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# Splicing vs. Connectorization in FTTP Networking

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Deploying a successful fiber-to-the-premise (FTTP) network requires careful planning and execution. It is clear after many years of trials that FTTP is here to stay. Taking FTTP networks from the lab/field trial mode to full-scale network deployment presents many significant challenges for service providers. One of these challenges is deploying the network for the lowest possible cost, while creating a fiber network infrastructure that has the flexibility and reliability to last long into the future.

When network visionaries first began looking at deploying FTTP (or FTTH as it has also been called) networks more than 10 years ago, they were focused on a fiber network that was all spliced. That is, every junction in the fiber network from the central office to the subscriber was made via an optical splice. At the time, the primary justifications for this mindset were cost and concerns regarding the reliability of optical connectors in OSP environments. While splicing the entire OSP fiber network is going to provide the lowest initial equipment cost, the reality is that those cost savings will quickly be lost to increased operational expenses and reduced network flexibility. The use of fiber connectors inside the central office for connecting fiber network elements has long been standard practice. Service providers around the world have realized the value that connector interface points provide in the network when it comes to troubleshooting the network, re-configuring the network, and turning up services. Similar benefits can be realized in the OSP portion of an FTTP network when connectors are properly placed in the OSP network.

Let's take a look at a general FTTP fiber network architecture outside the central office (see Figure 1). The network consists of feeder cables routing to a fiber distribution hub (FDH) where the optical splitters are housed. From the FDH, a distribution cable will route to the access terminal (FAT) where the drop cables will tie in. From the FAT, the drop cable will route to the optical network terminal (ONT) at the subscriber premise. Throughout this network, there will be many locations where fibers will need to be joined together. Along the feeder and distribution cable runs, where an in-line splice is normally used, that would still be the case. The locations that are of interest for optical connectors are at the FDH, the FAT, and the ONT. What we are looking for is locations where technicians will need to go on a more regular basis to test, turn-up, and re-configure services. These are locations where having a connector interface will provide significant operational cost and time savings advantages over fusion splices.

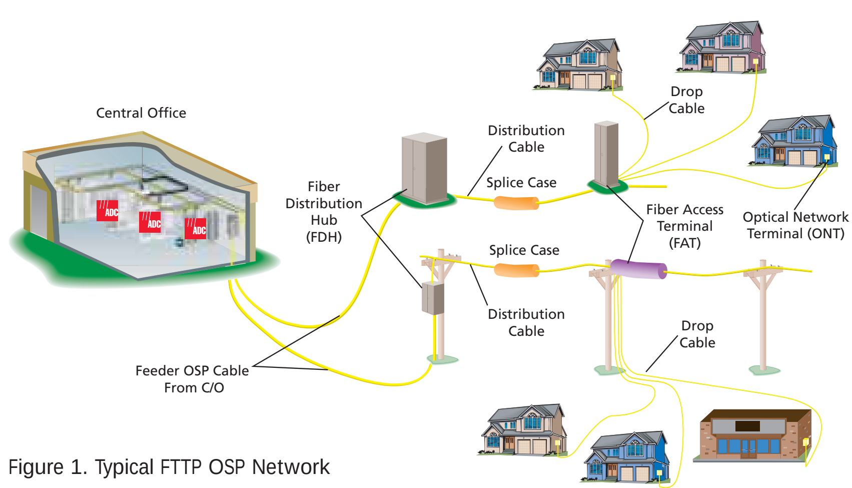


Figure 1. Typical FTTP OSP Network

## Easier Test Access

The first consideration for replacing a splice with connectors is the need for test access points. Fault isolation in an FTTP network presents new challenges for a service provider. Typically, fault isolation in a fiber network involves using an optical time domain reflectometer (OTDR). The OTDR trace will tell a technician where the fault is located within the fiber network. There are two key challenges that FTTP networks pose to technicians when it comes to fiber fault isolation. The first involves the 1x32 optical splitters that are used to minimize the number of optical line terminals (OLT's) used in the central office. OTDR traces are difficult to decipher once the trace hits the 1x32 splitter in the FDH.

