FTTx Designing Best Practices

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This paper discusses various approaches to FTTx Designing. It throws light on some of the leading network design considerations that are commonly factored in to assure successful deployment and consequent ROI.

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FTTx Designing Best Practices

Introduction

FTTx (Fiber to the X) represents the technology aspirations and ambitions of today's businesses that seek reliable technology investment guidance and reasonably assured ROI. It is a means of providing Next Generation Access (NGA) to corporates that rely on a robust IT communications mechanism to get more done, faster.

By nomenclature it can refer to any of below possibilities:

- Fiber-to-the-Node (FTTN) / Fiber-to-the-Curb (FTTC)
- Fiber-to-the-building (FTTB)
- Fiber-to-the-Home (FTTH)

A plethora of high bandwidth requirements drive businesses to invest in more bandwidth. These include enterprise cloud computing applications, virtualization, high definition 4K streaming, audio and video conferencing, Intelligent devices and IoT/ AI, SAAS applications, remote & work-from-home approaches, mobile traffic, social media & surveillance applications to name a few.

Why only FTTx?

Fiber is not only strongly trending but also future proof. Vis-a-vis copper, it stands out on below markers:

- Reliable, proven technology; replaces both coax and copper
- Competitive Capex ROI
- Excellent Opex ROI
- Lighter, faster, longer-life
- Easier to install, Compact form factors
- Ideal long-haul characteristics
- More secure medium
- Lower energy consumption
- High electrical & RF noise immunity
- High operational safety

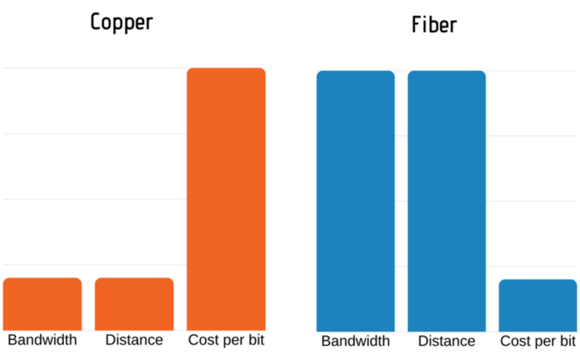


Fig 1. Copper vs Fiber

Most importantly, fiber as a backbone technology is extremely capable of feeding copper, wireless, and mobile media.

A Bandwidth Hungry World

The demand for internet bandwidth alone is doubling every year. Hence the most prominent reason fiber will continue to be preferred would be its the exponential bandwidth delivery capabilities.

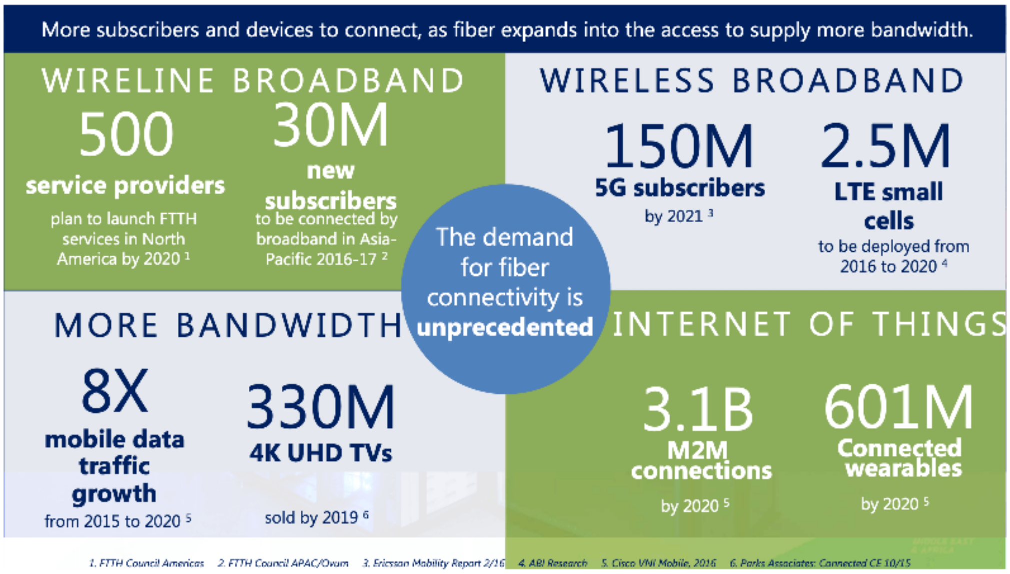


Fig 2. Growing Bandwidth requirements[1]

Why Plan for FTTx design?

