Rural fiber distribution TAP architecture

A more efficient approach for deploying a future-focused FTTH network

Bringing broadband service to rural and underserved exurban areas can pose unique challenges to providers. Deployments must cover great distances to reach just a few homes. Rural areas have higher costs per home passed, and require high subscriber take rates to make fiber deployments economically possible. Providers must invest heavily in equipment and labor, so solutions that can reduce expenditures in either of those key categories can make the difference between economic success or failure. This white paper will explore the tap network architecture option to create or expand rural fiber-to-the-home (FTTH) networks.
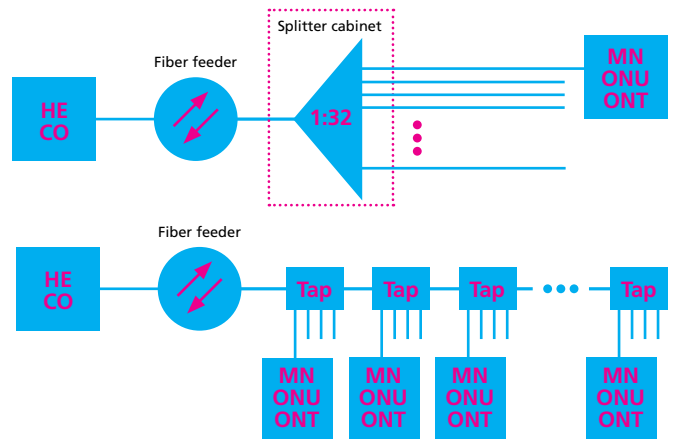

Figure A: A traditional, centralized, FTTH network architecture (top) compared to a distributed TAP network architecture (below)

FIBER-OPTIC TAPS

In a tap FTTH network architecture, a fiber cable is deployed throughout a service area, and fiber-optic taps divert optical signals to subscribers. It's a simple process: the cable is opened, and one of the fibers inside is carefully cut. A fiber-optic tap is spliced into the line, which siphons off a portion of the signal for a subscriber. The tap allows the signal to continue down the line to the next home or business, where the process is repeated. Multiple taps can be spliced onto the line until the signal is exhausted—usually at 32 subscribers. At this point another fiber in the cable is cut, and the process continues.

A tap network design is quite different from the design of a traditional "centralized" FTTH network, which typically uses splitters installed in a cabinet configuration to distribute data to subscribers. In this splitter-based architecture, a fiber-optic feeder line runs from the central office or head-end location to a cabinet in the street or service area. The feeder line terminates on an optical splitter in the cabinet, which distributes the signal to subscribers with additional fibers. This hub-and-spoke design gives providers great flexibility, as the cabinets allow easy management of both fiber connections and central office equipment, and can also be in proximity to remote central office equipment.

DIFFICULT TOPOGRAPHY

Of course, network architecture is a crucial decision for providers embarking on rural installations. These deployments can cover great distances of sparsely-populated terrain, with just three or four homes per kilometer. Land can be mountainous, forested, or desert, with little existing infrastructure. Providers need solutions with design simplicity, to keep labor and equipment costs as low as possible.

