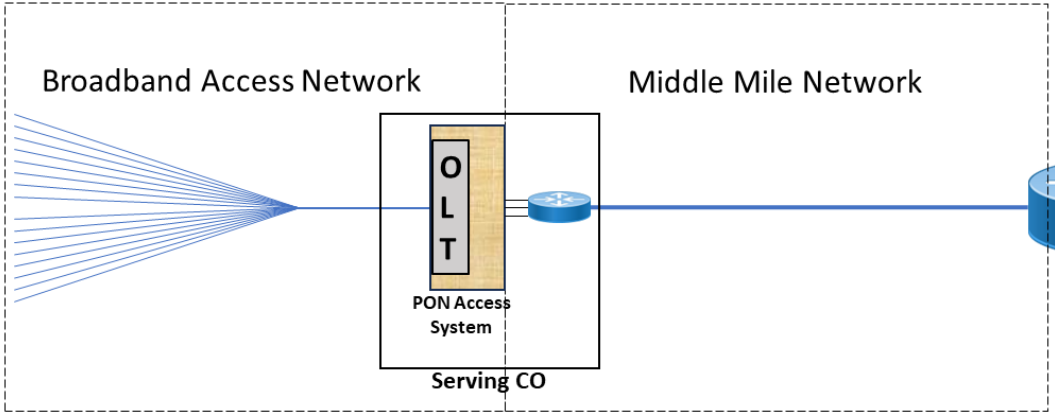


OLT – Optical Line Termination

BNG – Broadband Network Gateway

Middle Mile Network as a Service Element

All connections to subscribers must be made through the BNG.

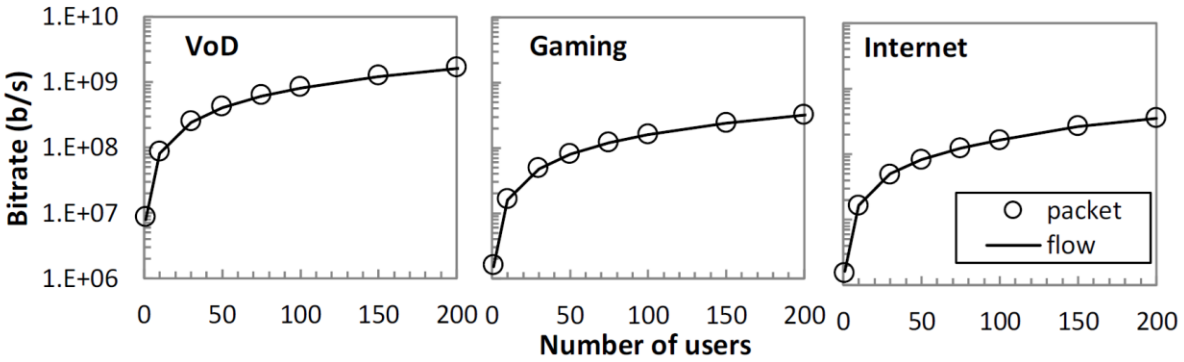


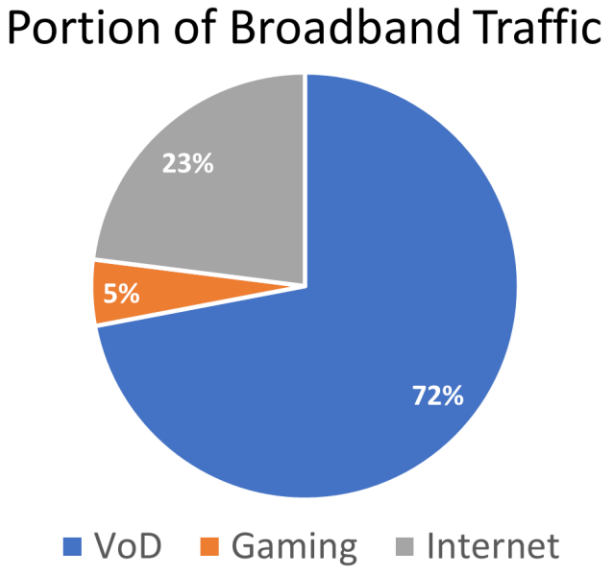
Assumptions for Scaling the Middle Mile Network