As with any project management initiative, goals are bounded by both timelines and budgets. Thorough planning **is** a great way to stay ahead of the curve and avoid offensive performance or budget surprises.

- Guarantees self-awareness of project goals & investment objectives
- Assures Quality Control
- Increased speed of network build
- Streamline build-cost estimation process
- Optimization of limited Project budget - improved ROI from Capex
- Strategic planning ensures scope for modifications, expansion and change management
- Increased efficiency & effectiveness while building
- Bird's eye view on problems and solving them before they threaten to derail any goals - redundancy, component & capacity planning.
- Strategize services matrix being offered

FTTx Network Design Objectives

- Future-proofing both your design and investment - Bandwidth planning, Equipment & Component choice, Scalability without breaking and rebuilding
- Minimize network installation complexity - to save design time and ensure faster go-live as well as to save time and effort during ongoing maintenance
- Cost-effective in terms of both upfront Capex - deferring as much Capex as possible to subscriber turn-up
- Minimize running Opex & maintenance efforts
- Efficiency at low and high take rates

Design Considerations

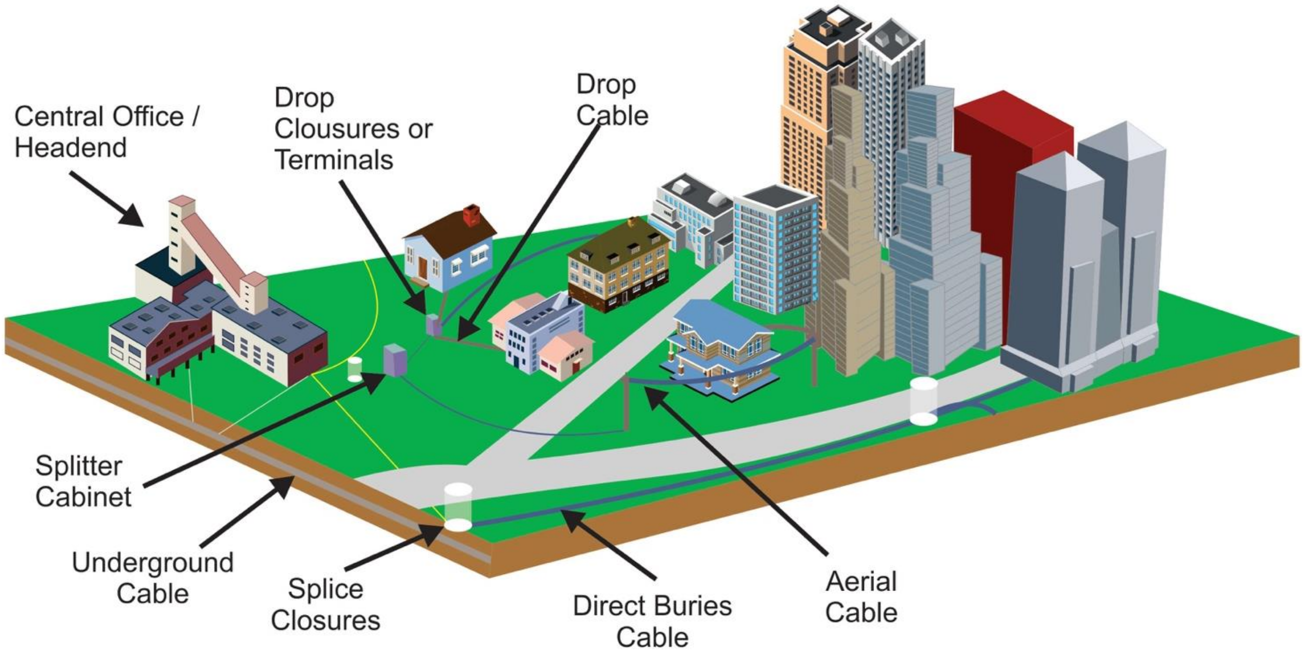
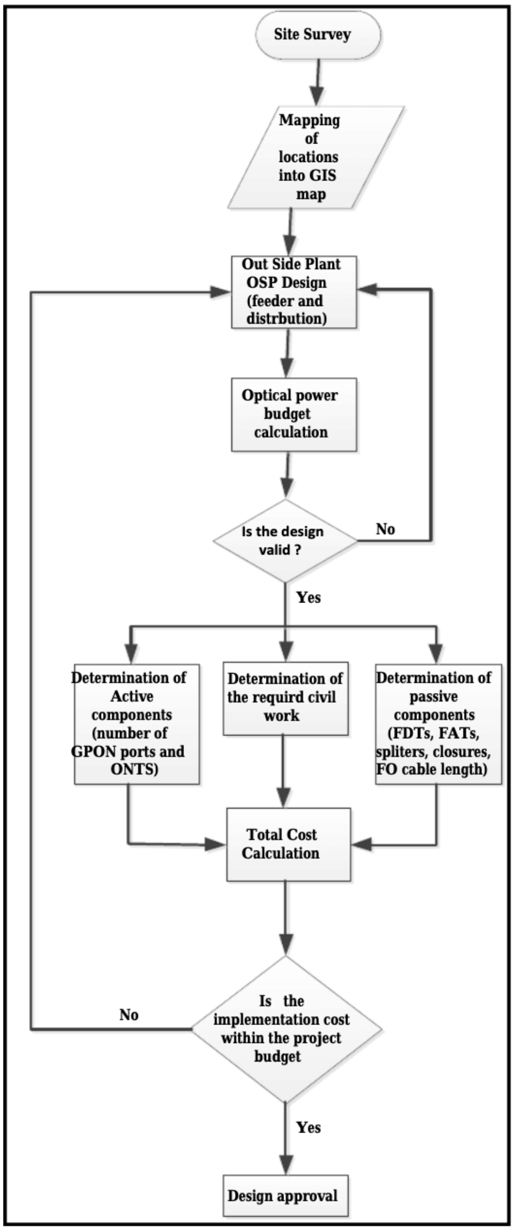


