
WHITE PAPER

# The Flexible Architecture Series:

Spliced vs. Connectorized—
A Comparison of Architectures

ADC

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## A Comparison of Architectures

Every service provider, when planning to deploy a next generation fiber network, must determine how to build that network for the lowest possible cost and in a way that creates a flexible, reliable, long-lasting infrastructure. In determining the best strategy for achieving both objectives, service providers must make some critical decisions, and one of the most important is whether to use splices or connectors when creating junctions in the network.

Ever since service providers began more than a decade ago to build the first fiber networks, their standard practice has been to use connectors inside the central office to connect fiber network elements. They know how valuable connector interface points are when it comes to troubleshooting, re-configuring the network and turning up services. However, many carriers are still using an all-spliced approach from the central office to the subscriber's premises. Their primary objections to connectorization are:

- The capital expense (CAPEX) savings of a fusion-spliced approach outweigh the operational expense (OPEX) savings of connectorization.
- Extra connection points within a connectorized approach can affect the loss budget and create additional points of failure in the network.
- Service providers are not certain that the number of network failures will not be large enough to require the additional test access points connectorization provides.

## Reduced OPEX for Service Turn-ups

In some cases splicing segments of the fiber network is less expensive than using connectors, at least in terms of initial equipment costs. However, many have discovered those upfront savings inevitably evaporate as splicing-related issues increase OPEX, as well as reduce the flexibility of the network over time. In fact, more and more service providers around the world now are turning to connectorization to achieve in the OSP the same benefits they get in the central office. For example, in early 2008, China's Minister of Information Industry (MII) released the China FTTH National Standard, which advocates a connectorized approach throughout the network, including feeder cables.

One of the areas in which the OPEX benefits of connectorization are readily apparent is service turn-up, and there are two network locations where connector interfaces offer clear advantages over splicing—at the fiber distribution hub (FDH) and the fiber access terminal.

In a greenfield application where there may be an expected take-rate of 100 percent, splicing all the optical splitter outputs to the distribution cables, as well as the distribution cable to the drop cables, may seem to make sense. However, the reality is not all of the homes will be occupied, or even built, on Day One. Because of this, service turn-ups will not occur all at once. In a brownfield or overlay application with a take-rate of less than 100 percent, most service providers prefer to deploy splitters one at a time, on an as-needed basis, and to have easy access to the distribution fibers at the access terminals for fast service turn-up.

In a splicing scenario, the service provider must dispatch a splice technician to splice a single fiber in the FDH and fiber access terminal each time a single customer requires service turn-up. Similarly, splicing forces the service provider, when upgrading service, to convert all customers, rather than just those who want the upgrade. As every service provider knows, both situations are expensive propositions in terms of equipment, manpower requirements, training and time.

By contrast, using connectorized interfaces at the FDH and fiber access terminal greatly simplifies the service turn-up and upgrade processes. A technician only has to plug the splitter output into the distribution output in the FDH and a drop fiber to the distribution fiber at the fiber access terminal. Service turn-ups and upgrades are as fast and easy as mating two connectors.

Further, connectorization, unlike splicing, enables service providers to customize their offerings more easily, quickly and cost-effectively—and customized offerings obviously help to attract and retain subscribers. When it comes to scaling the network, a connectorized approach also enables service providers to transition easily from a 1x32 to a 1x64 or from one PON to a different PON platform.

## The Right Connectors at the Right Locations Improve Flexibility and Loss Budgets

Although service providers initially rejected a connectorized approach in part because of their concerns about its potential impact on their loss budgets, connector-placement options and technology advances in the connectors themselves have persuaded many to change their strategy. It is true that for every connector in a fiber network, there is loss. Yet it is important to note that while connectors at certain locations in the OSP segment of the FTTP network definitely add value in terms of flexibility, deploying them at every location where fibers meet is not cost-effective. Service providers basically have three options for using connectors in the FDH:

### Real-Life Plug-and-Play Deployments

**Technicians Drive the Transition to Plug-and-Play**
Technicians at a large Southeastern carrier drove the transition to a connectorized architecture because they felt a spliced approach was too cumbersome and slow. In addition to addressing immediate field technician concerns, this approach also addressed various OPEX challenges including upgrades and testing.

