FiberZone Networks

White Paper

The Impact of Automated Fiber Management on FTTH Deployment and Operations

July 2008

Introduction

Competition for consumer voice, video, and data (triple play) services has sparked a massive build-out of high-speed access services worldwide. Until recently, traditional telecom providers and cable operators have largely favored leveraging their installed base of copper, by investing in xDSL and hybrid-fiber-coax networks.

Increasingly however, these operators and a growing number of municipalities have recognized that only the virtually unlimited bandwidth of fiber will provide a future-proofed network to serve all consumer needs. Consequently, fiber-to-the-home (FTTH) networks have gone mainstream and are being deployed in volume around the world.

A successful FTTH business model is heavily dependent on carriers' ability to manage costs, typically measured as costs per home passed and costs per home connected. Much attention has been paid in recent years to the capital expense required to deploy FTTH. The explosion in FTTH deployments over the last few years has facilitated a steep decline in optics costs. Carriers are now beginning to find, however, that their ability to serve customers – to provision, manage, and troubleshoot live connections – is limited not by capital expense but by operating expense.

In a typical FTTH deployment, up to 40% of the costs are associated with the labor required to deploy and provision the outside plant. Most of the provisioning labor cost is required for technicians – usually working in pairs – to manually connect drop cables to newly-signed subscribers. This burden will increase substantially as deployments go from the millions to tens of millions.

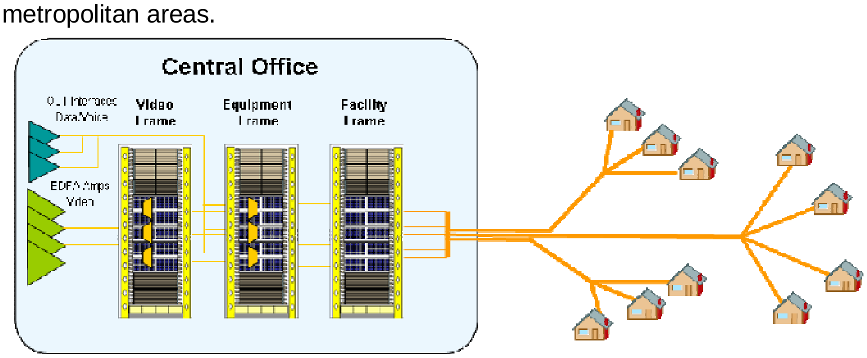
With capital expense decreasing and operating expense increasing, the only effective way to manage FTTH costs is to minimize labor requirements. Specifically, it is imperative to minimize the need for technicians to be deployed into the field to manually provision, test, maintain, and troubleshoot the network.

Automated fiber management (AFM) can play a meaningful role by reducing truck rolls and technician labor, and minimizing the need to manually touch the network. AFM enables FTTH operators to reduce rack space, eliminate labor requirements, minimize capex, and facilitate testing and maintenance. AFM significantly reduces operating expense, thereby improving the FTTH business case.

Real Estate Savings: Reduced Rack Space in the CO

Figure 1 depicts a representative fiber access configuration today, in which video is delivered via analog overlay. Video signals from EDFA amplifiers are de-multiplexed, combined with voice and data signals from optical line terminal (OLT) interfaces to form the combined triple-play signals, and then connected to the outside plant. This configuration consumes a great deal of of rack space and requires a large number of patch cords, which will become increasingly problematic as FTTH deployments roll out in greater volume, especially in crowded metropolitan areas.

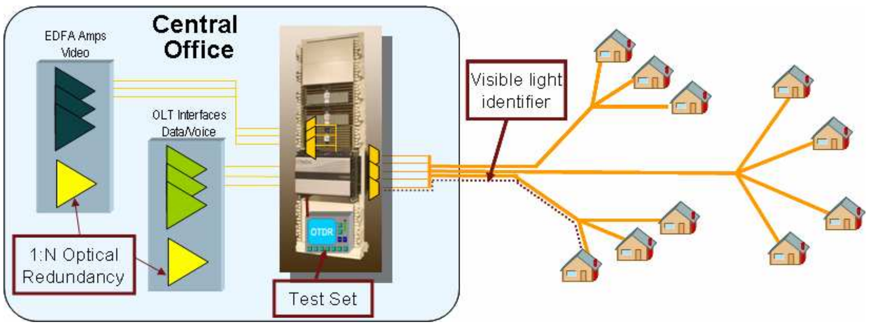
Figure 1.