Fig 3. Typical FTTx Macro View

- Abundantly establish project macro and micro objectives - when to optimize Capex, Opex, redundancy, or ease of deployment.
- Understand the Greenfield/ Brownfield status of the project - if the latter, understand how any existing components or inventory can be repurposed. E.g., ducts and pipes.
- Choosing the right network architecture - PON vs. P2P, aerial vs. underground, splitter sizing.
- Shortlist possible targeted locations for deployment - rural vs. urban.
- Create a clearance calendar/ timeline from municipal and regulatory bodies.
- Using FTTx network planning and design software can automate processes and speed up the design overall - consider going for one.
- Design High level Outside Plant Design (OSP) - Choose from ducts, subducts, direct buried, aerial, and existing conduits and pipe options. Verify the feasibility of the same using GIS data and Site survey.
- Estimate expected Utilization rate (in case of commercial deployments) & No. of Active Customers per OLT port.
- Ready accurate estimates of operational costs - digging, pulling, manual labor, product or material, etc.
- In the case of labour-intensive projects - skilled labor is hard to get. Civil engineering & construction works, obtaining permits and rights-of-way accounts for a significant percentage of the cost.
- Decide on a solid splitter positioning strategy - Centralised vs Decentralised; Cascaded (multi-staged) etc.
- Ready existing inventories of components or workforce resources, if any.
- Ready Low-level design with detailed specifications and labeling.
- Consider choosing an optimal Splicing technique - whether fusion or mechanical.
- Compute the Optical loss budget - designers must ensure adequate optical power going both directions
- Consider splice solutions vs. plug and play solutions. The former calls for skilled labor, which can extend costs. It also increases the time to restore and higher Capex investment on maintenance equipment. With plug and play solutions, none of these problems exist, but their increased network loss must be taken into consideration.

- Consider reliable cable management solutions for the physical protection of mission-critical solutions.
- Evaluate different splitting architectures to reduce costs/ free up fiber - Cascaded split at FDH and Terminals; Distributed split at Terminals; Tap Splits; Connectorise Splitters and fiber to maintain flexibility for upgrades.
- Opt-in for hardened connectivity to speed up deployment and add points of flexibility - i.e., hardened connectors to replace splices for both single and multi-fiber.
- Design points of flexibility to allow for new services or reconfiguration of old ones - design hidden points of flexibility like traditional FDH's with more functionality.
- Consider the use of fiber indexing - *daisy-chaining* connectorized cables and terminals, limiting the need for custom cable assemblies or splicing.