- Operators will scale network to support broadband traffic in **2028.**
- Operators will employ **XGS-PON.**
- PONs will have a **1:64 split.**
- **Operators will pass with FTTx** all households in their service areas.
- Operators will offer at least **1 Gb/s service.**
- Average **12,000 lines** served by a **small city** or suburban central office
- FTTx operators in **competitive** markets will garner **60% of broadband subscribers.**
- FTTx operators in **non-competitive** markets will garner **100% of broadband subscribers**.

Average Broadband Traffic on an XGS-PON System with 1:64 Split

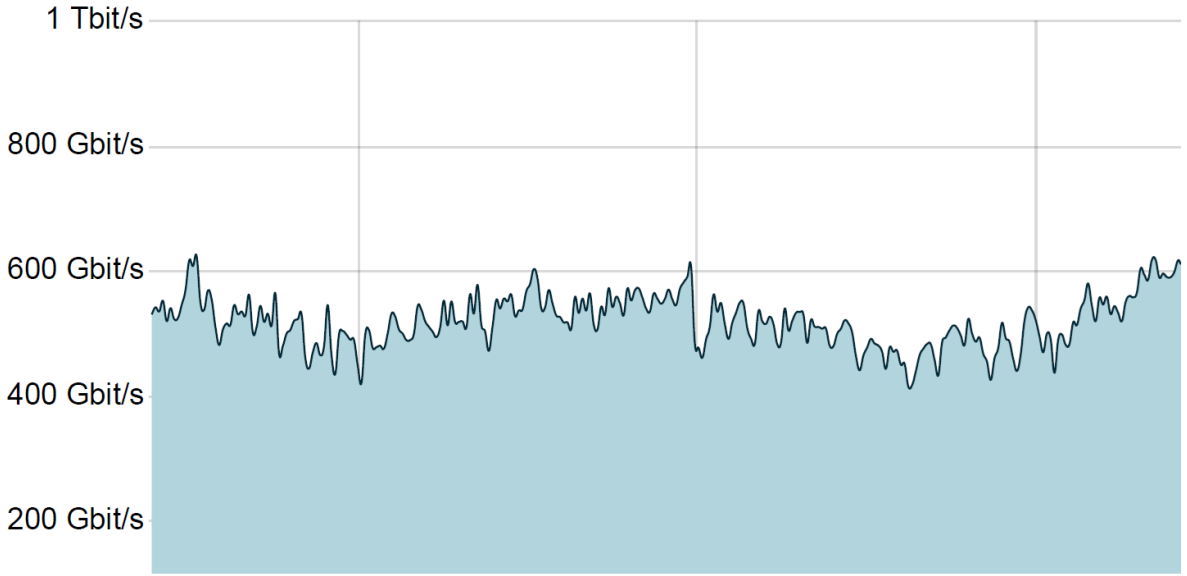
- 64 Homes Passed
- 2.55 Persons per Household
- Portion of Passed Households Subscribing: 86%
- Number of Users on System
  - In Competitive Areas (60% wins): 84
  - In Non-Competitive Areas (100% wins): 140





Broadband Traffic on an XGS-PON System with Peak and Growth

- Average Broadband Traffic on an XGS-PON System:
  - Competitive Areas: 524.3 Mb/s
  - Non-Competitive Areas: 873.1 Mb/s
- Internet Peak Traffic
  - DE-CIX Hubs Measured:
    - Chicago
    - Dallas
    - New York
    - Phoenix
    - Richmond
  - Total Annual Peak: 2,584 Gbit/s
  - Annual Average: 1,071 Gb/s
  - Peak Multiplier = 2.41
- Peak XGS-PON Traffic:
  - Competitive Areas: 1,264 Mb/s
  - Non-Competitive Areas: 2.104 Mb/s



