An ADTRAN® White Paper

Lessons Learned
from Verizon® FiOS®

Overview

Initial deployments of Verizon Fiber-to-the-Home (FTTH) consisted of Central Office- (CO) based Broadband Passive Optical Network (BPON) Optical Line Terminals (OLTs) connected in large part to GR-303 switches via DS1 for voice, Asynchronous Transfer Mode (ATM) switches via OC-3c for data and Erbium-Doped Fiber Amplifers (EDFA) to Wavelength Division Multiplexing (WDM) combiners for video in the office. Large fiber routes were established leaving the CO over both buried and aerial plant serving primarily residential areas. Fiber counts were designed around a 16 to 32:1 split ratio taking place in fiber splice pedestals typically located within three to five kilofeet (kft) from the customer premises. Customers were served with outdoor Single Family Unit (SFU) Optical Network Terminals (ONTs) and a host of Multi-Dwelling Units (MDUs), Multi-Tenant Units (MTUs) and Small Business Units (SBUs). All areas were served passively. No Remote Terminals (RTs) or "active" electronics were deployed.

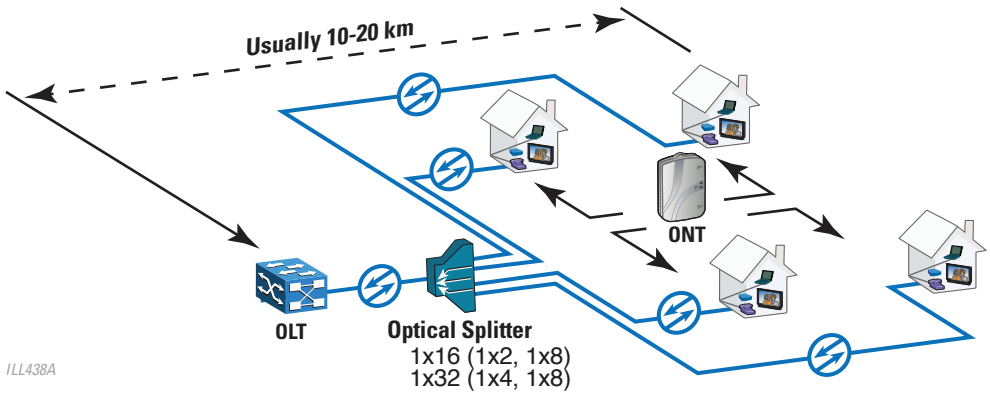


Figure 1: PON Architecture

Lesson 1: Passive vs. Active

Passive all-fiber networks are superior to active all-fiber networks in terms of simplicity as well as operational and maintenance costs. However, that is where the advantages end. Over the last decade, those advantages have been reduced significantly. The ongoing costs of supporting a cabinet's power, batteries and equipment is significant. However, those costs can easily be offset by the flexibility of an active, all-fiber network. For example, a passive fiber network requires significantly more fiber miles and can only replace specific copper networks. An active fiber network can replace AND augment copper at very low costs, resulting in lower maintenance costs and higher performance. This is a very important distinction since ultimately it is the customer who truly decides when to upgrade their service. In addition, fiber placement is best done over several years and budget cycles. However, because of that additional flexibility, the platform used in an active fiber network must be equally flexible or the trade-off value breaks down. In other words, if your active device cannot support your existing and future network services and requirements, you should deploy an all-passive network.

Lesson 2: FTTH vs. Fiber-to-the-Premises (FTTP)

This seems like a minor distinction. It is not. Defining which type of network you plan to build is the key to success. FTTH is a "residential-centric" network largely dependent on video line up. FTTP is a ubiquitous network designed to serve BOTH residential and commercial customers. Simply stated, the fiber access network MUST be capable of supporting residential services with a robust video offering and business customers with features like Quality of Service (QoS), Service Level Agreements (SLAs), survivability, etc. An all-fiber network is expensive and it makes sense to spread that cost over as much revenue opportunity as possible. Digital Loop Carriers (DLCs) are a great example. They supported Plain Old Telephone Service (POTS), Specials, T1, etc. from the same system over the same protected fiber. Can you imagine how much more expensive the deployment would have been if planning engineers had to place separate fiber routes and remotes for residential and business traffic?