Sample GPON FTTH Network - Design & Implementation Steps



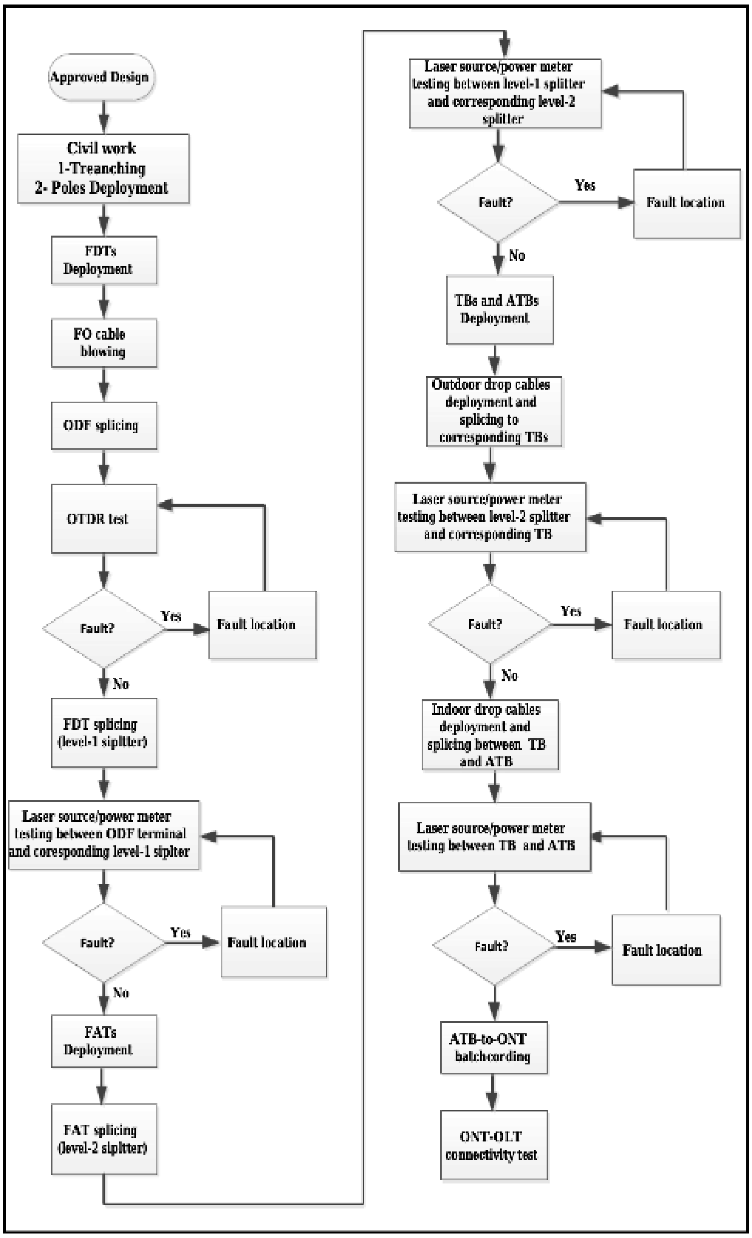


Fig 4. GPON FTTH Access Network Design Steps[2] Fig 5. GPON FTTH Access Network Implementation Steps[2]

