WHITE PAPER

Traditional PON Versus Mixed PON/Active Architectures Based on Ciena's Universal Aggregation Solution

10G XGS-PON CAPEX-centric Business Case

Introduction

The Passive Optical Network (PON) architecture employs shared fiber to achieve cost savings for network operators, which is quite cost-effective over short feeders. However, over long feeders, the Outside Plant/Optical Distribution Network (OSP/ODN) cost for the traditional PON architecture, in which the Optical Line Terminal (OLT) is located at the Central Office (CO) or local exchange, increases rapidly. Also, limitations in system reach/distance due to optical splitting power loss creates a major disadvantage for the traditional PON architecture.

Over long feeders, a mixed PON/active architecture enables network operators to achieve:
- CAPEX savings
- PON reach extension

By deploying a pluggable mixed PON/active architecture based on Ciena's Universal Aggregation (UA) solution, network operators can achieve both CAPEX savings and PON reach extension.

This white paper develops a business case employing Ciena's 5170 Packet Networking Platform to quantify the CAPEX savings achieved and determine feeder distances at which the pluggable mixed PON/active architecture becomes more cost-effective, compared with traditional PON architecture for optical splitting ratios of:
- 10G PON with 1-> 32 total optical splitting of feeder fiber
- 10G PON with 1-> 64 total optical splitting of feeder fiber
- 10G PON with 1-> 128 total optical splitting of feeder fiber

This business case assumes a CAPEX model in which the feeder infrastructure is owned by the network operator and the deployment scenario is brownfield; only feeder fiber cable material/installation costs are considered.

1. Ciena's UA solution summary

Network operators are looking for comprehensive solutions to address their main pain point around deploying PON-based broadband access networks—OSP/ODN cost and PON reach limitation.

Figure 1 shows Ciena's UA solution. This solution provides network operators with increased choice and control of tangible business value assets like coherent optics, pluggable dedicated and shared fiber optics, and Adaptive IP™. By supporting all services, including mobility 4G/5G services, Ciena's UA expands a network provider's application space and competitiveness. Choice—enabled by a smaller footprint, increased capacity, PON reach extension, and larger interconnect scale in platforms that automate and simplify deployment and turn-up tasks—results in operational flexibility and significant cost-savings for network operators now and in the future.