As shown in Figure 2, AFM can save considerable space by performing multiple functions in a single frame. A complete solution consisting of WDM couplers and the AFM system is integrated into the frame. Demultiplexed video signals and voice/data line cards (in addition to 1:N protection cards and FTTH test sets, discussed further below) are all connected into the AFM system. The AFM system combines voice, video, and data interfaces to generate each set of FTTH signals. Outside plant fiber is connected to the outbound side of the AFM system.

Fiber frame utilization in the FTTH CO can therefore be dramatically improved. The integrated systems also eliminate many patch cords that would otherwise be required.

Figure 2.



Network Uptime and Quality of Service: Remote Testing and Cost-Effective Redundancy

Network uptime is a key operating parameter for FTTH operators. Carriers specifically want to minimize:

- Frequency of network outages
- Time required to restore service

AFM's position at the critical connection points of the FTTH network makes it the ideal platform to improve quality of service, offering a number of critical capabilities (each depicted in Figure 2):

- Periodic monitoring
- Remote troubleshooting
- Rapid feeder fiber discovery
- Cost-effective 1:N redundancy

In today's FTTH networks, high-skilled technicians must be sent urgently into the field when a network outage occurs. Technicians in the field and CO must work together to manually locate the fault and troubleshoot the problem. This can dramatically increase the amount of time before service is restored. In addition, the network operator generally has no ability to anticipate faults; the "alert" system is typically a call from an angry customer.

By connecting FTTH test sets to AFM systems in the central office, the network operations center can observe network degradations before outages occur, thereby anticipating and potentially addressing the underlying problem before service is disrupted. Testing capabilities are made available to FTTH facilities from the network operations center, so troubleshooting can be performed before sending any technicians into the field.

When signal degradation is detected (either via dedicated test signal or FTTH equipment), it can be tracked to determine if an outage is likely to occur. In such a case, additional investigation can be performed to troubleshoot and address the problem before an outage occurs, and long before calls come in from customers. AFM can therefore save many hours of network downtime.

When an outage occurs, AFM can be utilized to perform remote troubleshooting. For example, the impacted fiber can be connected remotely to an optical time domain reflectometer (OTDR) to perform an OTDR trace and locate the fault. Technicians can then be efficiently dispatched directly to the location of the fiber break.

An additional benefit offered by AFM during maintenance and repair operations is the ability to rapidly identify the problem fiber in the field. With feeder fiber counts running into the hundreds, it can be a challenge for technicians to identify the correct fiber in a manhole or street cabinet. The problem is exacerbated by record-keeping error, a common problem with manually-recorded inventory. Expensive technician time is consumed to discover the fiber and confirm its identity with the network operations center, in order to avoid the disconnection of the wrong fiber and the interruption of service to live subscribers.

With AFM deployed in the central office, the target fiber can be connected to a visible light source in the CO. Upon arrival to the manhole or street cabinet, the technician instructs the operations center to connect the visible light source, enabling the field technician to immediately identify the target fiber.

AFM can also provide cost-effective redundancy capabilities in FTTH deployments. Because of the shared nature of PON networks, the loss of a singe video or OLT line card results in the disruption of service to dozens of customers. However, with carriers under pressure to minimize FTTH capital expenditures, it is not realistic to provide 1:1 redundancy to each of the line cards.

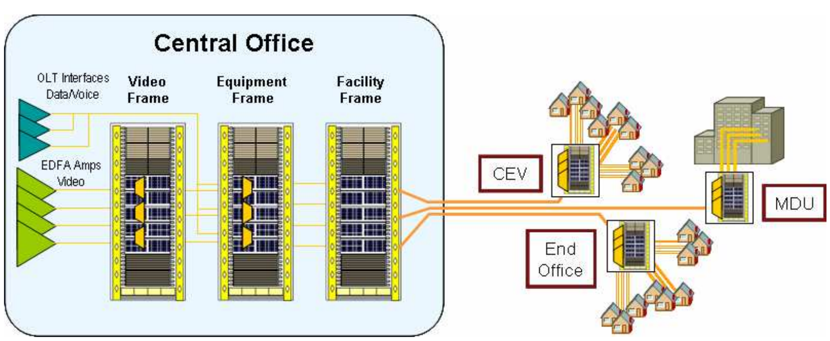
As Figure 2 shows, an AFM-enabled PON can provide 1:N redundancy, with a single spare OLT and video line card made available to all of the PONs. When a line card is lost, the affected PON is automatically and remotely connected to the spare card. Service can be restored immediately and cost-effectively, without requiring a high-urgency truck roll. A technician can be dispatched to replace the problematic line card according to a regular maintenance schedule.