FTTx Infrastructure Elements

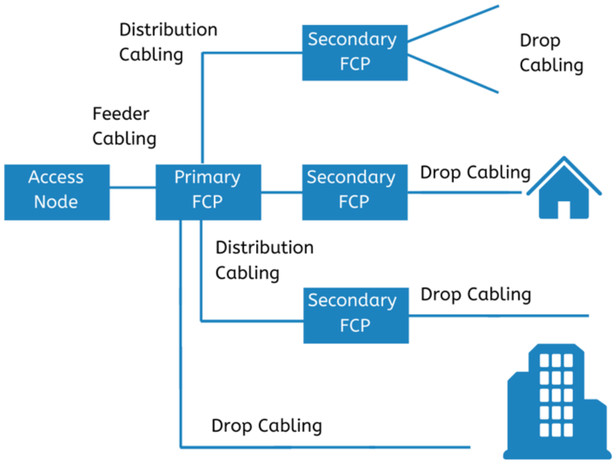


Fig 6. Various FTTx Infrastructure Elements

- Optical Line Terminal (OLT) - one of the leading network elements, placed in the local exchange. Conducts traffic scheduling, bandwidth allocation, and other essential functions.
- Optical Splitter - this unit splits the power of the signal, characterized by broad operating wavelength, low insertion loss, minimal dimensions, high reliability, and supporting network survivability and protection policy.
- Optical Network Terminal (ONT) - deployed at subscribed premises and links to OLT through fiber.
- Access Node or POP: Building a communications room or separate building.
- Feeder network: Large size optical cables and supporting infrastructure e.g., ducting or poles.
- Primary fiber concentration point (FCP): Easy access underground or pole-mounted cable closure or external fiber cabinet (passive, no active equipment) with large fiber distribution capacity.
- Distribution network: Medium size optical cables and supporting infrastructure, e.g., ducting or poles.
- Secondary fiber concentration point (FCP): Small, easy access underground or pole cable joint closure or external passive cabinet with medium/low fiber capacity and large drop cable capacity.
- Drop cabling: Low fiber-count cables or blown fiber units/ ducting or tubing to connect subscriber premises
- Internal cabling Fiber in the Home: Includes fiber entry devices, internal fiber cabling, and a final termination unit.
- Miscellaneous components at each aggregation layer: ODF/ ODR, Fiber, Splitter, Splice, Connectors, Cable joint closures, Cabinets, Manholes, etc.

Key Features of FTTx Designing Softwares

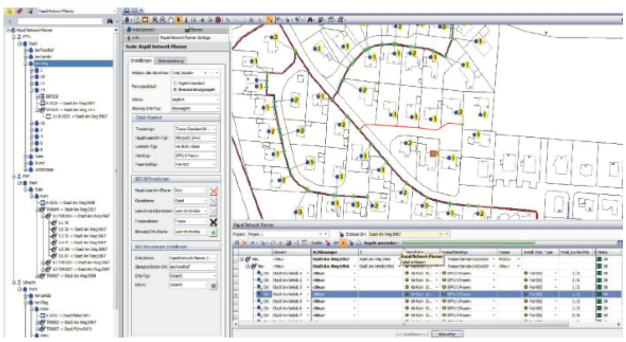


Fig 7. FTTx Design Software representation

- Fundamental planning including outside plant demographic evaluation
- Duct availability analysis and cable route assurance
- Network optimization through fiber network cluster definition
- Authority / Owner approvals
- Detailed backbone and fiber distribution line route planning
- Loss budget calculation, splicing, cable and blow length reporting
- Route surface area and digging length detailed reporting
- End-to-end visibility of Project and its micro aspects
- OTDR
- Capacity Planning
- Active Network & Passive Infrastructure - Planning, Build Design & Deployment
- Network Maintenance
- Auto routing
- Impact Analysis
- Fault Localisation
- Planning Layer
- Google GIS
- Inventory management

Advantages of using Software-driven Approach to FTTx Design

- Increased optimal provisioning of P2P and PON FTTx networks through a robust data-driven approach.
- Reduced provisioning cycle times with integrations and automation.
- Optimization of costs at every stage in the planning, design, build and operation of the active and passive network layers of an FTTx network.
- Rapid impact analysis to minimize downtime from fiber cuts.
- Accurate visualization helps with higher productivity and faster response times.
- Faster, more precise decision-making and improved design flow.
- Tight process and systems integration across network planning, design, build and operations to enable lower OPEX.
- Maximized asset utilization to defer or reduce network CAPEX.
- Timely and accurate network asset tracking for improved financial reporting and compliance.
- Reduced OPEX through optimization and consolidation of leased network capacity.

FTTx Architectures

Choosing the right fit architecture

The choice of architecture drives costs in an FTTx network.

- Passive Optical Networking (PON) - deploys an Optical Line Terminal (OLT) at CO and fiber run to the passive optical splitter with each end-user (maximum of 64) having an ONU (Optical Networking Unit) for termination.
- Point to Point (P2P) - Core switch at CO that links to an aggregation switch at the distribution point, which connects to ONT boxes at subscriber premises.