The second challenge involves accessing the fiber without taking up to 32 subscribers out of service to test a network when only one subscriber has a problem. In a scenario where more than one subscriber served by a splitter of FDH is reporting a problem, the problem is most likely somewhere between the OLT in the C/O and the FAT in the field. In this case accessing the fiber network inside the central office will provide a good look at the network from the OLT to the FDH. However, testing the network from the FDH to the subscriber will require a truck roll. This is the point where network design will have a significant impact on how quickly the problem can be isolated.

Putting the test access points at the ONT on each home requires a technician to tap into a network interface device at each individual residence. These interface points may not be easily or readily accessible. However, using the splitter output in the FDH as a centralized demarcation box provides a single location with test access to any fiber for multiple homes, thus allowing easy access to the network between the FDH and the ONT. In an application where the splitter is spliced into the network, a splice technician will have to be sent to the FDH location and break into the appropriate splice between the splitter output and the distribution cable, connecting the OTDR launch cable with a bare fiber adaptor or temporary splicing in a pigtail. Once the trace is done, the technician has to then re-splice the splitter output to the distribution fiber. This process can be very time consuming and costly as splice technicians and their equipment are billed at a higher rate than other technicians.

This procedure also poses a significant danger to the network. The process of accessing the distribution fiber to run an OTDR trace requires the technician to manipulate several fibers and break the fibers that are to be tested. The fibers then need to be spliced back together. This process will shorten the lengths of fiber available and there is a risk of breaking the fiber to a length that is too short to work with, thus stranding some of the networks capacity. With the additional time, cost, and risk to the fiber required to test from this particular location, a spliced connection simply doesn't make the most sense.

With a connector interface placed at the splitter output, easy test access is achieved for all of the distribution cables. In this case, test access is just a matter of locating the suspect distribution fiber on a bulkhead, disconnecting the splitter output pigtail from that port and plugging in the OTDR launch cable. Once the ODTR trace is done, the launch cable is disconnected from the distribution port and the splitter output pigtail is re-connected. In this procedure, no fibers are broken and no splicing is required. Also, in this application, since all of the splitter output fibers are connected to a bulkhead they are protected with protective jacketing that prevents them from being damaged during normal handling. Connector pairs in the FDH enable easier, less time-consuming testing, as well as lower labor rate requirements and much less risk to the fiber network.

## Faster Service Turn-up

Service turn-up is another area offering a benefit for using connectors rather than splices in certain locations of the network. There are two locations where connector interfaces provide service turn up advantages, at the FDH and the FAT. Splicing all the optical splitter outputs to the distribution cables and the distribution cable to the drop cables may seem to make sense in a greenfield application with a 100% expected take-rate. But the reality is that the homes will not be occupied from day one and service turn-ups will not occur all at once.

In a brownfield, or overlay, application with a take-rate of less than 100%, it makes sense to deploy splitters one at a time as needed and to have easy access to the distribution fibers for fast service turn-up. In a splicing scenario, a splice technician must be deployed on a regular basis to splice a single fiber in the FDH and FAT every time one customer requires service turn-up - an expensive proposition in terms of equipment, training, and manpower requirements. When connectorized interfaces are used at the FDH and FAT's, service turn up is a much simpler process. Distribution fibers are simply plugged into the splitter output in the FDH and drop fibers are plugged into the distribution fibers in the FAT and service turn-up becomes as simple as mating two connectors.

## Network Implications

As discussed, having connectors at certain locations in the OSP segment of the FTTP network is valuable, but having them at every location where fibers meet is not cost effective. Connectors should only be used at locations where they can add value to the network without adding additional cost or loss points. A major issue in using connectors, aside from more initial expense, is loss budget concerns.

There are three common architecture options for using connectors in the FDH field. The first is to provide a full crossconnect within the FDH. In this scenario, shown in Figure 2, the incoming feeder and distribution fibers are factory terminated and loaded to the rear ports on a bulkhead in the FDH. The 1x32 (or 1x16) splitter is also factory terminated with the input fiber connecting to the feeder fiber and the outputs connected to the rear ports on a bulkhead. The splitter output ports are then connected to any distribution fiber via a cross connect patchcord.