Labor Savings: Automated Provisioning and Pre-Provisioning Testing

While Moore's Law, increasing volumes, and improved optics manufacturing and integration will continue to drive down capital costs, labor-intensive provisioning and maintenance activities will put pressure on opex. The only way to control labor costs is to reduce the amount of labor required.

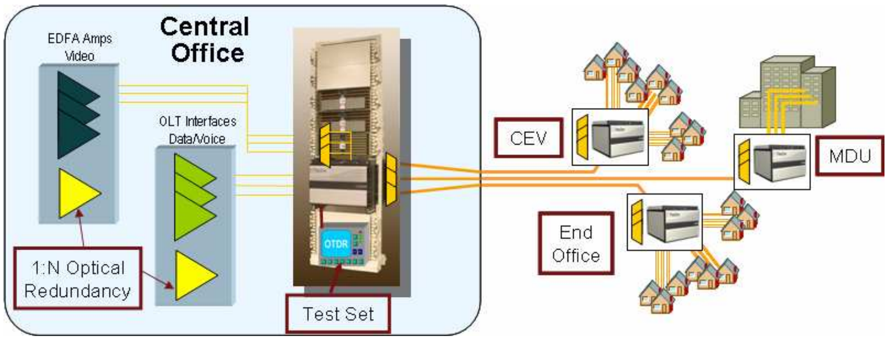
In today's distributed PON FTTH deployments, technicians must typically be dispatched to two locations to provision each new subscriber. One dispatch must be made to the customer's premises, to install a fiber from the drop location to the customer, and to deploy the ONT in the home. A second dispatch must be made to the location of the splitter (see Figure 3), which may reside in the field in a controlled-environment vault (CEV), basement of an MDU, or end office. This technician connects the distribution fiber and performs line testing operations with the CPE-side technician.

Figure 3.



In an AFM-enabled PON FTTH network, automated fiber management systems are deployed in the CO and in controlled-environment splitter locations[1] (Figure 4). The splitters and subscriber side fibers are each connected or spliced to the AFM system. Only one field-dispatch is required to perform the task of connecting the drop cable to the customer premises and install the CPE. Splitter connections and CO-side testing can be performed automatically and remotely from the CO or network operations center (NOC), where higher-priced facilities-based technicians can be amortized across a much larger set of customers.

Figure 4.



When a new subscriber is provisioned, the distribution fiber is connected to the splitter automatically and remotely from the CO or NOC via AFM. Test equipment can be connected automatically from the CO to the appropriate feeder fiber to perform link characterization.

The technician in the CO/NOC first performs test operations and communicates directly with the single field technician at the ONT. If line characterization testing indicates a line performance problem, the field technician can be dispatched immediately to the location of the fault. In most cases, the line condition is positively verified. The test equipment is remotely disconnected from this feeder fiber and the technician in the NOC can connect it to a different fiber and immediately conduct pre-provisioning test operations with a different field technician provisioning a subscriber on another fiber. Meanwhile, the single field technician completes the new customer provisioning operations and moves to the next new subscriber location.

Network operators can also use AFM to enable zero-touch provisioning, in which new subscribers are connected without sending even one technician into the field. In this scenario, drop cables are pre-connected during fiber installation. When a new end-user is to be provisioned, the splitter connection is made automatically to the appropriate drop cable. The CPE is shipped to the subscriber for self-installation, and is auto-discovered by the AFM-enabled network upon initial connection to the network. The zero-touch provisioning may save substantial costs in high-density scenarios such as MDUs, where entry-rights are often difficult to obtain from landlords.

