CLEARFIELD

Fiber to the Home Optical Network Architecture Choices

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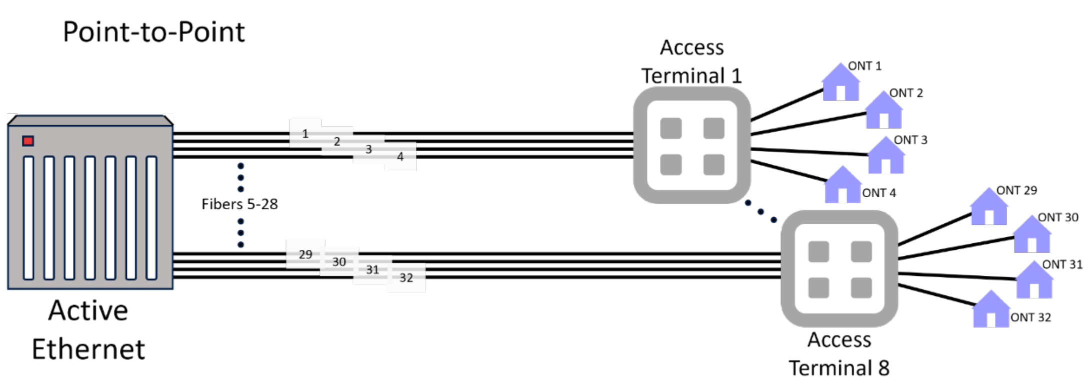
What's the best choice? This question is commonly asked about many things in life. What's the best restaurant? What's the best stock? What's the best car? The answer of course is "it depends". It depends on what criteria are important, recognizing that each criteria have tradeoffs in desired benefits. This is also true of the question which architecture should a service provider choose to deliver fiber broadband services to their customers.

Over the years, network operators have deployed Active Ethernet and Passive Optical Networks (PONs) to deliver fiber broadband to end users. Historically, higher density population centers were targeted first, where the number of homes per mile supported fiber rich architectures. As lower density population centers and rural geographic areas are targeted for broadband services, leaner fiber alternative architectures might be appropriate. However, there are important tradeoffs that should be considered before reaching a final architecture decision.

Before evaluating these important tradeoffs, it would be useful to take a brief look at the most common deployment architectures including home run, centralized split, distributed split and distributed TAP.

Home Run Architecture

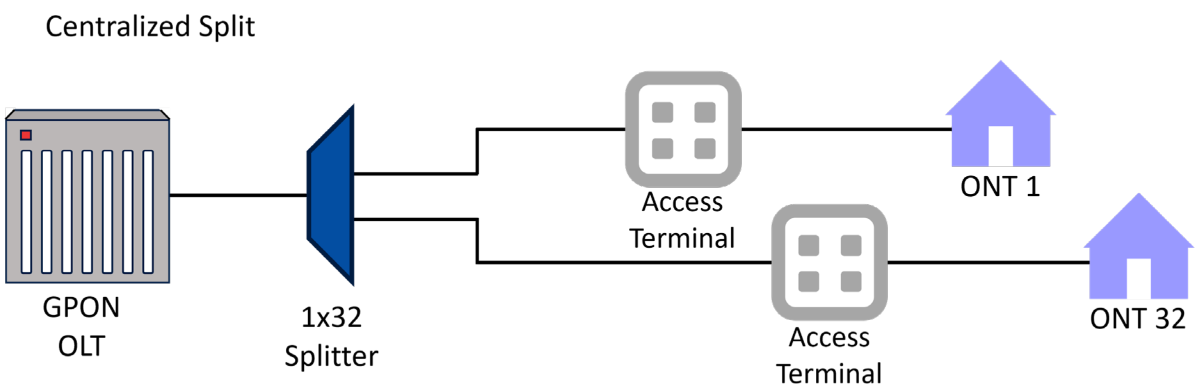
The Home Run method of deploying Fiber to the Home is the most fiber rich style of architecture. As the name implies, an individual fiber is installed and dedicated between the fiber signal originating at a central office/head end and each home in a serving area. With this point-to-point style architecture, maximum benefits of record keeping, systems design, testing, trouble shooting and system upgrades are achieved.



With all these benefits, it would seem that any/all service providers might consider the home run approach the most appealing. However, the upfront costs associated with the deploying a home run architecture are significantly higher than the other architectures. The higher costs include more optics in the central office/headend, more cables, more cable entry equipment, more splicing and splice cases and larger count fiber cables in the paths leading to homes. High costs frequently lead service providers to consider technologies that better meet their financial models at the expense of losing some of the favorable features that home run architectures provide.