Figure B: Rural terrain with little existing infrastructure

EQUIPMENT SAVINGS

The biggest difference between tap network and splitter-based architectures is cabling requirements. For a deployment serving 256 subscribers, the minimum number of fibers required in the splitter-based architecture is 256. These 256 fibers run in several smaller cables from the equipment cabinet. The cabinet is necessary to house the eight 1x32 splitter components, which route optical signals to subscribers, as well as permit fiber access. For many rural deployments, splitter-based architecture is considerably more expensive, as it requires the use of much more fiber cable and distribution equipment.
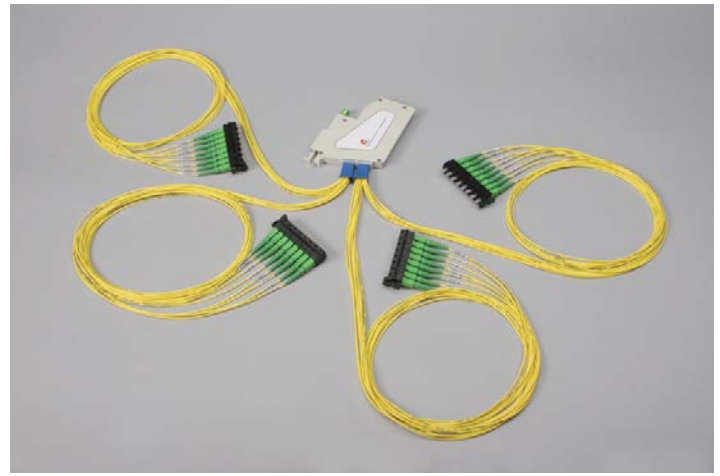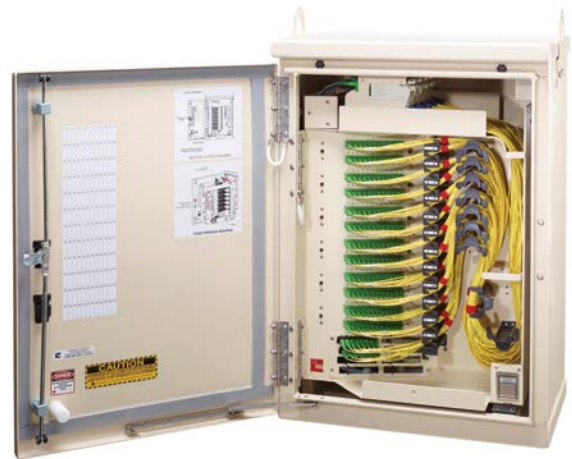

Figure C: 1x32 splitter

Figure D: FDH 3000 cabinet

In comparison, for a 256-subscriber deployment, tap architecture needs a minimum of eight fibers. Two four-fiber cables are run directly into the serving area, without the need of a cabinet to house splitters and connections. Cable savings would depend upon the length of the runs to the actual drop points; but, since four-fiber cable costs much less than 72-fiber cable, savings could easily run to thousands of dollars. With tap architecture, providers have seen large reductions in the number of optical fibers used in a deployment—some as large as 87 percent. Tapped architecture also avoids the need for an equipment cabinet, splitters, mounting pad, and cabinet installation labor.

TAP ARCHITECTURE

Key benefits:
· Equipment savings
· Labor savings
· More efficient to deploy
· Easier to maintain
· Easy future expansion

TAPER SPLICING

A common practice in a splitter-based approach is for a 72-fiber cable to be initially used in the serving area. Once 24 of the fibers are used, it's cost effective to splice the larger cable to a smaller 48-fiber cable. This is called "taper-splicing." Here, tap architecture enjoys another cost savings. Because the commonly-used four-fiber cable is so small, it does not need to be taper spliced. Tap architecture eliminates the cost of splicing the larger fiber cable to the smaller fiber cable, as well as the cost to install a splice closure. An additional management benefit: an operator need only stock a single distribution fiber cable type, as they can use the same four-fiber cable throughout the serving area.

LABOR SAVINGS

Tap architecture commonly uses four-fiber cables, compared to the 72- or 48-fiber cables used in splitter architecture, which creates considerable savings in splicing and material labor. The number of splices required is further reduced because tap architecture requires no splitters at the entrance to the service area. In a typical tap deployment, just two splices will be necessary for each two to eight homes: one for the input to the module, and one for the through-leg. This compares to as many as 72 splices required with a centralized architecture.

WORKS WITH PLUG-AND-PLAY EQUIPMENT

Operators can further reduce the need for splicing by using an optical terminal enclosure, or OTE, equipped with preconnectorized adapters. These fiber enclosures eliminate the need for drop cable splices, as technicians can simply plug preterminated drop cables into ports on the outside of the terminal. Because splices at residences and businesses are eliminated, this type of OTE will save even more labor time.
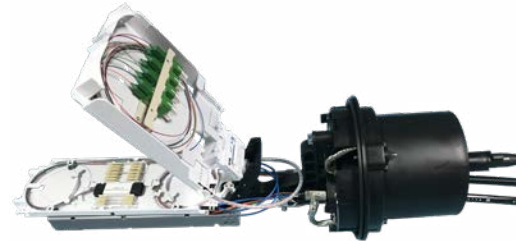

