

ADDING VALUE TO FIBER-TO-THE-HOME NETWORKS: INNOVATION MEETS APPLICATION

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History has clearly demonstrated that as long as scientists and engineers around the globe continue to invent the technology to transmit information at a lower cost ... creative people will find a reason to send proportionately more data.

— On fiber-optic innovation, Corning's Dr. Donald Keck, co-inventor of low-loss optical fiber, from *Lightwave* magazine (July 2000)

As bandwidth demand continues to grow unabated, fiber is driving inexorably closer to the end-user, replacing the legacy copper and hybrid fiber coax that is incapable of supporting this growth for much longer. And if consumer demand is pushing fiber into the last mile, the economics for fiber-to-the-home (FTTH) networks are providing additional fuel to drive it along. The first-installed costs (FIC) for fiber broadband deployment are already at cost parity with legacy wireline technologies for new builds (greenfield), and near parity for overbuilds (brownfield).

(Fiber economically outpaces — by far — the legacy broadband technologies in operational expenditures. See the feature article *The Economics of Fiber to the Home* in this issue of GuideLines® Online for more details on the long-term business case for FTTH.)

Driving the favorable economics of fiber in no small part are technology innovations developed to address last-mile network issues specifically, an approach that has long been in practice in long-haul and metropolitan networks. In particular, outside plant (OSP) products for FTTH networks can be — and have been — designed to decrease the cost of deployment and active electronic equipment (actives) costs.

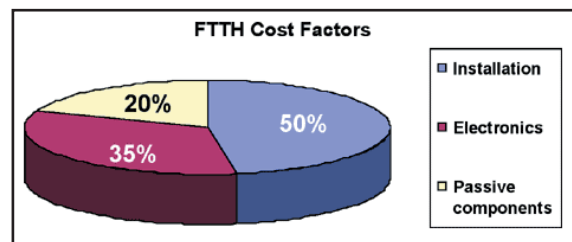


Fig. 1: Typical first installed cost breakdown.

The largest portion of FTTH first-installed cost is the labor of installation, followed closely by the cost of actives deployed throughout the network (See Figure 1). This is even true in the case of the highly efficient passive optical network (PON), where equipment is shared among multiple users and no actives are deployed in the field, but are only deployed at the central office (CO) or head-end (HE) and at the customer premises (CPE).

Interestingly, while passive components, which include fiber-optic cable, connectors and terminals, contribute the least — by far — to FTTH expenditure, they offer the greatest opportunity for reducing cost.

Reducing the Cost of Deployment

Installing a PON in the last-mile virtually assures savings during operation, as optical fiber networks require far less maintenance than copper or hybrid networks. But OSP product and architectural advancements for FTTH have also created opportunities to reduce deployment labor costs.

FTTH installation cost is twofold: the time to deploy, test and troubleshoot the network, and the hourly rate of the installer, which is dependent on the skill set and the equipment required to install the components. In a PON (see Figure 2), the outside plant can be viewed as having three sections: the feeder section from the central office to the local convergence point (LCP), distribution from the LCP to the network access point (NAP), and finally, the drop section from the NAP to the network interface device (NID) at the customer premises. With efficient planning of the outside plant architecture and innovative pre-terminated and factory-installed products, there are opportunities for significant cost savings in each of these three network areas.

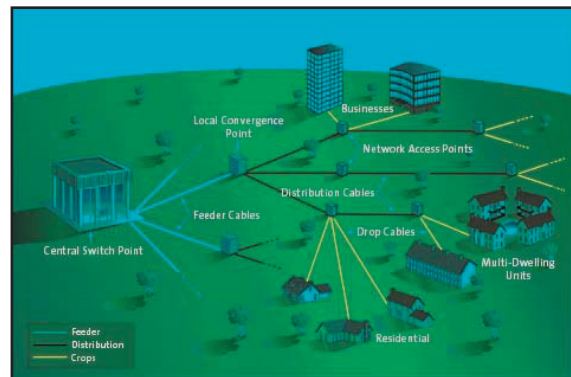


Fig. 2: Outside plant topology of a PON architecture.

