

Running for Home

What's the Best Network Design for You?

By Gary Schnick

In today's world of fiber-to-the-home (FTTH), design engineers routinely work with several types of network designs and architectures. The most prevalent network designs are based on three primary passive optical network (PON) protocols – Broadband PON (BPON), Gigabit PON (GPON) and Ethernet PON (EPON) – and two distinct active Ethernet protocols: point-to-point (P2P) and point-to-point emulation (P2PE).

Active Ethernet networks bear many similarities to PON networks. At first glance, an active Ethernet design can be easily confused with a PON design if the outside plant (OSP) fiber cable layouts are all that is visible to the observer. Let's take a closer look at what makes a good PON design and how closely the active Ethernet solutions can mimic these same designs.

There are three primary design architectures that support the PON network protocols: distributed split (DS), local convergence point (LCP) and central switch homerun (CSH). Each of these three architectures utilizes optical splitters, which by definition apply a passive 1x32 split to the primary broadband transmission. EPON typically uses only 1x8 or 1x16 splits and can also be described as an Ethernet point-to-multipoint (P2MP) architecture. Each of these architectures has its own unique attributes that can be deployed individually or in combination with any given network. The key to distinguishing each of the different architectures within a network will be the location of the splitters and the size of the OSP feeder cables leaving the central office (CO) or headend (HE).

Siting the Splitter

First, let's examine one of the most important aspects of designing a PON network – splitter location. When choosing the location for splitter placement, one must consider the impact that it will have on splitter deployment efficiency/scalability and the future-proofing of the network. Efficiency/scalability implies that all of the output legs of a splitter will be used to provide service to subscribers before an additional splitter and PON card will have to be purchased. This allows the network owner to make these types of expenditures incrementally, commonly referred to as "pay as you grow." Electronics and splitters are two of the most costly components in a PON network, and it is therefore very important to control these costs and maximize the return on these components. For example, it would be very inefficient to only use 50 percent of a 1x32 splitter before being forced to buy an additional PON card and splitter to bring your 17th customer on line.

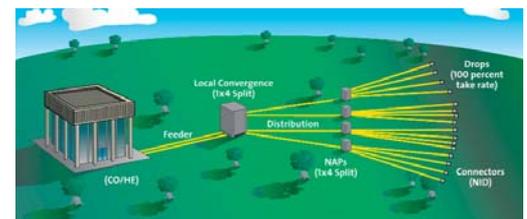
Future-proofing a network implies that the system has the potential to be reconfigured to accept new transmission technologies without rebuilding the OSP and allow the system to be upgraded by using lower split ratios (i.e. less than 1x32). Why does this become such an important consideration? Reducing the split ratio provides two important options for the network. First, reduced split ratios allow for increased bandwidth to subscribers. For example, subscribers serviced by a 1x16 splitter may

be provided with twice the bandwidth of those serviced by a 1x32 split. In a GPON network this could mean the difference between 75 and 150 Mbps. This incremental difference could be used to lure high bandwidth consumers such as businesses to the network. Secondly, because splitters with lower split ratios dissipate less power, the reach of the network can be extended. If one consumes 3 dB less power than another, the reach of the network can be increased by approximately 10 kilometers.

As we review the different PON architectures, it is important to note that the closer the splitters are to the CO/HE, the more future-proofed the network will be and the more efficiently the splitters can be deployed. Splitters placed farther from the CO/HE, as in an LCP or DS design, may or may not maintain splitter deployment efficiency but will certainly become committed to much smaller service areas. Splitters located at the extreme ends of a network, as in a DS design, will become isolated and under utilized. However, depending on the subscriber density of a service area, the attributes of one type of architecture may actually outweigh the attributes of another and become the better choice for that given application.

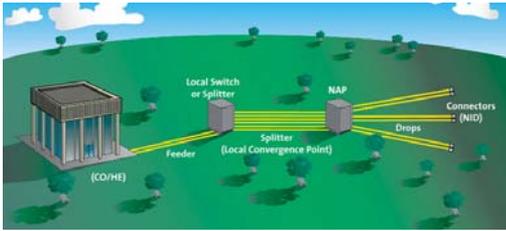
Distributed Split

In a distributed split (DS) architecture, the optical splitters are placed in more than one location in the system. The goal of achieving a 1x32 split ratio is accomplished by using splitter combinations of 1x2, 1x4, 1x8 and 1x16 that are concatenated in the system by locating them in strategic places in the network. The first layer of splitters may be placed in the CO/HE with the second layer being placed at a local convergence point (LCP) or at a network access point (NAP). For example: 1x2 splitters may be placed in the CO/HE and the 1x16 splitters might be placed at the LCP location in a closure or a cabinet. A more common method of deploying a DS network is to place the 1x8 splitters at the LCP in a cabinet, and the 1x4 splitters are placed in a closure or a pedestal that defines the NAP location. In this design, the number of fibers in the cable that feeds the 1x8 splitters can be minimized, as well as the distribution cables feeding the less-costly 1x4 splitters installed at the NAPs. We should note at this point the splitters located at



the LCP location retain a fair amount of deployment efficiency and scalability, while the 1x4 splitters at the NAP have become committed to an isolated service area.