Dallas Internet Hub Traffic over the Year

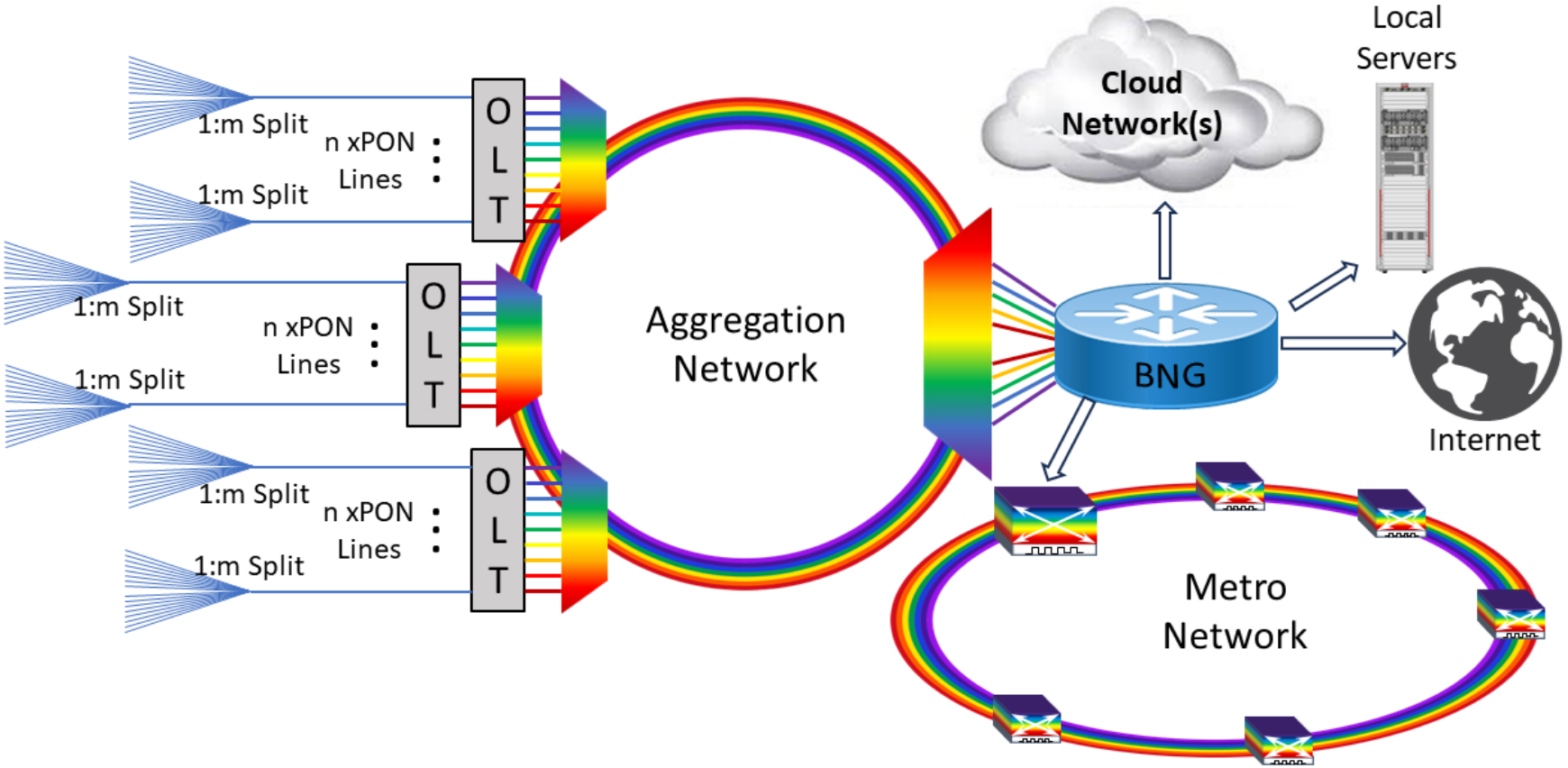
- Single-subscriber traffic **growth rate** (= overall traffic growth rate): **22.4%**

