Cost Innovations Speed Fiber Past Copper to Enable Widespread FTTH Deployment

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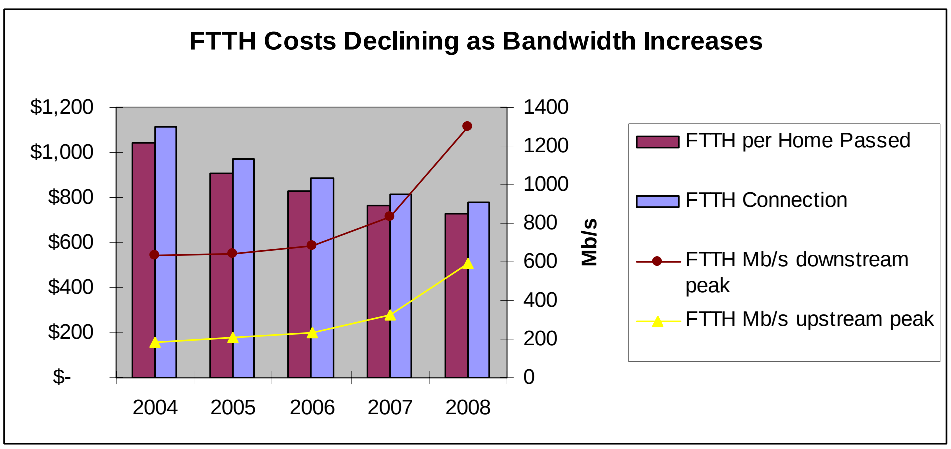
The need to justify Fiber to the Home is declining with each passing year, as both homes connected and success stories rise in tandem. With over 14M homes passed, and 4M homes connected by over 700 service providers, FTTH is fast becoming the architecture of choice. Yet 90 percent of U.S. residences lack access to fiber, and copper-based networks continue to predominate. While current forecasts predict that about 30M homes will have FTTH services available within the next five years, how can America close the gap to bring the remaining 110M residences up to speed with FTTH?

One key driver of FTTH deployments has been an estimated 30 percent reduction in FTTH cost over the past five years, while the downstream bandwidth has doubled and upstream more than tripled. (Figure 1). The transition to higher speed Gigabit PON FTTH systems has been achieved with lower costs as Moore's law continues to improve the performance-to-cost equation for access systems, as seen by the bandwidth growth shown in Figure 1. In addition, FTTH infrastructure and deployment cost has significantly declined with more efficient techniques and product innovations. This trend of lower cost deployment with higher-speed systems is expected to continue as 10 Gigabit, WDM, and even 40 Gigabit systems are introduced over the next three –10 years.