Figure E: Mini-OTE 300 with eight-port taps

Figure F: FOSC 450 with TAP Trays

SPLICE MAPPING

In most deployments, a special map must be produced to chart splice input and output locations, and to indicate which fibers are connected. This is especially true with a splitter-based architecture, as technicians need to keep careful track of which fibers are joined when working with 72-fiber cables. This information must also be created for each taper and branch point in the distribution network, as well as for splitters in serving area cabinets. Splice maps can add significant cost to system designs, as a typical service area could have hundreds of splices, and maps must be maintained and updated to show any field or customer changes.
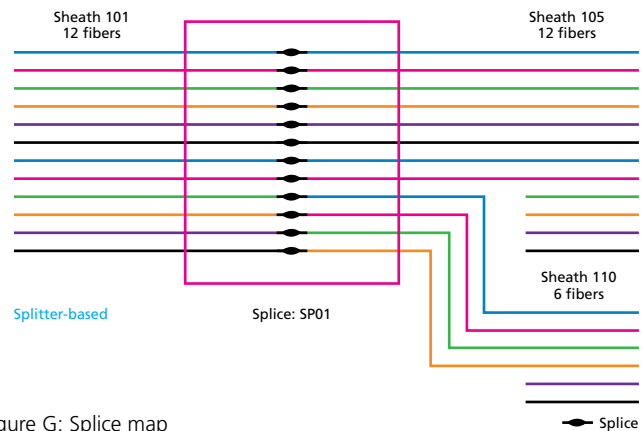

Figure G: Splice map

In tap architecture, no splice map is needed, as only a single fiber is used on each run, and the indication of which fiber is spliced is readily done on the standard design map. This simplicity helps avoid both expensive connection errors and the production time for the splice map.

DEPLOYMENT EFFICIENCIES

The high fiber-count cables used in traditional centralized architecture deployments are considerably larger than the four-fiber cables used in tap architecture. For technicians on a tap deployment, a smaller cable allows more cable to be wound onto truck reels, which further reduces the number of splices they must make when they reach the end of a reel of cable. Deploying smaller cable creates additional efficiencies, as technicians save time because fiber closures and other equipment can be smaller; and, if they must dig hand holes, they can be smaller.

> Rural electric co-ops have often deployed tap architecture networks, because they already have considerable infrastructure in place. Additionally, electric co-ops often find deployment efficiencies with tap network architecture, as there are many similarities to electrical system deployments.

MAINTENANCE EFFICIENCIES

Troubleshooting is efficient in tap architecture, as technicians can easily check connections through fiber-optic taps with an optical

time domain reflectometer, or OTDR. In splitter architecture, the OTDR signal can't pass through the distributed splitters, making it more difficult to check connections.

FUTURE EXPANSION

Some operators believe that, compared to splitter architecture, tap architecture networks are difficult to expand. While it's true tap systems are often designed with minimal fiber use, to save as much upfront cost as possible, designers can use a 1:2 split at launch to increase optic use efficiency. If expansion is required later, this 1:2 split can be removed to add capacity, and additional fiber-optic taps added to change to a higher port count. And, in another expansion strategy, many operators purchase dark fibers along with the initial four-fiber cables, as the economics are best with a full buffer tube of 12 fibers. The cable size doesn't change, and the additional dark fibers provide the highest utility of all solutions, with each fiber good for another 32 homes.

SUMMARY

While several fiber architectures have been developed to support FTTH deployments, tap network architecture is optimal for rural broadband networks. A major benefit of this design is the significant reduction in fiber required to serve a rural area. With the long distances typically involved in rural FTTH deployments, this reduction in fiber count can dramatically reduce up-front network costs, and allow providers to serve areas where deploying a fiber-optic network would have been cost-prohibitive.

Tap network architecture: simplified design with less cable, less equipment, and less splicing means faster installations at lower cost
- Fewer fiber cables required
- Design simplicity—one type of small fiber count cable can be used
- Less splicing required, saving skilled labor
- No need for complicated splice maps
- Large equipment savings—distribution cabinets and splitters generally not needed

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