Broadband Traffic Aggregation in the Central Office in 2028

- Single-subscriber traffic **growth rate** (= overall traffic growth rate): **22.4%**
- Peak Broadband Traffic on Each XGS-PON System:
  - Competitive Areas: 3.470 Gb/s
  - Non-Competitive Areas: 5.778 Gb/s
- Number of lines served by a central office
  - Former Bell Central Office (Competitive): 16,000 - Small City or Suburban (Not competitive): 12,000
  - Small town: 6,900 - Rural: 660

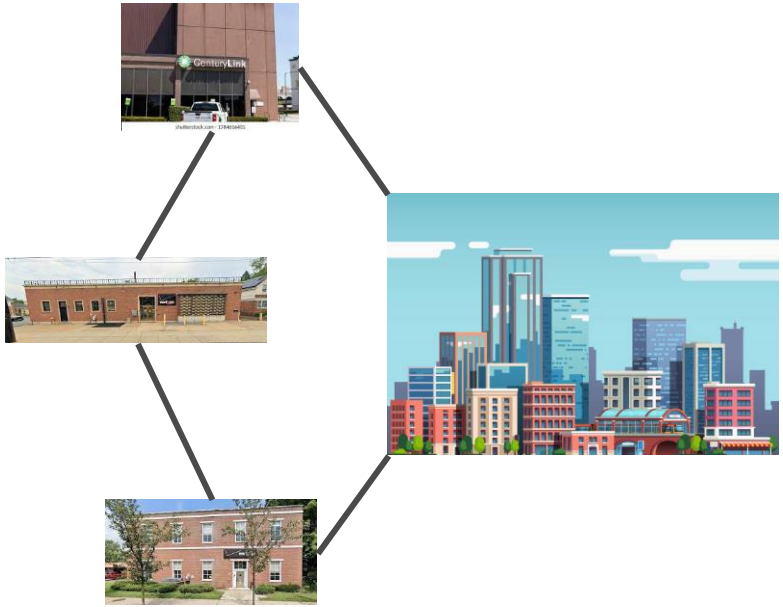
	Number of Lines	Number of XGS-PONs	Traffic per PON	Total Traffic (Gb/s)	No. of 400G Wavelengths
Competitive Market	16,000	250	3.470	868	3
Lone Fiber Provider	12,000	188	5.778	1,083	3
Rural Town	6,900	108	5.778	623	2
Rural Telcos	660	10	5.778	60	1 (100G)