This type of architecture works efficiently in rural locations because the subscriber base is highly dispersed and in low-density pockets. For example, a DS design using a single 12-fiber combination feeder/distribution cable can



Local Convergence Point Architecture

1x8 and 32 1x4 splitters. In this type of design, the efficiency/scalability of the splitter deployment is sacrificed as well as future-proofing to create a manageable OSP solution for a network that needs to service subscribers that are highly dispersed.

The OSP in this design is the leanest of three architectures. It minimizes the amount of fiber required in the OSP but potentially creates higher initial expenditures for splitters and PON cards to service the sporadically located subscribers. This design can yield a good return on investment as the subscribers take rate approaches 100 percent, due to the low costs of the OSP. When we look for an Ethernet solution that might use this same architecture, a P2MP or EPON are the only options. The OSP is too “fiber lean” in this network to support active Ethernet solutions such as P2P or P2PE.

Local Convergence

In a local convergence PON design, the optical splitters are all placed at one location in the field, termed the local convergence point (LCP). This LCP is typically a cabinet fitted with 1x32 splitters, but it can house any combination of splitters such as 1x8 and 1x16. This combination of splitters enables the cabinet to support both LCP and DS designs as discussed previously.

LCP cabinets come in a variety of sizes, typically supporting subscriber counts of 144 to 864. The feeder cable counts for an LCP design will again remain small. Only nine fibers are required to energize a 288-fiber cabinet and only 27 are needed for an 864-fiber unit. The distribution cables will then fan out from this cabinet to provide service to the surrounding subscribers. Since all of the splitters are located in one location, this design will provide a high level of splitter deployment efficiency/scalability and provides an increased capability over the DS architecture for future-proofing the network.

To fully future-proof a network with this architecture, one only needs to increase the fiber counts of the feeder cables. A 288-unit cabinet may only require nine fibers to be fully activated, but a 288-fiber feeder cable could provide 100 percent pass through fiber connectivity to the subscribers serviced by the cabinet (i.e. provide one dedicated fiber to each subscriber). The cost of this high-fiber-count feeder cable will not initially be required to activate the network and can be deferred until it is needed. Notably, feeder cables are generally less expensive to install per foot than are distribution cables. Distribution cables are typically routed in and around through the neighborhoods themselves where numerous obstacles will be encountered. Obstacles such as driveways and landscaping directly translate into cost for such things as directional boring and landscape repairs. The feeder cables are typically installed along main thoroughfares with major utility rights of way with minimal obstacles. Often, there will already be an existing future cable path in these locations. It may consist of space on an aerial messenger strand or maybe an unused duct.

The LCP design architecture works well in locations where the service areas consist of large concentrated

be deployed with some creativity to service up to 128 subscribers along a long rural highway by utilizing four

pockets of potential subscribers such as subdivisions. The design also provides a great balance between installation cost, splitter efficiency/scalability and network future-proofing. When we evaluate the OSP design in this type of PON architecture for use with an active Ethernet architecture, we find that it closely models what might be used in either a P2PE or a P2MP network. The LCP may represent splitters (P2MP) or could be active equipment (P2PE) such as a remote service terminal (RST). The distribution cables leaving an RST cabinet will be similar in fiber count as those required for a LCP GPON or BPON design. The feeder cables may vary slightly in count depending on the electronics vendor, but other than that, the OSP requirements are nearly identical.

Central Switch Homerun

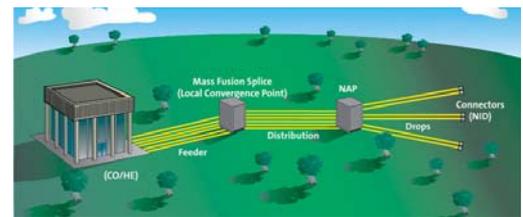
The central switch homerun (CSH) architecture is the third and final PON architecture that we will explore. The essence of this architecture is to provide a dedicated fiber to each subscriber that is continuous all the way back to the CO/HE. This sounds just like a P2P active Ethernet network, doesn't it? That is because it is! The only exception is, in a PON network there are splitters located within the CO/HE. This architecture provides the best splitter utilization/scalability of all of the PON architectures, and it also provides the highest future-proof capability.

The CSH design is often used to service subscribers that are near a CO/HE. This is not to say that an entire network can't be built with this architecture, but the high fiber counts in the feeder cables will add some notable costs to the OSP portion of the network during deployment. It would make sense then in this type of design to minimize the length of the feeder cables to reduce the cost of OSP. COs/HEs, by coincidence, are usually located in the business sections of town and are therefore naturally surrounded by densely populated buildings full of potential subscribers that will reduce the need for long feeder cables. Some of these subscribers will also be high bandwidth-demanding customers. If we recall our earlier discussion concerning reducing splitter ratios to yield increased bandwidth, we can see that this could be a very favorable environment to employ this concept. By doing so, it will enable the network to provide these subscribers with the maximum bandwidth available.

So the next time you are looking at the OSP design of an access/broadband network, be careful not to jump the gun in assuming what type of transmission protocol will be employed. What looks to be a PON LCP solution just might be an active Ethernet P2PE, and what looks to be a P2P active Ethernet solution just might be a homerun.

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Central Switch Homerun Architecture