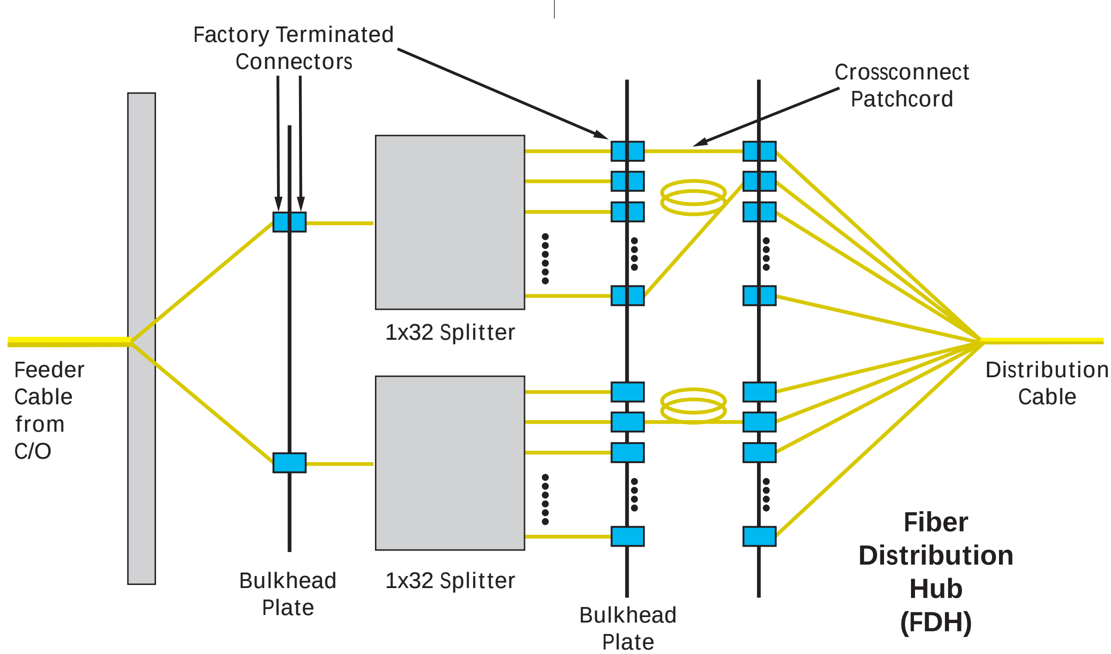


Figure 2. FDH Full Crossconnect Splitter Layout

In this application, the splitter modules are also added on an "as needed" basis simply by plugging the input and output connectors into the appropriate locations. Although this architecture offers the ultimate flexibility with completely accessible fibers, the downside is the added cost and the added signal loss of three connector pairs. The additional loss can be as much as .6 db in a FTTP network that may need to be stretched to its distance limit. The result could be up to 1-1/2 km of distance loss or a substantial number of unreachable homes. Therefore, although the full crossconnect adds substantial flexibility and protection for the optical splitters and OSP cables, it may not justify the cost - both in dollars and db loss.

An alternative architecture solution would be to use pigtails at the optical splitter output to connect directly to the distribution fiber ports. In this case, the optical splitters are loaded into the FDH on an as needed basis. The 32 output ports from each splitter are put into a "parking lot" configuration within the cabinet. In the parking lot, connectors are protected with dust caps until being assigned to distribution fibers on demand. a service order is issues, the technician simply goes to the cabinet and accesses the next available splitter output port and plugs it into the distribution fiber port - turning up service by simply mating a pair of connectors. In this scenario, the optical splitters are still added as needed, minimizing up front equipment costs and maximizing OLT usage efficiency.

This scenario provides ample flexibility and the up-jacketing provided on the splitter out-put ports provides considerable protection from damage during routing. An optimum balance is provided between cost and operational efficiency by using just two connector pairs, thus lowering cost and db loss.

A third scenario deals with high power required by the video signal to drive the receivers at the customer premise. The analog video signal leaves the central office with relatively high power and reaches the splitter in the FDH with a power level around 20dBm. This high power level at the splitter input port can create a potential laser eye safety issue for technicians. Therefore, the decision is whether or not to have a connectorized interface at the splitter input.