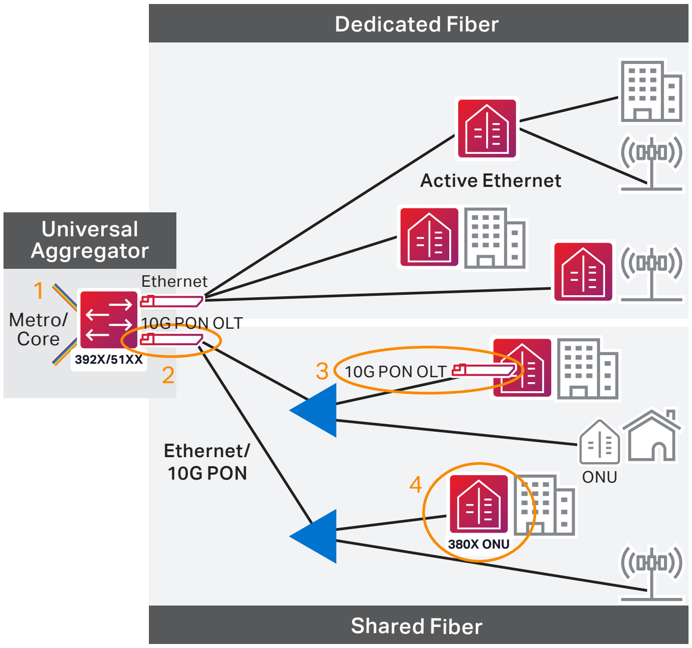

Figure 1. Ciena's UA solution

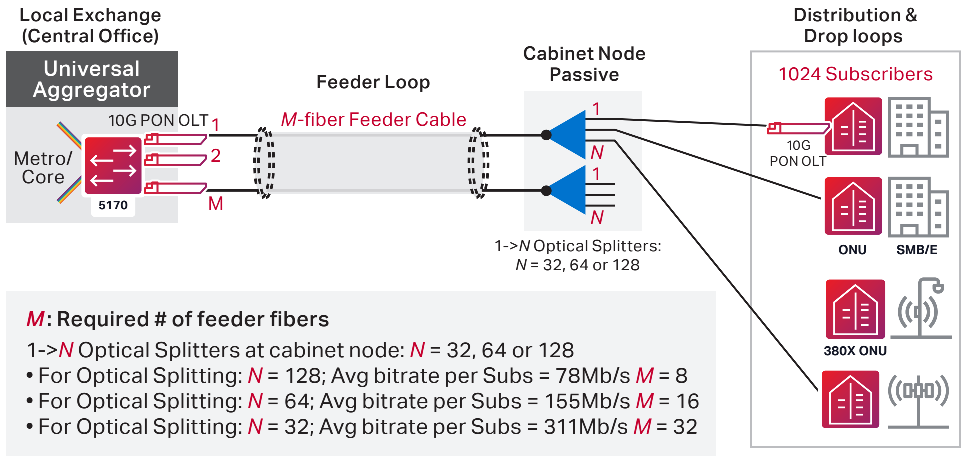

Figure 2a. Traditional PON FTTx architecture with OLT located in CO

- Solution components:
  1. 5170 Platforms
  2. 10G PON uOLT SFP+
  3. 10G PON uONU SFP+
  4. 380x 10G XGS PON ONU

2. The 10G XGS-PON FTTx architecture

2.1 Traditional PON architecture with OLT located in CO

Figure 2a shows the implementation of the traditional PON FTTx architecture, where symmetrical 10G XGS-PON OLTs are located at the CO and traffic is aggregated upstream on Ciena's 5170 Platform. Each 10G XGS-PON OLT is connected to the cabinet node on a feeder fiber, wherein a single feeder fiber from the CO/Local Exchange (LEX) OLT is split into N-fiber distribution cable (where N = 32, 64, or 128) by a 1->N optical splitters located at the cabinet node, as shown, assuming a centralized (local convergence) optical splitting. The cabinet distribution area contains 1024 subscribers. Each 10G PON's required number of feeder fibers is M, and average bitrates per subscriber for 1->N optical splitting (where N = 32, 64, or 128) are as follows:

5. For optical splitting: 1->N = 128; average bitrate per subscriber = 78 Mb/s and M = 8
6. For optical splitting: 1->N = 64; average bitrate per subscriber = 155 Mb/s and M = 16
7. For optical splitting: 1->N = 32; average bitrate per subscriber = 311 Mb/s and M = 32

The required number of feeder fibers—and, hence, cost—increases linearly as feeder length and/or delivered bitrates increase.

2.2 PON/active FTTx architecture (based on Ciena's UA solution) with OLT remoted to cabinet node

Figure 2b shows the implementation of the PON/active FTTx architecture based on Ciena's UA solution, with the 10G XGS-PON OLTs now remoted to a cabinet node and the traffic between the CO and the cabinet node aggregated on a pair of fibers using a pair of Ciena's 5170s, as shown. At the cabinet node, signal carried by each 10 Gb/s XGS-PON OLT is then split into N-fiber distribution cable (where N = 32, 64, or 128) by 1->N optical splitters located at the cabinet node as shown, assuming a centralized (local convergence) optical splitting. The cabinet distribution area contains 1024 subscribers. Each 10G PON's required number of feeder fibers is M, and average bitrates per subscriber for 1->N optical splitting (where N = 32, 64, or 128) are as follows:

8. For optical splitting: 1->N = 128; average bitrate per subscriber = 78 Mb/s and M = 2
9. For optical splitting: 1->N = 64; average bitrate per subscriber = 155 Mb/s and M = 2
10. For optical splitting: 1->N = 32; average bitrate per subscriber = 311 Mb/s and M = 2

Hence the required number of feeder fibers is two for all split ratios. The cost increases marginally as feeder length and/or delivered capacity increase.

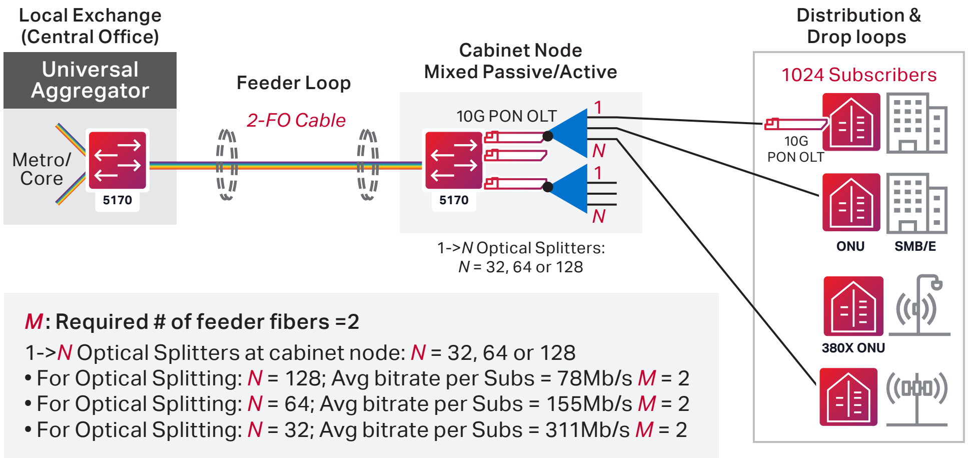

Figure 2b. PON/active FTTx architecture (based on Ciena's UA solution) with OLT remoted to cabinet node

