

Optimizing the Fiber Distribution Hub: Radial Layout, Short Jumpers, Easily Upgradeable Splitters

Can PON fiber management be simple, flexible and cost-effective? Advances in fiber technology, along with a rethinking of design, offer new solutions.

By Guy Swindell ■ OFS

For as long as fiber optics has existed, so has fiber management. The most sophisticated networks in the world would be useless if a thin filament of glass could not be properly routed, protected and traced from its origin to its destination. This is even more true for fiber-to-the-home networks because of the sheer volume of fiber and the amount of route diversity. In FTTH applications employing passive optical network (PON) technology, the difficulties of fiber management are further complicated by optical splitters and by the challenge of managing unknown take rates. In response to this complexity, of course, a new system for managing outside plant was developed: the fiber distribution hub (FDH).

The FDH is a simple box that houses multiple optical splitters, and to which multiple subscribers are routed for connection to those splitters. The smallest FDH might house three optical splitters and serve up to 96 customers, while the largest might support 27 splitters or more, and 864 customers.

The most common FDH typically houses a maximum of 9 splitters and supports up to 288 customers. FDHs are designed to be installed outdoors; they are all passive devices (no power required); and most of them can be installed on a pole, on a pad, or on top

of a vault. Regardless of size or design, the FDH represents one of the greatest opportunities to either succeed or fail miserably in developing a network with long-term viability.

DISTRIBUTED VERSUS CENTRALIZED ARCHITECTURE

To understand the functions and features of the FDH, it helps to first understand the economics driving FDH deployment. One of the most beautiful features of PON technology is the flexibility it offers for splitter deployment. That same flexibility is also one of the most exasperating features of PON. Designers can employ many creative techniques to reduce fiber counts and splicing costs in the outside plant. Frequently, they do this by deploying a “distributed” architecture in which the optical splitters are placed as close to the subscribers as possible and spliced directly into the network (Figure 1).

A distributed architecture usually makes sense for many reasons, and is the best option for many applications. Carriers ranging from NTT – Japan’s largest phone company – to small telephone companies in North America have all used distributed architecture to good effect.

The trouble with a distributed architecture begins with the first sign of competition. If a carrier is not the only game in town, it is not likely to get every subscriber to connect. So if we splice a 1x32 splitter as close to the customers as possible, only half of that splitter capacity (16) will be used if there is a 50 percent take rate for the service. Since optical splitters are relatively inexpensive, this might not be a problem – except that every unused splitter port in a distributed architecture translates into unused capacity at the central office. The per-subscriber cost at the central of-

A fiber distribution hub allows efficient use of splitters and line-card ports even when the take rate is low. This is useful in a competitive scenario, where not all customers may sign up for service.

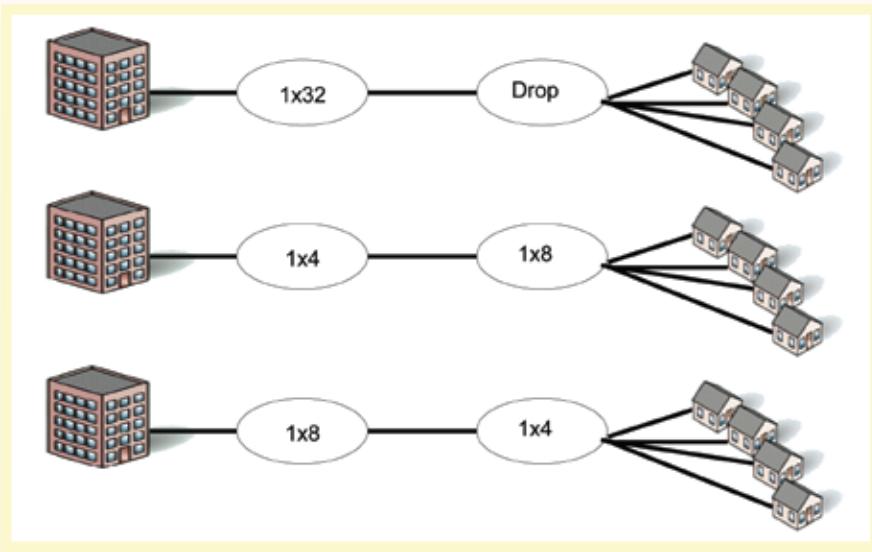


Figure 1. Distributed PON architectures.

office is \$250, then a 50 percent take rate means that \$4,000 of capital expense at the central office will be squandered.

The most common answer to this dilemma is the “centralized” architecture (Figure 2) and the FDH that accompanies such a design. By routing 288 subscribers back to one central location, we now have nine times as many potential subscribers to connect using a 1x32 splitter. So we have much greater odds of fully using our splitters and central office equipment even if we only have a take rate of 50 percent, or lower.

CLEANING UP THE CLUTTER

Understanding the primary function of the centralized architecture reveals both the promise and the ugly truth about the FDH. Originally, fiber management occurred at the central office and was a simple, direct affair. A handful of experienced technicians routed fibers in an orderly fashion from switches and rou-

ters to a rack of fiber termination shelves. This is far removed from our scenario with the FDH.