In order to eliminate this potential safety issue from the network, the input to the optical splitter could be spliced. Although less flexible than the two connector pair scenario, this architecture would still have a connectorized splitter output for easier test access and on-demand service turn-up at the distribution end. This scenario reduces cost, lowers db loss, and eliminates the high power laser safety issues. However, it still requires a splice technician to be present to add splitters to the FDH, mitigating some of the sought-after cost savings.

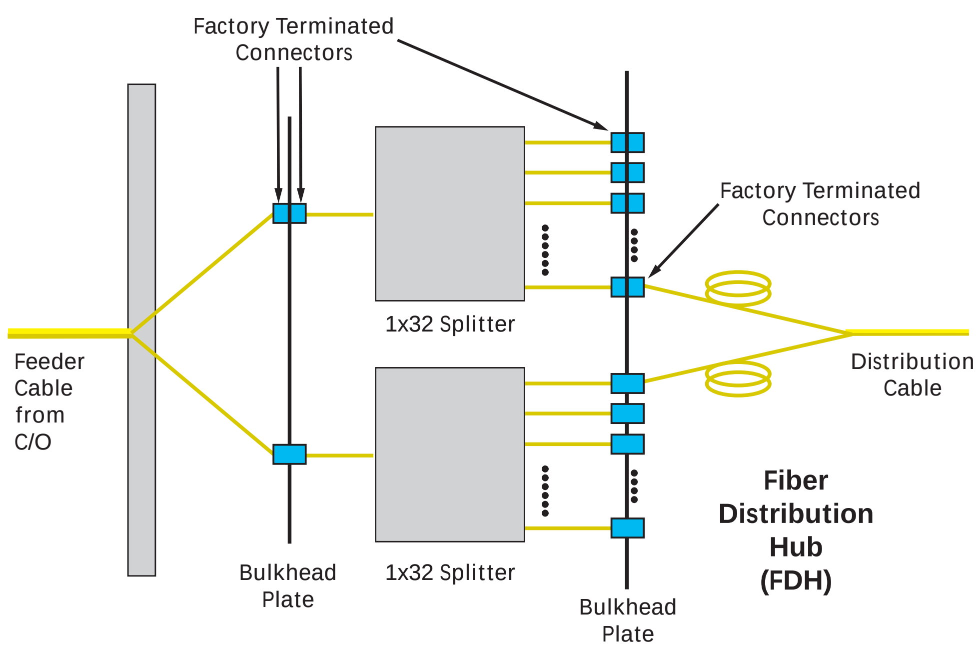


Figure 3. FDH Optimum Splitter / Connector Configuration

## Long-term Performance

The goal in any network is to achieve the right balance between up-front initial equipment costs and the operational costs involved in long-term performance of the network. Connectors are always more expensive than a splice in terms of initial equipment costs. However, network planners must look ahead to operational costs for service turn-up to individual customers and easy test access. Using connectors where they make the most sense in the network justifies the initial equipment costs by saving operational expenses over the life of the network.

Vast improvements have taken place in fiber-optic connectors over the years that have improved their performance in the network. Higher performance standards and manufacturing improvements have resulted in lower insertion and return loss, automated tuning, superior endface workmanship, and vastly improved factory termination methods.

Several studies on connector performance have been done over the years and Telcordia GR-326-CORE addresses connector performance requirements in OSP applications.  ADC put its connectors to the ultimate test back in 1995. On a rooftop in Minneapolis, Minnesota, a series of fiber connectors were exposed to the harsh Minnesota climate for five years. Enduring temperatures ranging from -43 degrees F to 137 degrees F, each connector was automatically performance-tested every hour. Despite the severe extremes in weather observed in Minnesota, the connectors performed within the manufacturer specifications through the duration of the test. Over the years technical design and manufacturing improvements have been made on optical connectors to ensure that they will continue to perform reliably in a wide variety of environments.

Today's next generation connectors have a proven track record for successful deployment in OSP applications. In a more competitive business environment, there is little margin for error when deciding to splice or connectorize the FTTP network. Although the majority of connections will still be spliced together, replacing some of those splices or interfaces with connector pairs will provide additional flexibility and test access - and improve turn-up time to the customer. Superior long-term network performance is achievable for the FTTP network that deploys connectors where they make the most sense. The sensible use of connectors will result in optimal performance while providing cost and flexibility benefits that cannot be attained through splicing alone.

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