Pre-terminated drop cable assemblies and network access point (NAP) terminals

Fusion splicing in the field requires highly skilled personnel, expensive equipment and a significant amount of time to perform, and is particularly inefficient if there are only a few splices to be made at a single location. Recent innovations from Corning allow optical connectors to be used in the drop section of the OSP. These environmentally sealed, hardened and strain relieved connectors for the optical drop cable assemblies and NAP terminals allow subscribers to be connected easily, quickly and reliably when they sign up for service. Field installations have shown these innovative products save up to 50 percent of the labor time needed compared with classic installation methods from the drop. Without the need to re-enter the NAP terminal and fusion-splice the drop cable, sophisticated equipment and specially trained installers are no longer required, and the hourly rate can drop significantly — up to 40 percent, depending upon the carrier's cost structure.

Factory-installed NAP terminals on distribution cables

The latest development from Corning takes the pre-terminated solution one step further: NAP terminals with hardened connector capability are factory-installed on a distribution cable in a daisy chain configuration — typically up to 8 or 10 in a series. Field installations have shown that an installation that usually takes a full week can be done in a day. This premier solution is done with fewer person-

nel, less expensive equipment and with a proven solution that has been successfully deployed in the field.

Centralized split architecture

While generically defined as a “cascaded star architecture,” PONs allow carriers different implementation schemes for reaching subscribers. Typically, one PON will serve up to 32 subscribers (typically known as a 1x32 “split”). As illustrated in Figure 3, international standards allow this 1x32 split to be achieved in any number of ways. For example, a 1x8 splitter can be installed at the LCP, with several 1x4 coupler/splitters are used at the NAP to serve up to 32 subscribers. Or the same 32 subscribers can be served with a single 1x32 split at the LCP. The first scheme is typically called a distributed split and the latter a centralized split.

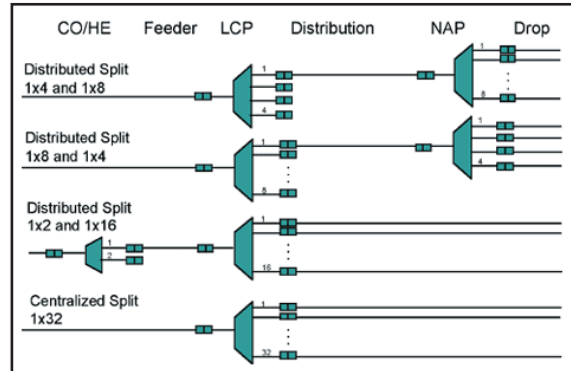


Fig. 3: Schematic to illustrate the different splitting implementations.

The centralized split architecture is appreciably advantaged compared with the distributed split, which is why it is the solution of choice for most PON deployments.

First, it affords a single point of maintenance in the network. As the typical network test method for PONs is using an optical time domain reflectometer (OTDR), this allows the network to be tested in both directions from the LCP to the CO/HE and to the premises. If coupler/splitters are deployed at the LCP *and* the NAP, as in distributed split architectures, an additional truck roll is required to determine whether a network problem is located in the distribution section of the network or the drop section.

Centralized split architectures also allow more port utilization and cost efficiencies. Reasonable initial take rates among subscribers typically result in couplers/splitter ports that are unused for some period of time. In a distributed split scheme, this can mean unused ports at the NAP, and possibly even the LCP. In a centralized split architecture, where the coupler/splitter is installed at the LCP only, the ports can be populated with subscribers across the complete distribution area from one location until they are fully utilized. If that isn’t compelling enough, keep in mind that 1x4 coupler/splitters typically cost more on a per port basis than a 1x8, a 1x8 more than a 1x16, etc. This may result in up to a 40 percent higher per-port cost with a distributed split.

Finally, distributed split schemes can also realize much higher optical loss compared with centralized split architectures. The concatenation of couplers/splitters usually creates a higher insertion loss than a single component, because another interconnection point is introduced. Depending on the performance of component and connector, this can result in a loss penalty of up to 1.5 dB.

Solutions to Reduce Active Equipment Cost

Passive optical networks have proven to be very cost efficient for the reasons described above, again making them the architecture of choice for FTTH networks. However, this technology also imposes some technical constraints. Addressing these limitations to optimize network coverage and maximize services can only improve network performance and, as a result, provide additional cost savings.