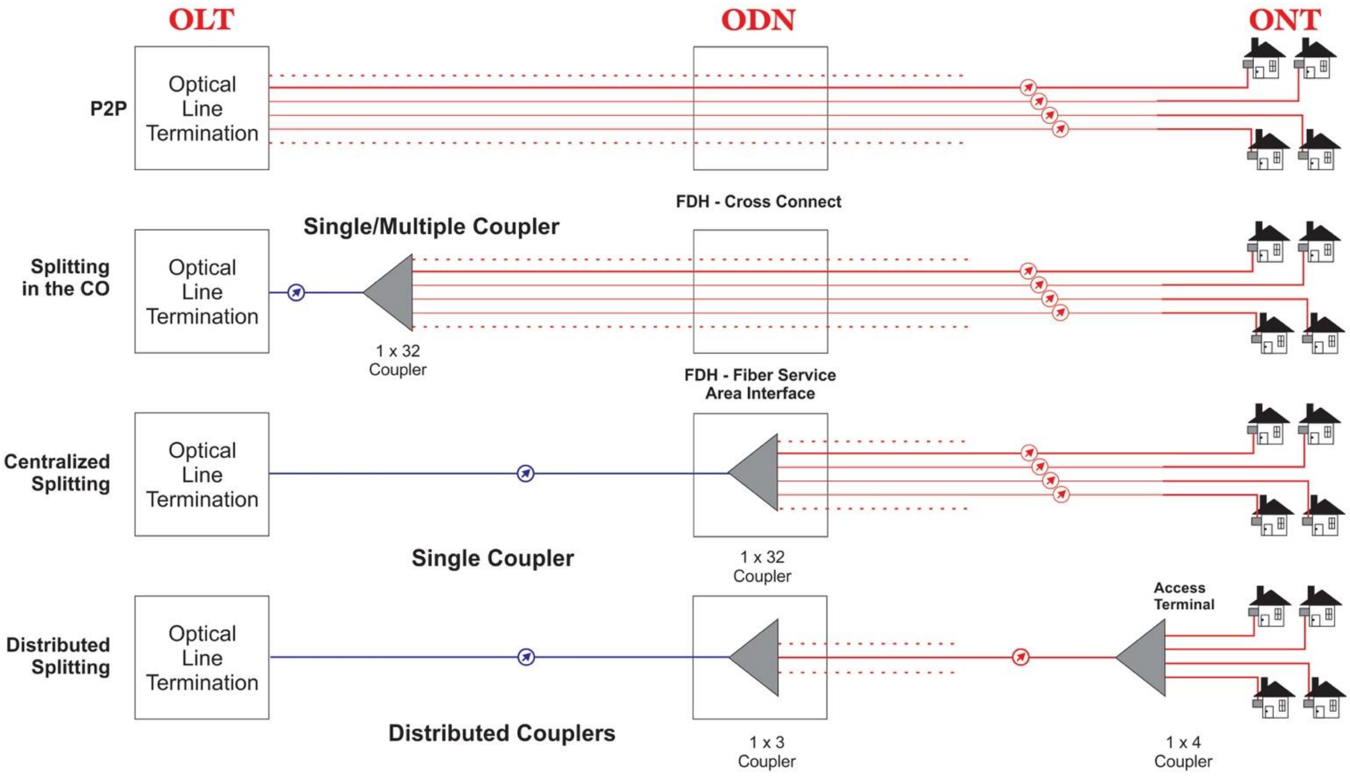


Fig 8. FTTx Network Architecture[1]

	PON	P2P
Deployment	Easier, Faster	Difficult, Time Consuming
Architecture	Simpler	More Complex
Bandwidth	Shared	Dedicated
Bandwidth	Asymmetrical	Symmetrical
Bandwidth Per Customer	Less	Maximum
Rollout Time	Less	More
Losses @Optical splitters	More	Less
Fiber & Splicing requirement	Less	More
Cost of electronics per Customer	Less	High