A platform capable of serving both residential and business customers should also be able to support Internet Protocol Version 6 (IPv6), Multi-Protocol Label Switching (MPLS) and Carrier Ethernet 2 (CE 2.0). This is just a fancy way of saying you will need a platform capable of switching and transporting a growing number of IP addresses and traffic at TDM SONET levels of quality, survivability and testing. The days of IP traveling at "best-case" levels are nearing an end. The customer wants the ease and flexibility of an all-IP network, but will be expecting TDM quality. Unfortunately, PON is not suited for this technology. Active Ethernet (AE) or dedicated fiber is the best solution for business customers and will grow in popularity for some residential customers as bandwidth, home-grown businesses and the number of home devices increase over time.

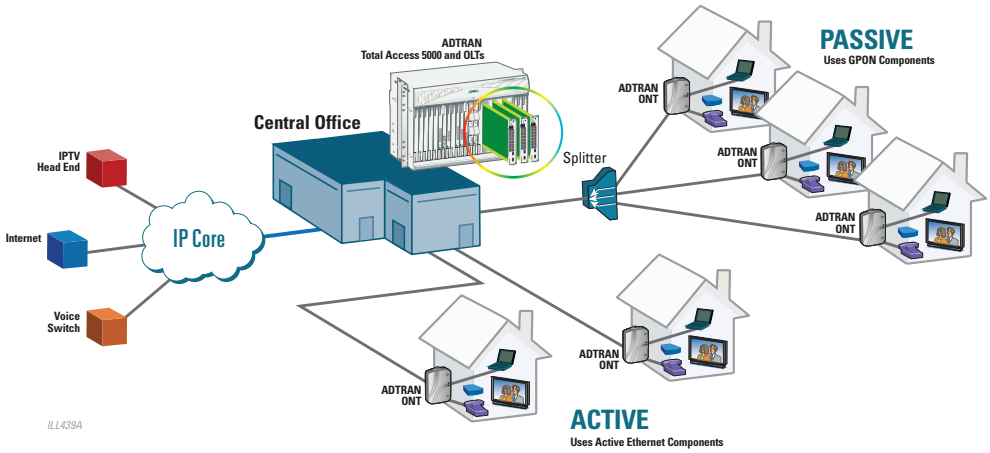


Figure 2: PON and Active Ethernet Architecture

Lesson 3:
The First Rule in Planning

No matter how much time and money was put into laying out a network, the first rule in Outside Plant (OSP) planning is: "The plan will be wrong". Nothing against planning engineers, but it is important to remember that planning is a very difficult task. It requires the ability to stay within a budget and lay out enough infrastructure in an area to serve all customers for the next couple of decades. This is not easy!

If the telecom provider deploys a platform that again has the flexibility to support unforeseen growth and changes in the network; then it is OK for the OSP planners to be human. More specifically, due to FTTP, the OSP will experience much of the same bandwidth challenges as the inter-office network. Therefore it is time the OSP engineers start learning the same terms commonly used by today's inter-office transport planning engineer. The use of Course Wave Division Multiplexing (CWDM), Dense Wave Division Multiplexing (DWDM) and Reconfigurable Optical Add-Drop Multiplexing (ROADM) should become commonplace in the OSP. Essentially, these are tools to deliver service over the least amount of fiber just as T1 was a critical tool for copper pair gain.

Let's use the passive fiber network as an example. It has large buried or aerial routes of fiber that leave the CO going to fiber splice enclosures or essentially optical F2 termination points. Depending on customer and bandwidth growth as well as the types of service, the passive fiber plant can only adjust the number of splits and the OLT bandwidth to meet the needs of any given route. An active network can not only use those same tools, but can also take advantage of Wave Division Multiplexing (WDM) to increase the number of routes per fiber.

AE to segment an individual fiber for a dedicated type of service (i.e. business, cell tower, etc.) and multi-degree ROADM to take advantage of multiple routes. Figure 3 is a common diagram for inter-office transport. That same capability could also be used in the OSP. Instead of connecting COs, Figure 3 could be an OSP diagram connecting a CO (on the left) through multiple remotes to provide a customer (on the right) with service. The route was configured based on the best path and least overall fiber, allowing them to avoid new construction. If the customer was a cell site, that connection could easily be just a wavelength in this configuration. RTs capable of multiple routes not only make connectivity easier, but survivable as well.