**Retrofitting a Brownfield Network**
A mid-size carrier in Calilfornia needed to retrofit a legacy network that was experiencing severe bottlenecks. Their challenge in this brownfield environment was to keep CAPEX costs in line while minimizing service interruptions. They elected to use multi-port service terminals and connectorized drops, executing all the initial work within a four-week time period.

**Simplified Testing**
A small Midwestern carrier uses connectors as test points to give them flexibility for monitoring and troubleshooting without impacting service to customers.

1. **Provide a full splitter cabinet interface within the FDH –** The FDH comes loaded with the incoming, factory-terminated feeder fiber routed to the splitter chassis and distribution fibers to the rear ports of the distribution fiber bulkhead in the FDH. The 1xn splitter module is also factory terminated, with the splitter input connector mated to the feeder fiber in the splitter chassis. At the time of service turn-up, the technician simply routes a splitter output connect to any of the distribution output port. Adding splitter modules on an as-needed basis requires the technician simply to plug the splitter into the next available slot in the splitter chassis. The output connectors are placed in the appropriate parking lot location.

   Despite the fact that this option, with completely accessible fibers, offers the greatest flexibility, it has two downsides: added cost and the added signal loss of two mated fibers. The highest typical loss is .5 dB.

2. **Use pigtails from the optical splitter output to connect directly to the distribution fiber ports –** A technician loads the optical splitters into the FDH on an as-needed basis and puts the output ports from each splitter into a "parking lot" configuration within the cabinet. In the parking lot, dust caps protect the connectors until they are assigned, on demand, to customer distribution fibers.

   This option enables the service provider:

   - to add optical splitters as needed, thereby minimizing upfront equipment costs and maximizing efficient use of the optical line terminal (OLT)
   - have ample operating flexibility, further enhanced by the fact that upjacketing on the splitter output tails protects against damage during the routing process
   - achieve an optimum balance between cost and operational efficiency by using just two connector pairs and thereby reducing both cost and dB loss

3. **Splice the input to the optical splitter/connectorize the output –** This option addresses the safety issues associated with the high power required by the video signal to drive the receivers at the customer premises. Although the analog video signal leaves the central office with relatively high power, it reaches the splitter in the FDH with a power level around 20 dBm. This high power level at the splitter input port can create a potential laser eye-safety issue for technicians, but this concern has been resolved by employing a protective splitter shutter adapter.

   To eliminate this potential safety issue from the network, a technician can splice the input to the optical splitter. Although less flexible than the two-connector-pair option, this option:

   - still has a connectorized splitter output for easier test access and on-demand service turn-up at the distribution end
   - reduces cost
   - lowers dB loss

Nevertheless, it may not deliver all the cost-savings the service provider wants, simply because a splice technician must be present to add splitters to the FDH.

As noted earlier, technological advances also have persuaded many service providers to turn to a connectorization strategy. As FTTP equipment volumes increase, vendors such as ADC have significantly improved connector quality and performance in the network. More stringent performance standards, such as the Telcordia GR-326-CORE specification, combined with improved manufacturing processes, have resulted in:

- lower insertion and return loss
- automated tuning
- superior endface workmanship
- vastly improved factory-termination methods

ADC, in a test that began in 1995, put a series of its fiber connectors on a rooftop in Minneapolis, exposing them for the next five years to the harsh Minnesota climate at temperatures ranging from -42° to 58° Celsius (-43° to 137° Fahrenheit). Automatic performance tests on each connector every hour demonstrated that despite the severe extremes in weather, the connectors performed within ADC's specifications throughout the entire five years.