Middle Mile Ring Transport Network

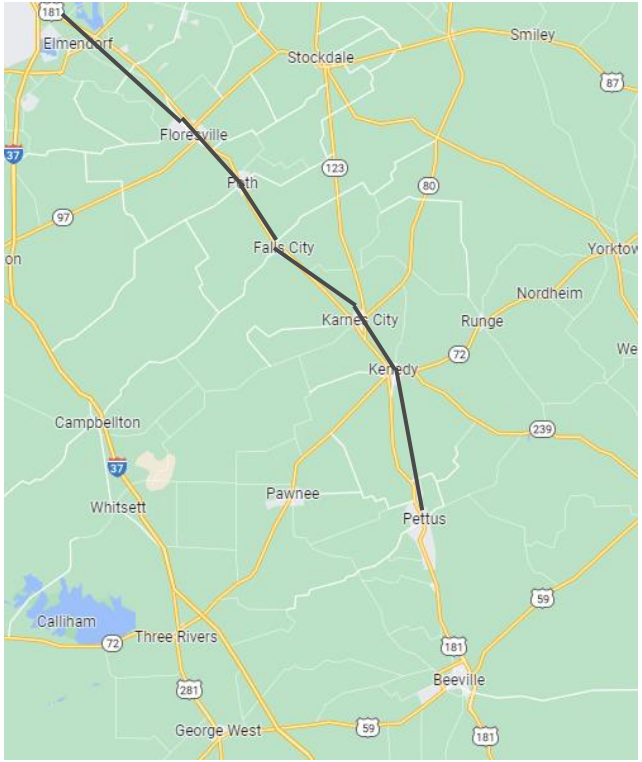


Federal Funding Requires Geographic Diversity

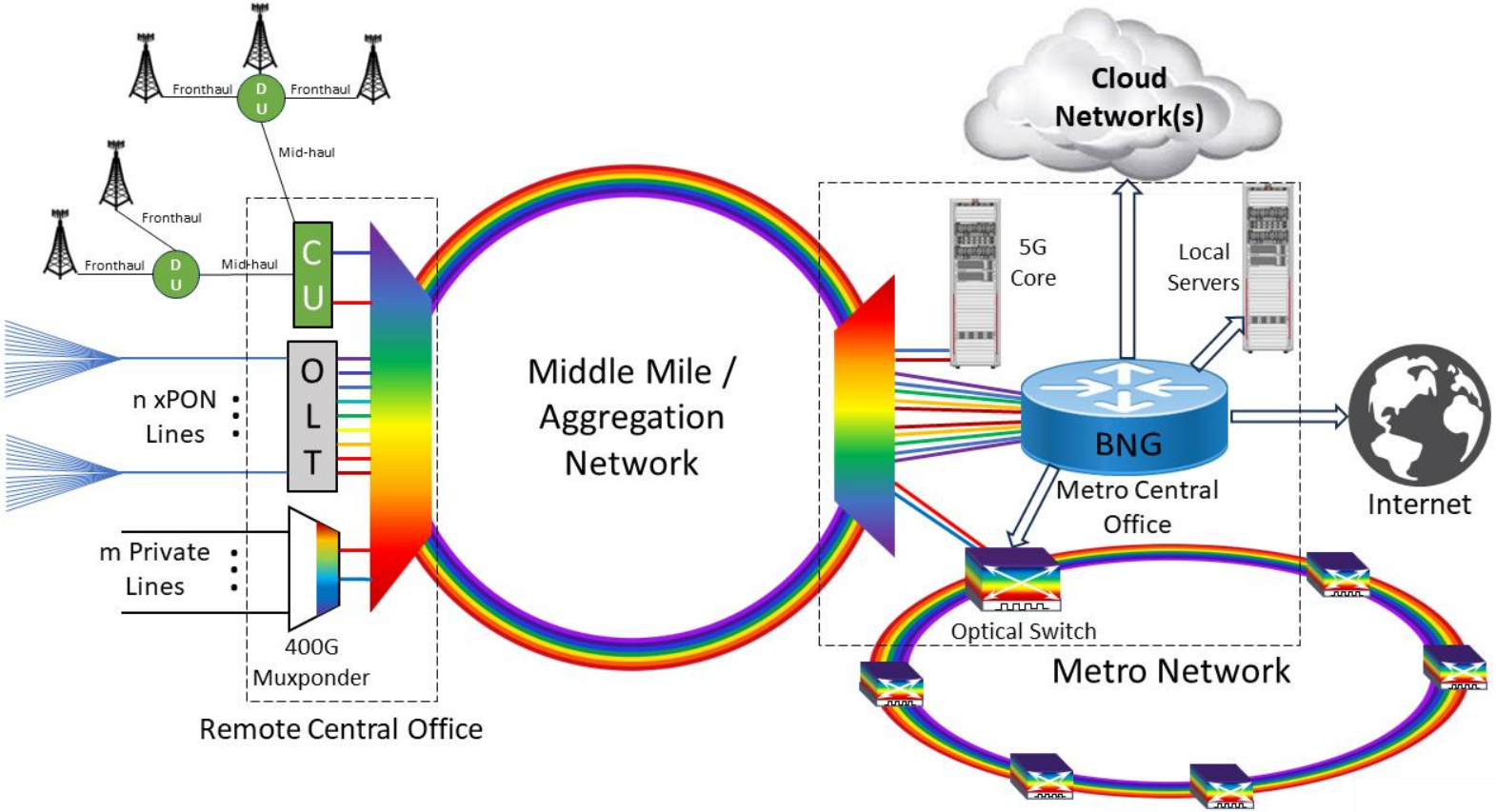
Suburban Areas – No Problem



Rural Areas – Not So Easy



Multi-Service Middle Mile Ring Network



Network Direction - SDN Enabled Broadband Access (SEBA)