2.3 10G XGS-PON business case: A comparison of traditional PON architecture versus mixed PON/active architecture based on Ciena's UA solution

Figure 2c shows the sizing of the required aggregator capacity for various optical split ratios as follows:

11. For optical splitting: 1->N = 128; required aggregator capacity: 80 Gb/s (=10 Gb/s x 8 feeder fibers)
12. For optical splitting: 1->N = 64; required aggregator capacity: 160 Gb/s (=10 Gb/s x 16 feeder fibers)
13. For optical splitting: 1->N = 32; required aggregator capacity: 320 Gb/s (=10 Gb/s x 32 feeder fibers)

3. Cost modeling

Figures 3a and 3b show the network cost components of the traditional PON FTTx architecture and the mixed PON/active FTTx architecture based on Ciena's UA solution, respectively. A CAPEX business model is assumed in a brownfield deployment scenario. Network cost components include:

14. CO/OLT node: electronics (Ciena 5170), software, power
15. Feeder loop: cable material/installation
16. Cabinet node: optical splitters, electronics (Ciena 5170), power, enclosure, Controlled Environmental Vault (CEV)

# of Subs in Cabinet Area	Capacity per 10G XGS-PON: (Gb/s)	Optical Splitting of a Feeder Fiber: 1->N (N=16, 32, 64, 128)	Average Capacity/Subs: (Mb/s)	Req'd Capacity of Cabinet Area: Gb/s	Trad-PON Solution Feeder Loop	PON/Active Solution* Feeder Loop+ Aggreg. Sizing
1024	10.0	1->128	78	80	8-FO	2-FO + 80G 5170
1024	10.0	1->64	156	160	16-FO	2-FO + 160G 5170
1024	10.0	1->32	311	320	32-FO	2-FO + 320G 5170

*based on Ciena Universal Aggregation solution

Figure 2c. Sizing Ciena's UA capacity requirement for different optical split ratios