Centralized Split Architecture

When deploying a centralized split architecture, the signal from the Optical Line Terminal (OLT) leaving the central office/head end is directed down a single feed fiber to a single optical splitter, generally located inside a PON splitter cabinet. In a GPON system, the splitter is typically a 1x32 or 1x64 balanced splitter, meaning that all light power that arrives at the input to the splitter is divided equally to the splitter output ports. The output ports leave the PON cabinet into a neighborhood to access terminals located near each home. When a customer signs up to receive broadband service, a drop cable is installed between the access terminal and the Optical Network Terminal (ONT) located on the side or inside the home.

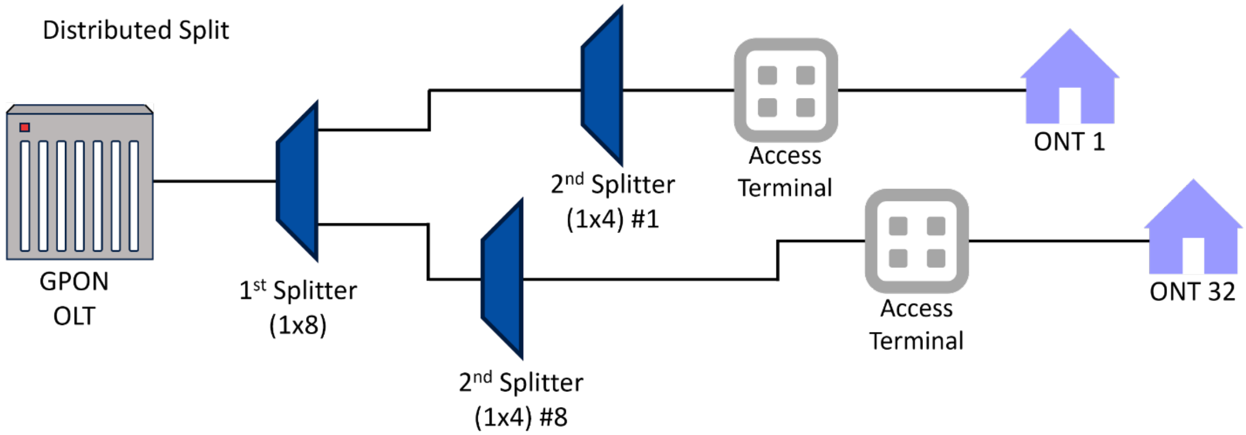


In addition to providing physical protection to the 1x32 splitter, the PON cabinet provides a convenient location to organize and document the network, access to perform testing and troubleshooting of the network and finally the ability to maximize OLT port utilization by allowing any OLT output port to reach any home in a serving area.

Distributed (Cascaded) Split Architecture

In contrast to a centralized split architecture where a single balanced splitter is utilized, a distributed split architecture (sometimes referred to as cascaded split) uses two or more balanced splitters in sequence enroute from the central office/headend to the ONT at each home. For a GPON network feeding 32 homes, the feed signal can be split initially with a balanced 1x8 splitter. This first splitter is typically deployed inside a terminal or splice case. The outputs of this initial splitter are routed into a serving area where a second balanced splitter is deployed. In this example, the second splitter would be a 1x4 splitter which is routinely incorporated inside the access terminal. Again, when a customer requests service from the carrier, a drop cable is installed between the access terminal and the home.

Distributed Split

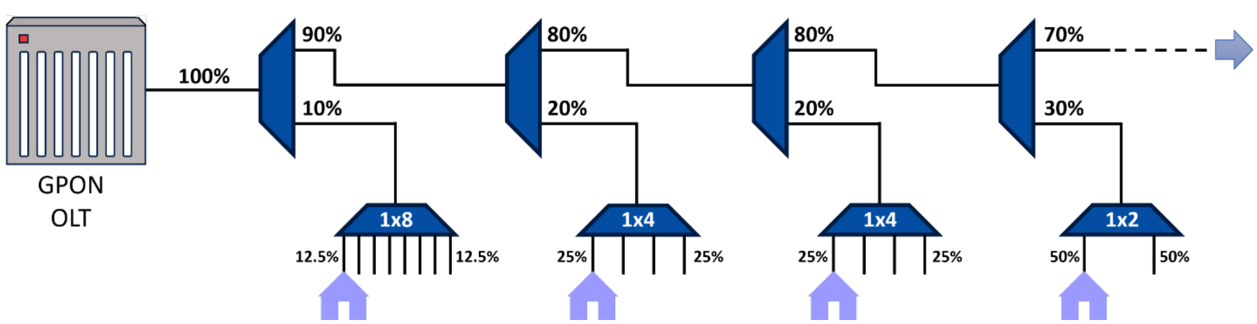


A distributed split architecture will result in less fiber in the network and may be more suitable for lower populated serving areas including rural geographies. In distributed split scenarios, multiple splitter locations can make record keeping, testing and troubleshooting more complicated. In addition, with less fiber deployed, OLT output ports are limited in the number of homes they can serve, reducing overall OLT port utilization.