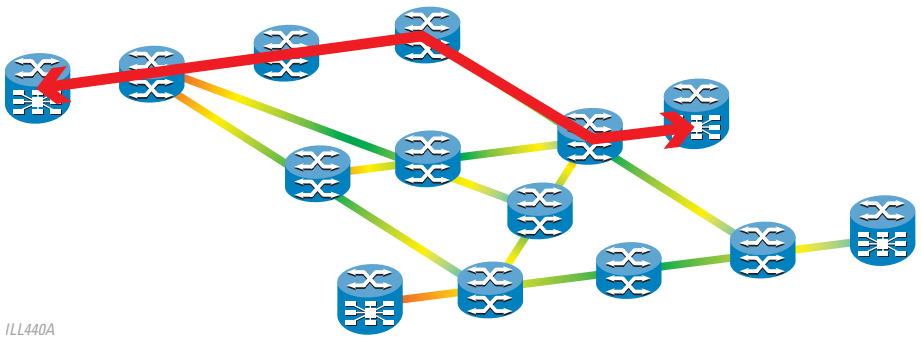


Figure 3: Multi-Degree ROADM with WDM

Lesson 4: Modernize Your Existing Network

One of the main reasons Verizon deployed an all-fiber passive network was to lower operational and maintenance costs. However, as stated earlier, a completely passive fiber network does not easily lend itself to replacement of embedded copper. Even though Verizon replaced some of its copper plant; the cost of maintaining the remaining locations (cabinets, crossboxes, etc.) was escalating. Those remaining locations continue to exist mostly due to budget constraints, location and service mix. But like any other aging asset, they grow as a percentage of the total maintenance cost.

Consider Figure 4. How many of these cabinets exist in your network? What do they cost to maintain? What is their total service revenue? The answers to these questions are not usually positive. This is why you need to use the deployment of an active, all-fiber network to enable the modernization of your existing network. Deploy a platform that not only has service flexibility (i.e. POTS, T1, xDSL, Specials, Active Ethernet, xPON, etc.), but slot availability as well. As an example, imagine a RT serving around 200 customers in a 5 kft Carrier Serving Area (CSA). Two slots of Gigabit Passive Optical Network (GPON) should cover the area, right? What if some customers want to stay on Asymmetric Digital Subscriber Line (ADSL)? What if some customers just want POTS? What if a new MetroCell site pops up and needs Symmetric High-Bitrate Digital Subscriber Line (SHDSL) or Very-High-Data-Rate Digital Subscriber Line 2 (VDSL2)? What if a business customer wants a direct Ethernet connection? What if you need to add CWDM to the shelf to carry fiber from another RT location? What if you want to remove some old DLC sites and collapse the traffic into this new node? All of this boils down to…**more slots**! This is where single-purpose shelves and service blade technologies break down. They lack the ability to be truly flexible from a service mix standpoint. Moreover, to meet the service mix they need to be rearranged or reconfigured causing outages and additional maintenance requirements. New services and old services need to coexist to improve customer satisfaction and drive down maintenance costs (ex. removing old cabinets, closer serving areas, etc.). It is a win-win situation as long as you have an access platform with a wide service array and enough slots.

Figure 4: Cabinet Versions

Lesson 5: SFU vs. MDU vs. MTU vs. SBU

Working to have ONTs fit a specific FTTP deployment is a difficult task. All too often the telecom provider sees this as purely an ONT/mechanical/cabling issue rather than a market issue. For example, what is the difference between serving a single-family home and a small business like a dry cleaner? Not much. However, a quad-plex apartment and a 100-unit high rise are very different. FTTP deployment is NOT about fitting a particular type of ONT to a particular dwelling. It is about finding the right solution for a particular market and sometimes ONTs may not be suitable solutions. Moreover, it is a misperception that FTTP lowers operational support complexity. Actually, deploying ONTs (especially multiple versions), increases support complexity.

New technologies that have become mainstream over the past decade can help with the selection of a solution for a particular market. The biggest is Wi-Fi®. This improvement has solidified the solution for the SFU market making it a must to place ONTs indoors, either as media converters or residential gateways. It also plays an important role in large apartment complexes when delivered from Wireless Access Points (WAPs) throughout the building, including common areas.

Using VDSL2 for service delivery over copper wire can aid with speed to market and help avoid the costs of installing CAT-5 or fiber to every unit in the less competitive, smaller MDU/MTU (MxU) market. However, it should be noted that due to the "transient" nature of the MxU market; it makes a great deal of sense over the long term to rewire every MxU dwelling with CAT-5 or fiber cable even at the high expense. It is critical to have a successful MDU strategy to have a successful FTTP deployment since MDUs represent a substantial portion (~30 percent) of the residential market (see the white paper "*Multi-Dwelling Units: The Pathway to a Successful FTTP Deployment*")

It is also critical to remember which services are important where and the changing trends of those services. The take rates of landline TDM voice are dwindling in the residential market. However, many telecom providers deploy ONTs to support that service. It would be wise to use residential FTTP deployments as a means to introduce Voice over IP (VoIP) service and begin turning down traditional Class 5 TDM switches (i.e. Lesson 4). This is especially true in the large MDU market where ONTs are not the best solution and VoIP can enable a superior solution.