First, subscribers must be provisioned at the FDH as they sign up for service. This means that multiple technicians of various experience levels are accessing the cabinet with a high level of frequency. Second, and more importantly, the FDH exists because of the unknown take-rate variable; therefore, almost by definition, subscribers will be connected in a haphazard fashion. A situation where multiple technicians have frequent access to haphazard connection patterns is going to be messy – very messy. Not surprisingly, field reports indicate that, when technicians are troubleshooting the outside plant, they often find the FDH to be the source of the problem.

How do we clean up the mess in the FDH and make FTTH more manageable? The need for frequent access by

multiple technicians and the haphazard connection pattern are not likely to go away anytime soon. The best option is to simplify the process inside the FDH. If too much fiber and too random a connection pattern are the problems, and the random connection pattern is a constant, then we have to ask whether the amount of fiber can be reduced. Once, the answer to that question would have been an emphatic “no.” However, time and technology have created new possibilities.

The number of subscribers served by a FDH is dictated by its design. If we need to serve 288 subscribers out of a cabinet, then we need at least 288 jumpers to connect those subscribers. No clever design options will reduce that number. However, we could consider the possibility of shortening the jumpers. Obviously, it is easier to trace and manage a 2-foot jumper than a 2-meter jumper. Furthermore, a cabinet full of 2-foot jumpers would be less likely to have jumpers broken by a closing door, jumpers hopelessly intertwined, or jumpers improperly routed in a vain attempt to contend with excess fiber length.

TWO BREAKTHROUGHS ALLOW SHORTER JUMPERS

So why have we not always used 2-foot jumpers in every FDH? For one thing, old standards support outdated optical fiber technology. Telcordia GR449 specifies that single-mode jumpers such as those used in FTTH should be at least 6 feet long so as to prevent intermodal noise from limiting network performance.

Many people are familiar with the 6-foot jumper requirement, but are not familiar with the reasons behind it. The optical physics behind intermodal noise can be complicated, but the gist of the problem is that a transmission can replicate and interfere with itself if two events (i.e. connectors) are too close together in a network.

Most of the legacy fibers on the market need the 6-foot distance to guarantee that any event created when a transmission impacts with a first connector will be stripped from the system before it can impact the second connector and create noise that interferes with signal quality. This capacity to mitigate noise

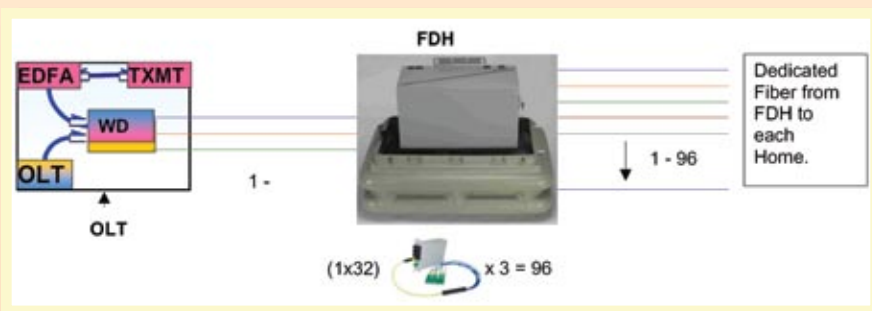


Figure 2. Centralized PON architecture.

in the presence of two optical events is a function of optical fiber technology and can be fixed by improvements in the technology.

OFS has such a fix in its AllWave *FLEX* ZWP single-mode fiber. Extensive measurements with this new bend-optimized fiber demonstrate that it can mitigate intermodal noise in jumper lengths as short as 1.5 feet (Figure 3). Additionally, AllWave *FLEX* fiber is bend-optimized so as to be very forgiving of inexperienced technicians and poor routing habits. Not surprisingly, it has become the fiber technology of choice for some of the more creative FDH offerings on the market.

If the first step toward solving FDH problems requires a highly technical breakthrough in optical fiber technology, the second step requires only a minimal understanding of grade-school geometry. The shortest distance between an optical splitter and the customer we wish to connect is a straight line. However, a straight line between the splitter and subscriber would cross directly over other subscriber connections and would block access to those intermediate connections.

This is unacceptable and explains why traditional fiber management has always employed rectangular schemes that go down or over and around before routing to the desired connection (Figure 4).



Figure 3. AllWave *FLEX* ZWP jumper with MPO splitter compared with traditional-length jumper and 1x32 splitter.

The traditional fiber management structure works fine in an FDH serving 144 subscribers or fewer. These smaller FDH designs can accommodate the limitations of traditional fiber management and the haphazard take-rate pattern while still maintaining a relatively short jumper length and a modicum of manageability. However, things get ugly beyond 144.

As the number of potential connections grows, the required jumper length grows longer in order to reach the farthest connection from the splitter while negotiating down and around all of the connections in between. FDH manufacturers can reduce this distance problem a little by packing all of the connections into a smaller space. However, this sacrifices accessibility for anyone with fingers of normal size, and creates a need for special tools just to connect and disconnect subscribers in the FDH.