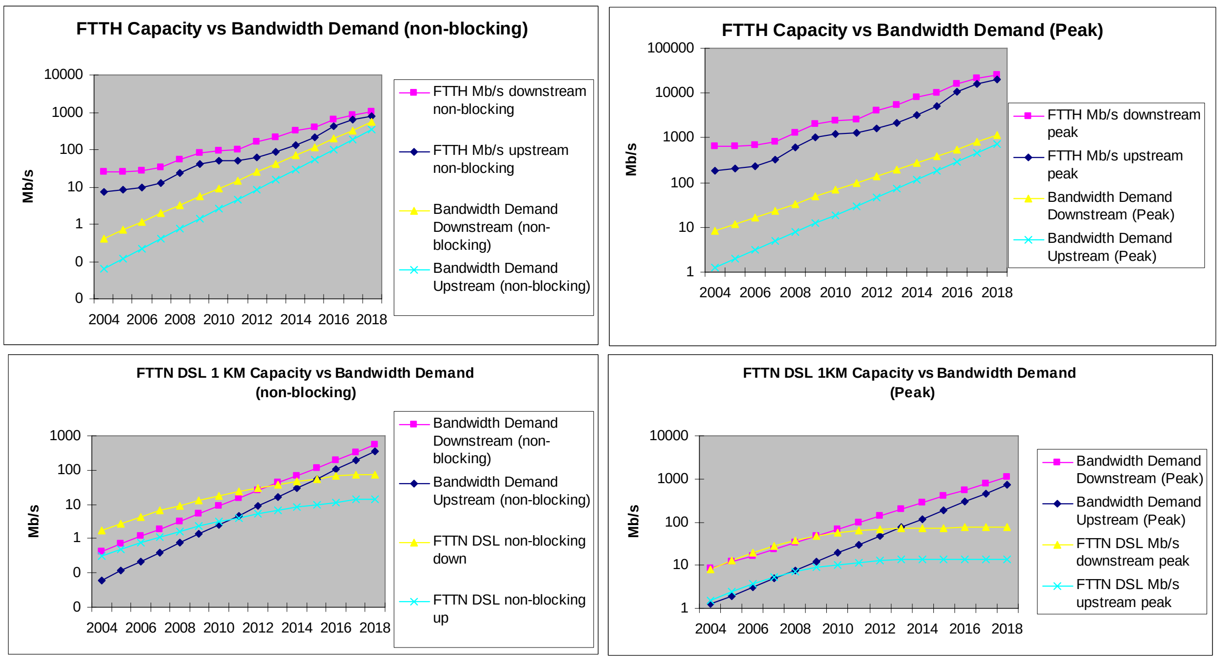
Figure 1 – FTTH Costs vs. Bandwidth



Source: OFS. Shown is a composite view of published FTTH Cost per home passed and connected estimates for Triple Play (Video, data, and voice) deployment. Bandwidth is estimated weighted avg. peak potential of systems deployed annually. Bandwidth shown is for internet and IP Video. Video broadcast RF bandwidth often used for PON systems is not included, and would add 5 Gbps to the downstream peak bandwidth.

The extent to which FTTH can provide greater bandwidth at lower cost is unmatched by any other technology. Bandwidth demand continues unrelenting, driven now by increasing adoption of video-based applications that enable in person virtual interactions for tele-working, entertainment, health monitoring, and commerce. The marriage of large screen HD monitors with video conferencing and video telephony applications will drive much higher demand for upstream bandwidth and continued overall access bandwidth growth exceeding 40 percent annually. Next we will see the adoption of 3D video and higher definition requiring 1 Gbps or higher speed access connections. The projected result is that fiber-to-the-home architectures might be uniquely capable of supporting access bandwidth demands in three to five years, as shown in Figure 2. As copper-based networks are beginning to reach theoretical limits, fiber to the home is tapping less than 0.01 percent of its theoretical 50,000 Gbps capacity.

Figure 2 – FTTH and FTTN + DSL Data Rate Capacity vs. Demand



The Passive Contribution to FTTH Cost Reduction

Over the past five years, tremendous progress has been made in FTTH cost reduction in the passive optical portion of the FTTH network. The optical fiber, cabling, and connecting elements comprise only about 8 – 15 percent of the typical $1200-$2000 FTTH total network cost. Leveraging key innovations in the relatively low-cost passive plant can reduce the labor and electronics costs, resulting in overall reductions in total FTTH network costs.

With that in mind, three innovations have been developed and deployed in volume in the past few years to help make FTTH a success. While many have adopted all or some of these innovations, lack of complete adoption compels the need to educate prospective FTTH providers on their potential benefits. The innovations are not just in technology, but also in methodology. They begin at the beginning: **Network Design** can affect the cost per home passed by hundreds of dollars. Having an efficient and optimized design plan in hand before buying the first piece of hardware can make or break the FTTH business case.

The capability of the **optical path** can have a large impact despite its comprising only a few percent of the network's costs: The optical fiber and splitters should enable use of the full spectrum of optical wavelengths to support many generations of network equipment as bandwidth increases from Megabits to Gigabits per home. **Cable improvements** such as fiber ribbons, fully dry cables, and micro cables can reduce costs per home while speeding deployment.

Lastly, as fiber is reaching into multiple dwelling units, newly created **pluggable and bendable MDU optical cabling** are helping make fiber to each unit the preferred architecture for apartments, condominiums, and even hotel rooms.