In the years since service providers first began building FTTP networks, vendors have improved the technical design and manufacture of optical connectors to ensure they perform reliably in a wide variety of environments over long periods of time. In addition, vendors have improved optical splitters to reduce loss even more; typical loss for a splitter has improved from about 17.4 dB previously to about 16.5 dB today. The combination of these design and manufacturing improvements significantly increases the loss budget for service providers adopting a connectorized architecture

## Connectors Provide Easy Test Access

Acknowledging that connectorization provides additional test-access points in the network, many service providers have argued that is not an important factor. They believed, at least initially, that the number of fiber-network failures is too small to necessitate extra test sites. However, in the long run, as their fiber networks grow larger and more complex, leading service providers have come to recognize that simplified test access is very important, and is one of the strongest arguments for replacing splices with connectors.

The first and most necessary testing requirement takes place during service turn-up. If there are no connectors in the network, technicians are required to splice connectors onto bare fibers, perform testing on both ends of the network fiber and then break the fiber. A connectorized approach streamlines this process dramatically.

Regarding ongoing test access needs, service providers are faced with two tough challenges when trying to isolate faults in the network: The first involves the 1x32 optical splitters in the FDH. Typically, a technician uses an optical time domain reflectometer (OTDR) to trace the location of the fault, but OTDR traces are difficult to decipher once the trace hits the 1x32 splitter.

The second challenge arises when only one subscriber has a problem. How does a technician access the fiber to test a network—without taking as many as 32 subscribers out of service? When more than one subscriber served by a splitter in the FDH reports a problem, that fault likely has occurred somewhere between the OLT in the central office and the FDH in the field. In that scenario, a technician can access the network inside the central office to get a good look from the OLT to the FDH. However, testing the network from the FDH to the subscriber requires a truck roll. Here, network design has a significant impact on how quickly a technician can isolate the problem.

If the service provider adds test-access points at the optical network terminal (ONT) on each home, the fault-isolation process requires a technician to tap into the network interface device at each individual residence. These interface points may not be easily or readily accessible. However, using the distribution output port in the FDH as a centralized demarcation box, gives a technician 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 cases in which the installers have spliced a splitter into the network, a splice technician has to:

- go to the FDH location
- break into the appropriate splice between the splitter output and the distribution cable and
- connect the OTDR launch cable with a bare fiber adaptor or temporary splicing in a pigtail.

After completing the trace, the technician then has to re-splice the splitter output to the distribution fiber—a very time-consuming and expensive process, particularly because the service provider bills for splice technicians and their equipment at a higher rate than for other technicians.

This process also poses a significant danger to the network. To access the distribution fiber in order to run an OTDR trace, the technician must manipulate several fibers, break those that are to be tested and then splice the fibers back together. Consequently, the lengths of available fiber are shorter; there also is the risk, if the technician breaks the fiber to a length that is too short to work with, of stranding some network capacity. When it comes to testing from this particular location, a spliced connection—with its time, cost and risk to the fiber—simply is not a practical, cost-effective approach.

By contrast, placing a connector interface at the splitter output provides easy test access for all of the distribution cables. It simply is 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 complete, the technician disconnects the launch cable from the distribution port and reconnects the splitter output pigtail—without having to break any fibers or do any splicing. Further, because all of the splitter output fibers are connected to a bulkhead, protective jacketing prevents the technician from being damaging them during normal handling. Compared with splicing, connectorized fiber in the FDH clearly make it possible for service providers to test the fibers faster and more easily, at lower labor rates and with much less risk to the network.

## Connectors Ensure Long-term Network Performance

The goal of every service provider building a next generation fiber network is to strike a balance between upfront equipment costs and the operational costs involved in long-term performance of the network. When it comes to the former, connectors may be initially more expensive than splicing. However, savvy network planners look ahead to the operational costs incurred by service turn-ups for individual customers and to the ongoing need for easy test access. Leading service providers have discovered that using connectors where they make the most sense in the network justifies the initial equipment costs because it reduces OPEX over the life of the network.

Today's next-generation connectors have proven their value in OSP applications around the world. Although service providers continue to splice the FTTP network connections, many are replacing some of those splices in the OSP with connectorized fibers where it makes sense to do so.

As a result, they get maximum operating flexibility, easy test access, shorter service turn-up times, lower overall costs and superior long-term performance of their networks. These benefits, which are not available from splicing alone, are essential to success in today's extremely competitive market.

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