Distributed TAP Architecture

Unlike centralized split and distributed split PON architectures that use balanced splitters, distributed TAP devices utilize a combination of an unbalanced splitter with a balanced splitter. Light power that enters the input to a TAP device is first divided unequally through a 1x2 splitter, with one output leg getting significantly more power than the other. In the case of a 90/10 TAP device, 90% of the incoming light power is directed to the first output leg, with the remaining 10% routed to the second output leg. The 90% leg is considered the express port which is connected to another TAP device down the road. The 10% or drop leg is connected to a balanced splitter which equally divides the light power two ways, four ways or 8 ways depending on how many drops to homes are required.

Distributed TAP



As more TAP splitter devices are deployed in series down the road, optical power entering downstream TAP devices becomes weaker and weaker to the point where the optical power in the last device reaches the minimal light power allowed for the ONT to function. To maximize the power at the end of a series of TAP devices, several different express/tap ratios are deployed including

90/10, 85/15, 80/20, 70/30, 60/40 and 50/50. Typically, a distributed TAP system will begin a run with a 90/10 device and move to lower express ratios down the line, based on light power needed to operate an ONT at the home. A thorough link loss budget with all components accounted for is critical to the success of distributed TAP architectures.

In simple terms, TAP devices are cascaded in series until the minimum optical power required to operate an ONT downstream is exhausted. Although TAP networks typically use the least amount of fiber, record keeping, testing and trouble shooting and OLT port utilization are all impacted. Upfront design work is also more complicated in a distributed TAP architecture.

So what is the best PON architecture to deploy? From the discussions above, it’s obvious that each choice comes with advantages and disadvantges that must be rated in terms of importance to the carrier. The following table lists decision criteria and a rating associated with it.

		Values Features and Less Complexity		Values Lowest First Cost and Speed to Deployment	
		Home Run	Centralized Split	Distributed Split	Distributed Tap
FEATURES/FLEXIBILITY	Amount of Fiber Required	MORE ◔	◑	◕	● LESS
	OLT Port Utilization	BETTER ●	◕	◔	◔ WORSE
	Engineering Complexity	LESS ●	◕	◔	○ MORE
	Flexibility/Upgradability	BETTER ●	◕	◔	○ WORSE
	Testing/Monitoring	BETTER ●	◕	◔	○ WORSE
	Amount of Splicing Required	MORE ○	◔	◕	◕ LESS
SPEED/SPEND	CAPEX	MORE ○	◔	◕	● LESS
	Time to Build	MORE ◔	◑	◕	● LESS
	Time for Customer Turn-Up	MORE ◔	◑	◕	● LESS

○ ◔ ◑ ◕ ●
← WORSE BETTER →

For example, home run and centralized split architectures require a higher amount of fiber up front, but achieve benefits of maximizing optical port utilization, reduced engineering complexity, access for centralized testing and troubleshooting and flexibity to upgrade the network in the future. An additional benefit of fiber rich deployments is the availability of dedicated/dark fibers to support high revenue non FTTH customers along fiber routes. Examples would include financial institutions, hospitals/medical facilities and cell site operators. The benefits available to high fiber count architectures could outweigh the adverse factors including upfront costs and time to build and turn up customers.

Similarly, the tradeoffs between distributed split and distributed TAP architectures must be considered to reach a decision on what is the best choice. In general, carriers choosing distributed split and distributed TAP architectures are more sensitive to upfront costs and speed to deploy the network over operational activities like testing, maintenance and record keeping. In addition, added upfront design efforts and reduced flexibility to upgrade the network in the future are both inherent elements of these two architectures.

Keeping this all in mind, the answer to the question of which PON architecture is the best really is “it depends”. Regardless of which PON architecture a service provider chooses to deploy fiber broadband services, Clearfield is in position to provide best in class components, from PON cabinets, optical splitters, access terminals, outdoor drop cables and home deployment kits containing test access NID’s, indoor drop cables and wall fiber outlet jacks. Please reach out to your Clearfield representative to review comprehensive solutions that will meet your requirements, or visit Clearfield at www.SeeClearfield.com.