Fig 9. PON vs. P2P

	GPON		GE-PON		Point to Point (Active Ethernet)
	GPON	XGS-PON	GE-PON	10G-EPON	
Downstream Bandwidth (Gbps)	2.4	10	1.2	10	100-1000 Mbps per sub
Upstream Bandwidth (Gbps)	1.2	10	1.2	10	100-1000 Mbps per sub
Typical Distance (km)	20	20	20	20	20
Downstream Wavelength (nm)	1490	1577	1550	1577	1550
Upstream Wavelength (nm)	1310	1270	1310	1270	1310

Fig 10. PON vs. P2P Performance Characteristics

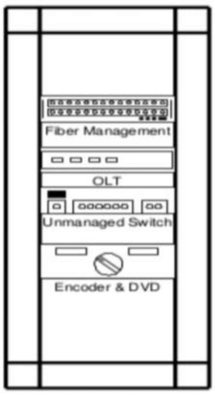
Splitter Deployment Strategy

Optical Splitters are used in an FTTH Deployment to provide the most effective use of OLT electronics. Typically, 1 x

32 Optical Splitters are used, 1 x 16 Splitters may be used in applications where loss budget will not allow 1 x 32's to be used; 1x64 can be used as well. Where to locate the splitters is a critical decision; possible alternatives include:

- Central Office (CO) splitting: works well when subscribers are close to C/O, creates a large amount of fiber in the OSP network.
- Centralized splitting: provides best OLT utilization flexibility in limited take rate builds and provides easy craft access for troubleshooting.
- Cascaded splitting: Cascaded splitters reduce distribution cable material costs but creates inefficient use of OLT equipment and increase troubleshooting difficulty.

Setting the Optical Power Budget



Designers must ensure adequate optical power going both directions

Component	Typical loss values @ 1550 nm
Fiber	0.2 dB/km
Splices	0.05 dB
Connectors	0.2 dB
Splitters (1x32)	17-18 dB

Fig 11. Optical Power Budget Calculations

PON Evolution

- G-PON (Gigabit-capable PON) - Recommendation ITU- T G.984 series
- NG-PON1 = XG-PON (10Gbit-capablePON) - Recommendation ITU-T G.987 series
- NG-PON2 = TWDM-PON (40Gbit-capable PON) - Recommendation ITU-T G.989 series

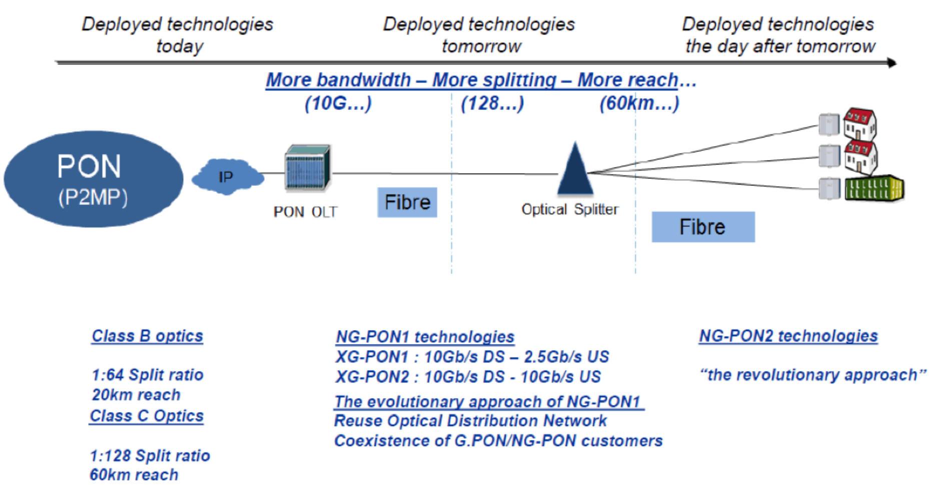


Fig 12. PON Evolution Steps[1]

Summary

Fiber continues to grow at an alarming rate in the last-mile. While corporates benefit from the multitude of use cases that a high capacity infrastructure can provide, service providers, on the other hand, are looking for tried and tested design approaches, so their Capex and Opex investments are optimized. FTTx is here to stay for a while, and it only makes sense for us to ensure that such a high-performance network is built with high levels of optimizations right from the design phase itself.

References

1. https://www.bicsi.org/docs/default-source/conference-presentations/2018-mea-conference/opportunitiesandchallenges.pdf?sfvrsn=71a8b909_2
2. Design and implementation of a Fiber to the Home FTTH access network based on GPON