It is important to note two distinct characteristics of a PON: First, it is, by definition, a totally “passive” network, requiring active components, such as amplifiers, transmitters and receivers, and media converters, only at its ends. Second, its efficiency is based on a power-sharing concept, where the same optical signal is partially shared among multiple subscribers.

Clearly, then, optical power is critical to the performance of the PON. The power launched from the CO/HE to the customer premises, and vice versa, must be high enough to compensate for the losses introduced by all of the network components, with enough margin to reach the appropriate receiver at an acceptable level. By increasing the network’s launched power and reducing component loss, the number of actives required for acceptable network performance is reduced and cost savings realized.

Increase the launched optical power

All standard single-mode optical fibers have a physical limitation called stimulated Brillouin scattering (SBS). SBS occurs when a high-power optical signal, such as that produced and required by analog video transmission, generates an acoustic wave in the fiber.

This acoustic wave, well outside the range of human hearing, causes variations in the fiber’s refractive index, which in turn scatter the transmitted light in the reverse direction. As power levels increase, this effect becomes stronger and the transmitted signal loses power and becomes distorted. In analog video transmission, this results in very noticeable signal degradation for the subscriber watching television. As analog video technology is more cost-effective today than digital video, most network operators considering video services for their last-mile networks would rather start with analog video and migrate to digital over time.

This fundamental SBS limitation, then, creates a constraint in the PON power budget, imposing a limit on the maximum amount of power that can be launched by the transmitters. The result can be fewer subscribers per PON or smaller coverage areas — sometimes both — and ultimately wasted capital and lost revenue.

A standard single-mode fiber with a higher SBS threshold would allow network operators to deploy their PONs farther, and serve more subscribers, as it would allow higher launch powers without signal degradation. By implementing a fiber solution to the power-limitation problem, expensive active solutions can be avoided, as can passive workarounds that are incompatible with the advantages of the centralized split architecture. Solving these network limitations with a fiber solution allows simpli-

fied engineering, as well as potential reductions in the amount of both active and passive devices required in the network.

Corning’s new NexCor™ fiber was created to meet this challenge. A standard single-mode fiber, compliant with the ITU-T G.652.D standard, it has been specifically designed to allow *twice* the optical launch power of other G.652.D fibers. Twice the power means more subscribers and/or greater distances without specialized electronics or increased amounts of otherwise unnecessary passive elements in the field, optimizing revenue potential and saving network operators money.

Figure 4 depicts the various components that contribute to the optical power loss in the network and where this recent fiber innovation from Corning can now overcome the SBS limitations of broadcast video optical networks for maximum efficiency.

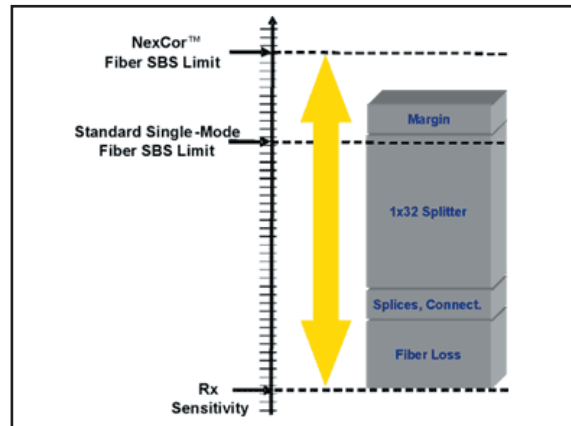


Fig. 4: The SBS threshold of an optical fiber imposes limits on your network’s overall power budget.

Reduce the loss of the individual network components

Finally, when using the pre-terminated solutions described previously to reduce network installation costs, the performance of the optical connectors becomes critical. One way to ensure performance is to specify a maximum insertion loss for each individual connector, and to ensure that the connectors have been proven reliable in the field. Also, specifying splitter loss under all environmental conditions — heat, humidity, etc. — is as critical as asking for a full qualification report for this key OSP component.

FTTH is gaining on its dated, legacy counterparts every day in first-installed cost advantages, and product innovation will only make it more so. Outside plant technologies that reduce deployment costs by attacking the two largest contributors to deployment expenditure — labor and actives — make good economics economics.

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