CAPEX Savings: Efficient Population of the PON

About one-third of FTTH deployment costs are associated with active equipment capital expense. The primary benefit of PON's shared network architecture is that it enables operators to spread expensive central office costs across several dozen homes. As well, some incremental costs can be born on a success basis (i.e., when subscriber are signed), such as the customer-side ONT device.

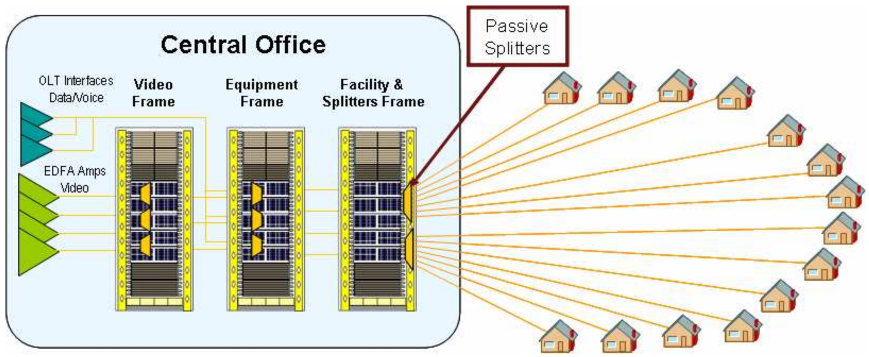
The objective of this architecture is to minimize first costs of the PON. However, the rigid structure of today's

[1] Current generation AFM products can only be deployed in controlled environments. Therefore splitter connections in street cabinets, on poles, or in other exposed locations, can not be automated with current products.

PON architectures actually imposes one particularly burdensome first cost: as soon as a single subscriber on a given PON is turned up, an expensive OLT line card must be provisioned, and this expense will only be amortized across the actual users of the PON. If a 32-subscriber PON achieves 100% penetration, then the OLT card is shared across 32 users. However, experience has shown a more typical penetration rate of around 33% in overbuild environments, where competition exists for subscribers. In this case, the OLT card is effectively 3X more expensive on a per-home-connected basis, which is more relevant to the operator than commonly-quoted per-home-passed costs.

Some carriers have responded to inefficient PON use by concentrating splitters in the central office, as shown in Figure 5. In this architecture, end-users can be connected to one of many PON splitters co-located in the CO. When new subscribers sign up for service, a patch cord is connected to a splitter with an available port. In this manner, the splitters can be populated fully before additional OLTs must be deployed.

Figure 5.

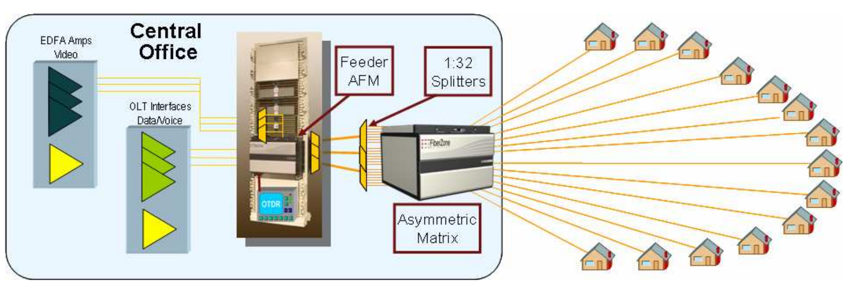


Splitter concentration addresses the issue of efficiently populating the PON, but it raises other concerns. Concentration of the splitters is most efficient in high-density areas, but results in a very large number of fiber ports and patch panels in the CO. Technician labor is consumed during the time-consuming operations of identifying the correct fiber, conducting pre-provisioning tests, and running patch cords, all of which drive up opex.

The implementation of AFM with a flexible splitter architecture results in an optimal FTTH business case, by not only efficiently managing expensive OLT costs, but also by providing all of the operational advantages discussed above. In this architecture, splitters are integrated into asymmetric AFM systems serving multiple PONs.

For example, Figure 6 shows an asymmetric AFM system located in a central office, serving multiple, 32-subscriber PONs. After the network is deployed and the first subscriber is signed, an expensive OLT line card is provisioned in the CO on one of the feeder fibers connected to the feeder AFM system. The network manager connects the new customer’s distribution fiber to the appropriate splitter via the asymmetric AFM, automatically and remotely.