Furthermore, the actual fiber management advantage achieved by this tight spacing is nominal. Even with the sacrifice in craft-friendliness, we would be left with a need for 6-foot jumpers in a FDH that would serve 288 subscribers. That is 6 feet to reach the farthest connection from the splitter, and 5 feet worth of unused jumper slack to contend with when connecting the closest.



Figure 4. Fiber distribution hub with traditional rectangular fiber management.

Since breakthroughs in optical fiber now give us the technical capability to employ shorter jumpers, breakthroughs in fiber management can now be achieved with some basic geometry skills. If a rectangular fiber management scheme will not allow us to employ the closest line between the splitter and subscriber, perhaps it is time to reconsider the basic shape of fiber management in a FDH.

If we position all of the optical splitters and subscriber connections in a circular pattern, the farthest point between a splitter and subscriber connection would be no more than the diameter of the circle. Additionally, because all subscriber connections are positioned around the circle, they can all be reached by a splitter in a straight line without crossing over other connections. This is referred to as “radial fiber management” and is incorporated into FDH designs such as the OFS Orbital Fiber Distribution Cabinet (Figure 5).

While a radial design appears radical to those conditioned to viewing fiber management from a central office perspective, it has many advantages in the field. By eliminating the need to go over and around intermediate connections, we can employ a much shorter jumper length and a much simpler fiber manage-



Figure 5. John George of OFS displays hub with radial fiber management; it was first shown at our Broadband Summit in September 2006.

ment scheme. Because there is little to no fiber slack to manage, fiber management is simpler. Jumpers simply lie across the center of the circle. As the cabinet becomes densely populated, many jumpers overlap in the center. However, an overlapped 2-foot jumper is easy to trace, route, and reroute when compared to a 6-foot jumper intertwined with dozens or hundreds of others in the troughs of a rectangular design.

MAKING SPLITTERS EASIER TO REPLACE

The market's first reaction to radial fiber management could best be described as shock. It is one thing to build a better mousetrap, and another to create awareness that a radically different mousetrap is required. Within a relatively short amount of time, however, that awareness developed. Radial fiber management can now be found in a number of FTTH deployments around the country, sitting next to previously deployed rectangular cabinets, and representing a significant upgrade in FDH design.

Interestingly, as radial fiber management gains acceptance, it is being accompanied by a paradigm shift concerning the optical splitter itself. The traditional FDH solution (if we can use that term for so recent a concept) employs a bundle of 32 long jumpers that are used to route directly to subscriber connections. In this design, there is only one connection on the distribution side

of the splitter – the connection that routes to the subscriber. Thus, a splitter can only be removed from a FDH by tracing all 32 of its distribution jumpers and disconnecting them individually, one subscriber at a time.

This solution has the advantage of eliminating an extra connector in the network, reducing optical loss, and reducing some manufacturing costs. It is a good concept so long as you subscribe to the theory that no splitter will ever need to be replaced under any circumstances.

We are now far enough along in FTTH deployment history to realize that splitter replacement is a reality. The technology roadmaps for PON and the advent of new bandwidth-intensive applications provides every indication that today's 1x32 split may not be the next-generation solution. However, we do not

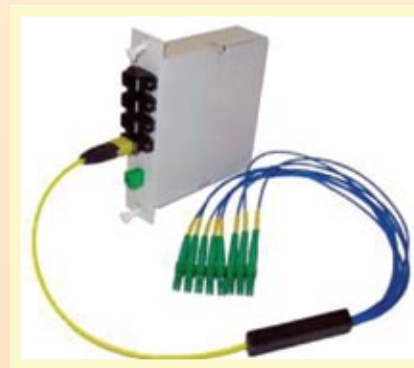


Figure 6. Quick-disconnect MPO splitter module.

need to wait for next-generation technologies in order to want a simpler means of changing a splitter. As we say in the world of high tech: stuff happens.

Perhaps the split ratio just needs to be reduced in order to provide a lower loss budget for a traditional video application. Or perhaps our old nemesis, the 6-foot jumper, has gotten slammed in a door and needs to be replaced. In any case, we would prefer to not deal with taking down customers for an hour or two while we trace 32 connections and snake jumpers back through an intertwined mess.

The answer to this dilemma is to devise a solution that will allow us to disconnect and replace a splitter easily – preferably with less than a minute of customer downtime – and without tracing all of the connections back to the subscriber. This solution is enabled by multifiber connectors, which give us an advantage in detaching a splitter from all 32 subscribers with minimal downtime, and without the need to detach on the customer side of the FDH.

Additionally, improvements in optical splitters and connector technology allow this advantage to be realized with no more optical loss than is found in older FDH designs using the less upgradeable splitter. Figure 6 shows an optical splitter solution that employs this type of design advantage.

CONCLUSION

Fiber management for FTTH should look different because it *is* different. The issues that confront technicians in the FDH need to be addressed, and they can be addressed through a combination of technology improvements and good logic. When the right solution is deployed in the right application, we can realize both the management features that are required to keep costs in line and the upgrade features that are required to enable FTTH to realize its full long-term potential. **BBP**

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