Even after all the expenses Verizon experienced deploying an all-fiber network, the video was at best, as good as the competition. Therefore, it was a classic case of a newcomer with a comparable offering trying to win against well-entrenched competitors. However, one thing has changed dramatically over the last 10 years. The traditional means of watching TV has been challenged by on-demand offerings from Google, Netflix and iTunes. This means that the future of TV is likely to shift from a multicast model to a unicast model. Content, choice and bandwidth will become the new requirements for video and will be achieved through the data stream. The service capable of supporting this new application is called the Ultra High-Speed Internet (UHSI) and it is important that your FTTP network be designed to support it.

Summary

Passive advantages are declining, while active advantages are increasing.

The lessons learned from Verizon's FTTP deployment are helpful to other telecom providers. The First Lesson is that although passive is an attractive architecture its advantages are dated. Costs of deploying and maintaining active equipment are declining. Moreover, the advantages of an active architecture have grown over time. New features and flexibility continue to "tip the balance" toward an active fiber network. That trend should continue.

FTTP networks share both residential and business traffic.

The Second Lesson is all about deploying a FTTP network where the goal is connecting all customers over the same fiber network. This means supporting both residential and business traffic over the same access platform. It also means being able to support the technology and standards required for business applications and their various levels of service quality.

CWDM, DWDM and Multi-Degree ROADM are FTTP fiber pair gain tools.

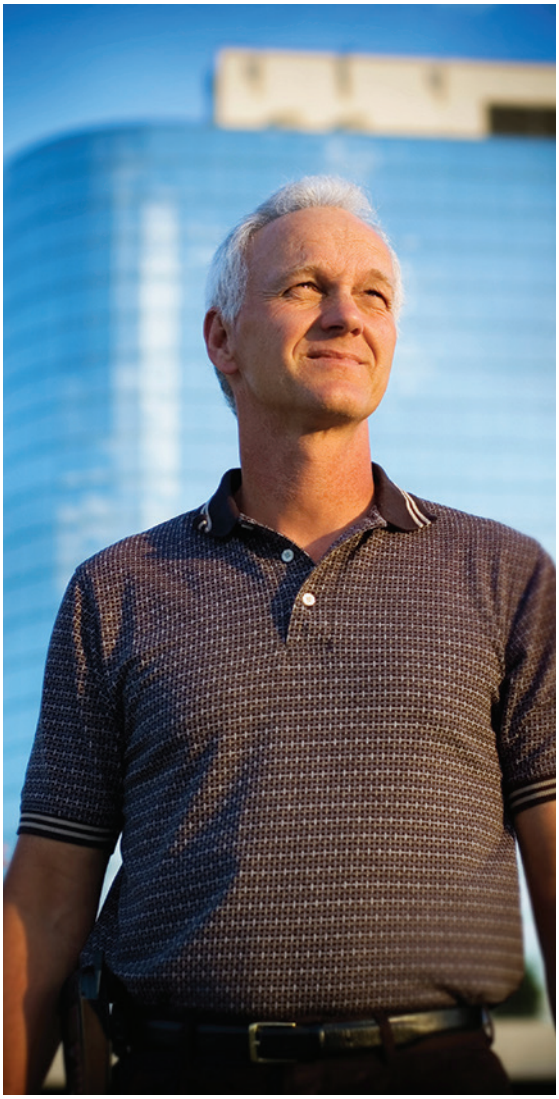
The Third Lesson is rooted in understanding that fiber is VERY precious in an all-fiber network. Not using tools like CWDM, DWDM and Multi-Degree ROADM in fiber access networks is the equivalent of not using pair gain in copper networks. They are fiber pair gain tools and are used every day in the interoffice network.

Lowering maintenance costs takes flexibility, a wide service mix and "lots of slots".

The Fourth Lesson is all about taking advantage of the opportunity to lower maintenance costs while deploying an FTTP network. However, this also means your platform must be able to support both legacy and new services in any combination. Therefore, lowering maintenance costs takes flexibility, a wide service mix and "lots of slots". Moreover, a good motto for your planning engineers to make part of their process is "when you are going to place a new cabinet look to see if you can retire two existing ones".

The right FTTP solution may not use an ONT or even PON.

The Fifth Lesson is remembering that FTTP is not about ONTs. It is about addressing each type of service and market with the right technical solution. The right FTTP solution may not use an ONT or even PON. What is important is to be successful in every sector of the FTTP market.



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