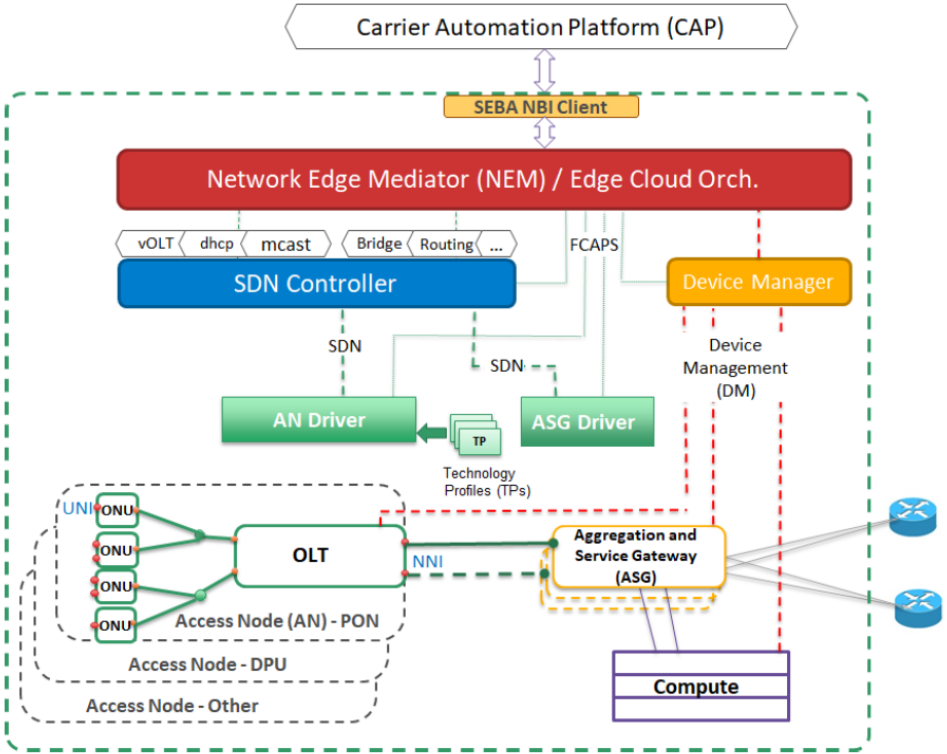


Figure 1: High Level Target Architecture

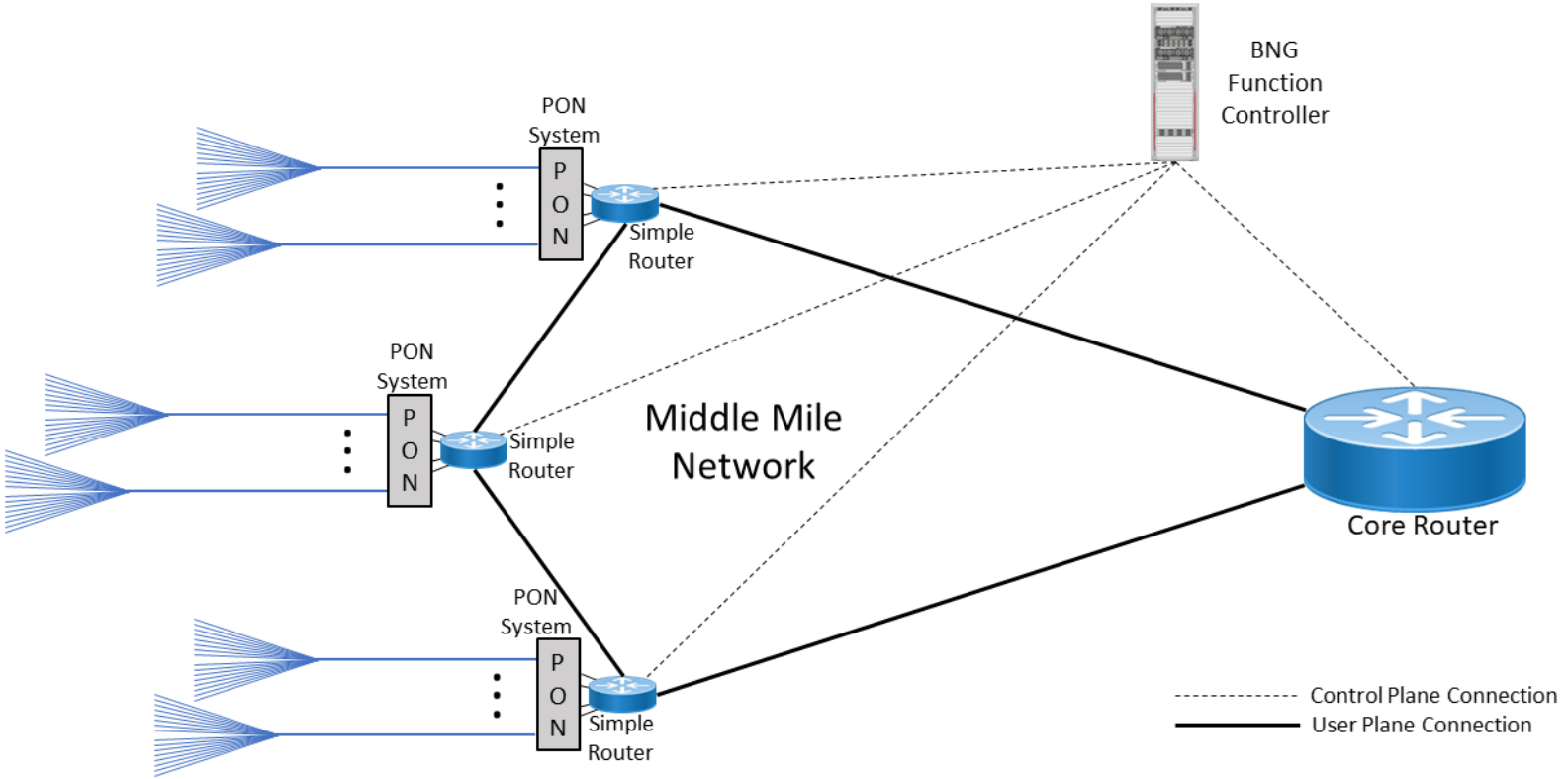
Source: ONF TS-103, Version 2.0 | March 2021

- The OLT (and therefore the PON) becomes part of an IP network.
- The OLT (and therefore the PON) is controlled by an SDN Controller.
- The OLT control is orchestrated with the BNG (shown here as the ASG).
- The Edge Cloud Orchestrator coordinates the PON with the Internet.

Moving the BNG out to the Serving Central Office

- Reduce the traffic on the middle mile network
  - Reduce overhead
  - Offload traffic
- Provide access to subscribers at the edge of the network
  - Reduce latency
  - Facilitate edge computing
  - Extend the cloud to the edge of the network
- But BNG routers are:
  - Large
  - Expensive
  - Complex
- Solution – Disaggregate the Network

Disaggregated Network Configuration



Summary

- A typical Middle Mile Network connects a remote central office to the nearest metro central office (a central office that is on the metro network).
- The current version of a Middle Mile Network is based on a physical connection between a Passive Optical Network (PON) and its Broadband Network Gateway (BNG).
- The transformed Middle Mile Network extends into the PON Access System and the BNG on the other end.
- The introduction of over 100 Mb/s capacity to all subscribers of a central office causes the data traffic aggregated onto the Middle Mile Network to mushroom into hundreds of megabits per second of traffic.
- Disaggregation of the network will facilitate moving the BNG function to the serving central offices (even remote ones).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