3.1 Network cost components of traditional PON FTTx architecture

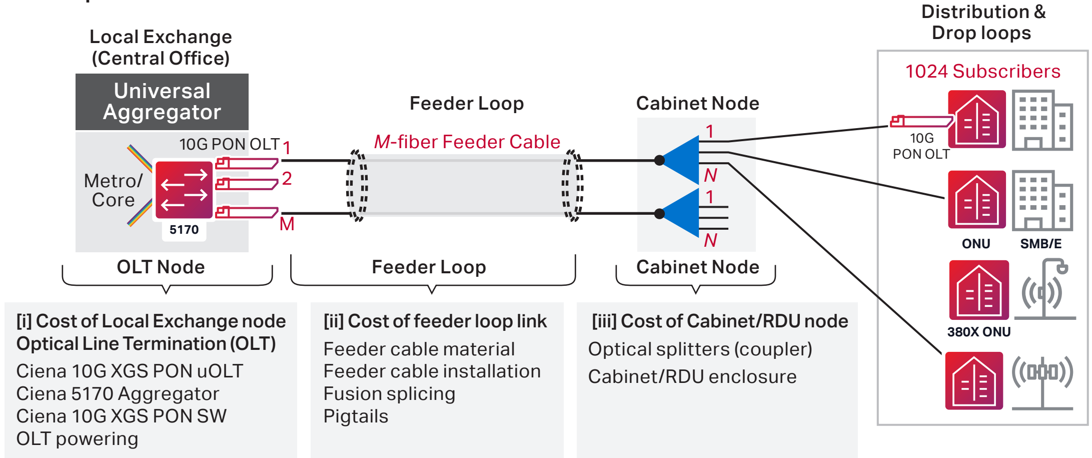

Figure 3a. Network cost components of traditional PON FTTx architecture

3.2 Network cost components of mixed PON/active FTTx architecture based on Ciena's UA solution

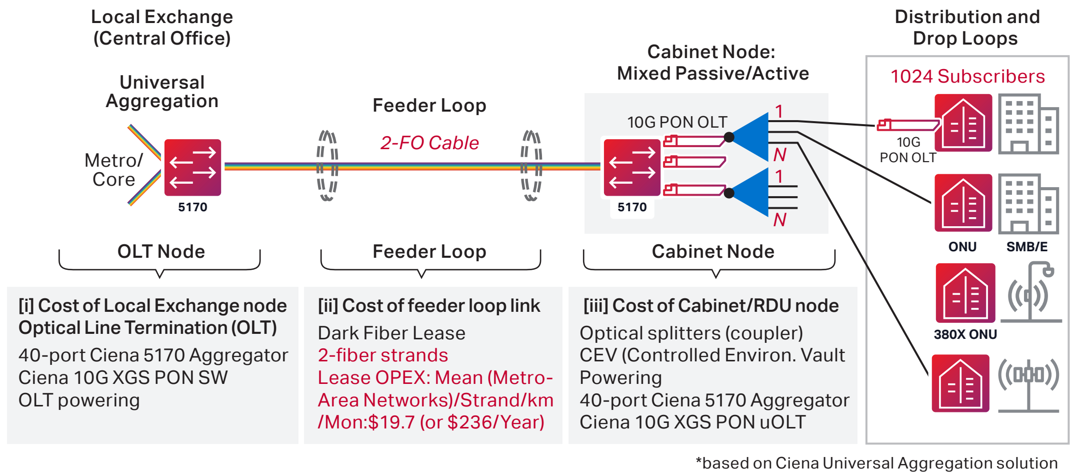

Figure 3b. Network cost components of mixed PON/active FTTx architecture based on Ciena's UA solution

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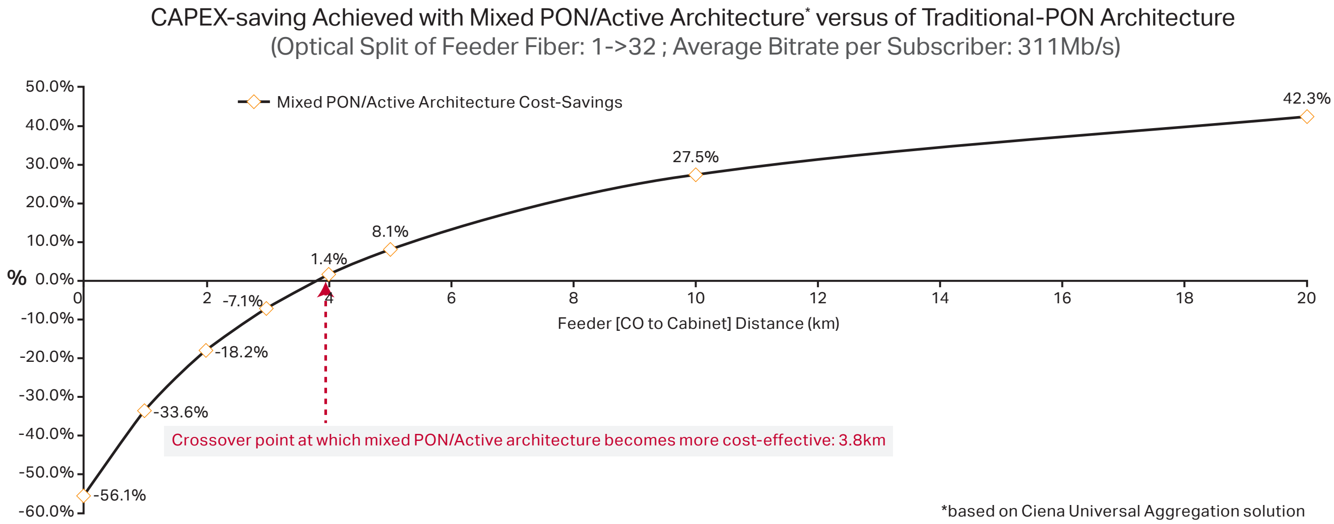

Figure 4. CAPEX savings achieved by mixed PON/active architecture for optical splitting of feeder fiber: 1->32

4. Cost modeling results: CAPEX savings achieved by mixed PON/active architecture based on Ciena's UA solution versus traditional PON architecture

Figure 4 shows the crossover point—at which mixed PON/active architecture becomes more cost-effective for an optical split ratio of 1->32, versus the traditional PON architecture—to be 3.8km. The CAPEX savings increases to 27.5 and 42.3 percent at feeder distances of 10 and 20km, respectively.