Figure 6.



When a second subscriber is signed from any of the homes connected to the asymmetric AFM system, the new customer can be provisioned on the same OLT line card. In fact, the first 32 new subscribers connected to the AFM system can all be connected to the first OLT card. Therefore, each PON is fully populated before the carrier is required to invest in an additional line card. Churn can be managed with these same OLT line cards, with cancelled subscribers moved remotely off the lit feeder fibers, and new subscribers moved onto them. Grooming operations can also be performed to spread high-use subscribers across PONs, thereby delaying the need to upgrade to higher-bandwidth technology.

It is important to note that such an AFM-enabled PON architecture enables carriers not just to defer OLT costs, but to dramatically decrease capex altogether. Based on a 33% penetration rate, when the “mega-PON” reaches maturity, only 1/3 of the OLT cards will have been required as would have been using an inflexible splitter architecture.

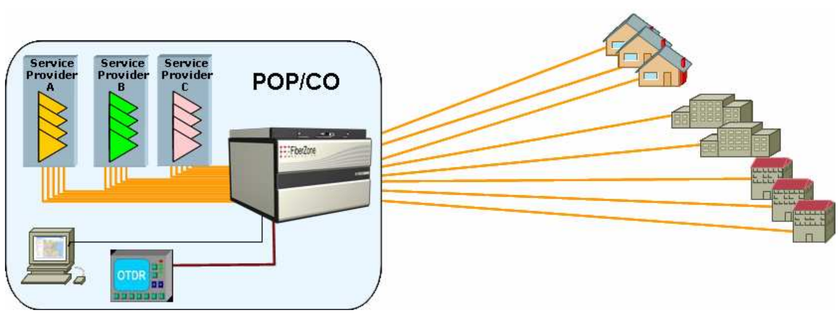
Open Access Networks: Efficient Management of Competitive Service Providers

Some FTTH networks being deployed by municipalities, utilities, and other publicly-financed consortia are designed to provide an open infrastructure over which multiple providers can deliver a diverse array of services. Typically, wholesale networks are deployed in point-to-point architectures, facilitating competition by enabling the network operator to physically connect the end-user to the service provider of his choice.

However, providing such physical connectivity to competitive service providers using manual distribution frames requires the laborious and error-prone manual patching and re-patching of end-user ports. To be cost-effective, the network operator must be able to control the infrastructure end-to-end, without sending technicians to the field for manual connectivity operations.

AFM enables the network operator to connect customers to any service provider co-located in the service POP as shown in Figure 7, without any manual intervention. When an end-user chooses to churn to a different service provider, the end-user port can be physically switched, remotely, to the new service provider.

Figure 7.



Requirements of AFM for FTTH Applications

Automated fiber management (AFM) can offer powerful operational benefits to FTTH deployments. In order to deliver these benefits, AFM solutions must comply with several strict requirements.

First, the insertion loss must be very low. The optical power budget of today’s PON network is very tight. PONs are typically designed with total power budget of between 25 to 30 dB. Losses from splitters run around 16 dB, from WDM couplers 1 dB, fiber loss up to 5 dB, and analog video around 4 dB. There is very little loss available for connectivity and splices. For AFM solutions to be acceptable in FTTH applications, the insertion loss certainly can not exceed 1 dB.

As well, uptime is critical. FTTH networks are deployed to end-customers without redundant paths. Any outage in the network means angry customers and lost revenue. Since AFM would be deployed in place of manual connectivity products, it is imperative that AFM does not introduce an additional point of failure. Specifically, connectivity can not be dependent on power or any active components. AFM must be able to maintain connections in all scenarios via a passive latching mechanism. The latching mechanism must also protect customer connections during any AFM servicing process.

AFM systems that meet these requirements can improve FTTH operations in a variety of aspects discussed in this paper:

- Faster time to revenue
- Reduced provisioning times
- Fewer truck rolls and direct labor savings
- Remote testing and troubleshooting
- Minimized downtime and fewer outages
- Efficient use of capex and central office space
- Cost-effective open network access
- Accurate record keeping