5. Conclusions: Cost comparison of 10G XGS-PON solutions: Traditional PON versus pluggable mixed PON/active architectures based on Ciena's UA solution

Figure 5 shows the CAPEX savings achieved with mixed PON/active architecture based on Ciena's UA solution, at different optical split ratios of a feeder fiber as a function of the feeder [CO to cabinet] distance. A CAPEX business model is assumed in a brownfield deployment scenario, where network cost components include:

- CO/OLT node: electronics (Ciena's 5170), software, and power
- Feeder loop: cable material/installation
- Cabinet node: optical splitters, electronics (Ciena's 5170), power, enclosure, CEV

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- **For optical split of feeder fiber: 1->128 (average bitrate/subscriber:** 77.8 Mb/s): the mixed PON/active architecture based on Ciena's UA solution becomes more cost-effective at a feeder distance of 6.2km and results in cost-savings of 15.7 and 32 percent at feeder lengths of 10 and 20km, respectively.
- **For optical split of feeder fiber: 1->64 (average bitrate/subscriber:** 155.5 Mb/s): the mixed PON/active architecture becomes more cost-effective at a feeder distance of 5.2km and results in cost savings of 20.5 and 36.2 percent at feeder lengths of 10 and 20km, respectively.
- **For optical split of feeder fiber: 1->32 (average bitrate/subscriber:** 311 Mb/s): the mixed PON/active architecture becomes more cost-effective at a feeder distance of 3.8km and results in cost savings of 27.5 and 42.3 percent at feeder lengths of 10 and 20km, respectively.

Network operators are looking for comprehensive solutions to address their primary pain point around deploying fiber in the access network—OSP/ODN cost and PON reach limitation. This business case analysis has established the fact that the mixed passive/active architecture based on Ciena's UA solution addresses a technical limitation of the purely passive PON-only architecture (reach limitation due to optical splitting loss), while resulting in significant cost-savings for network operators.

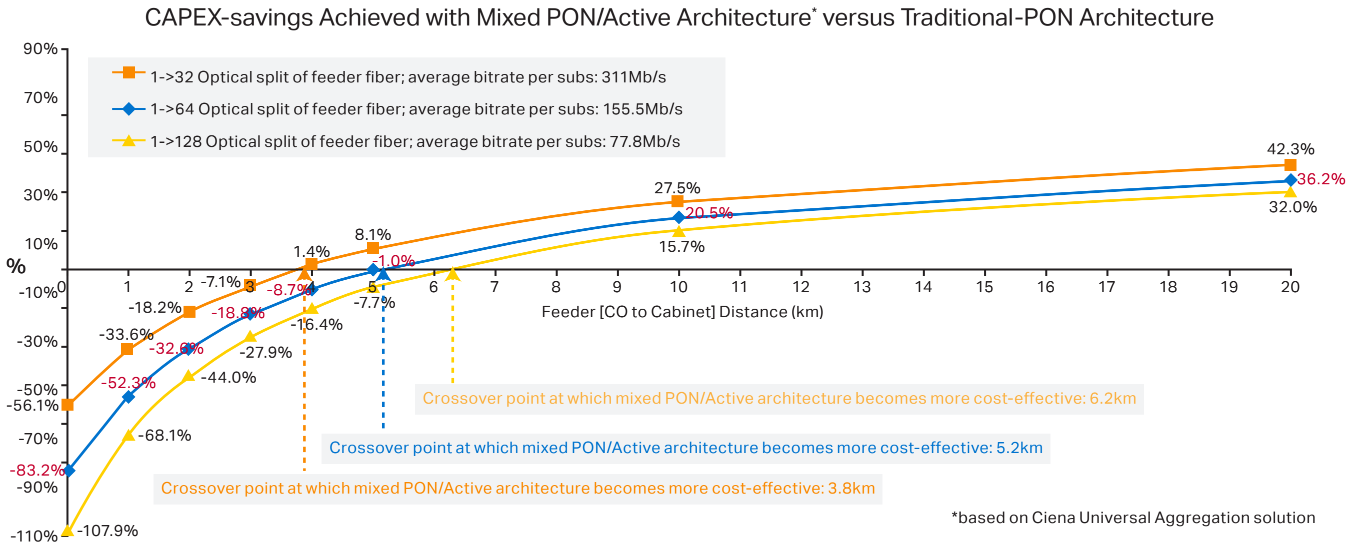

Figure 5. CAPEX savings achieved with mixed PON/active architecture at different optical split ratios of a feeder fiber as a function of the feeder [CO to cabinet] distance

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