Smart FTTH Design Innovations

Optimizing the design of the FTTH network to each service provider's unique needs can save hundreds of dollars per home passed. Competent and experienced FTTH designers have learned that one design philosophy does not fit all. Instead they will seek to understand the dynamics of each service providers' deployment plan, use cost models to compare the cost of multiple architecture options, and let the customer decide on the option best suiting their needs.

One example of a Smart FTTH Design benefit is for a Passive Optical Network (PON) deployment in which one expects a high subscription rate. Many FTTH deployments house splitters in cabinets, known as fiber distribution hubs, that each typically have the capacity to serve 288 homes. However, with greater than about a 50 percent take rate, fusion splicing the splitters in a terminal can save \$50 – \$100 per home passed, even accounting for lower electronics utilization. The use of fusion spliced splitters in terminals closer to homes avoids the need for cabinets, connectors, adapters, handholes, digging, and right-of-way acquisition. While some claim it is essential to have a test point through a connector near the splitter in the network, available test equipment can characterize the ODN and locate faults from the CO or home. Predicted take rate as the deciding variable between centralized and distributed splitting, and making the cost optimized choice, can save \$50 - \$100 per home passed, or up to \$1M per 10,000 homes passed.

Other examples of smart design benefits abound. FTTH in rural areas can be particularly cost challenging, but an efficient rural design can save \$50 or more per home passed using a creative cascaded splitter architecture. Placing splitters in the Central Office to serve homes within 1 km of the CO can save about \$25 per home passed. For the vast majority of customers, fusion splicing in the distribution and drop plant results in a lower installed and life cycle cost for the passive FTTH network, in some cases saving over \$100 per home passed compared to outdoor connectorized cabling systems.

Selecting an FTTH passive network design based on unbiased cost modeling can identify a more efficient and cost effective architecture. Such a model should account for the individual dynamics of each deployment including projected take rate, geography, density, as well as labor, material, and life cycle costs. Starting with a smart design in one key to FTTH success.

Optical Path Improvements

Carefully selecting the FTTH optical path can help lower the cost per Mbps for current- and future-generation networks. The optical path consists of the optical fiber, splitters, and connectors that connect the residence to the central office or head end. Once the optical path is installed, it will last many decades and thus need to support many upgrades to higher speeds. Using an optical path that can carry the full spectrum of fiber optic transmission wavelengths at lower loss can help reduce the cost of current and future FTTH systems. The need for full spectrum support is being validated by the consumption of additional wavelengths by emerging applications including 10GE-PON, 10GPON, and the RFOG, as shown below in Table 1. Lower optical path loss enables greater reach and network design flexibility. Full Spectrum support is improved through the use of zero water peak, bend optimized optical fiber, low loss full spectrum splitters, and low loss connectors.

Table 1 – Full Spectrum (1260 nm – 1625 nm) FTTX Optical Path Innovations

Optical Path Element	Benefit	Wavelengths and Applications
Zero Water Peak G.652D Fiber	Up to 12% longer reach than low water peak fiber via lower loss.	E-Band (1360 – 1460 nm) used by CWDM and possibly future WDM PONs. The E band is designated as "for future use" by the International Telecommunications Union. (ITU). Some CWDM systems available today use the E band.
Full Spectrum Splitters	Predictable reach through specified performance.	
Bend Optimized Optical Fiber	Lower cost installation, smaller fiber management, and increased service reliability through lower bending loss. In some cases bending loss is reduced by >90% compared to conventional SMF.	S, C, and L Band (1480 nm – 1625 nm). Current and Future applications using "long wavelengths" BPON/GE-PON/GPON (1490 nm), RF video over PON (1550 nm), CWDM, and DWDM, Ethernet point to point (1490 nm and 1550 nm), emerging 10GE/10G-PON (1577nm), HFC (1550 nm), RFOG (1610 nm).
Low Loss Connectors	Longer reach.	All Applications.

Source: OFS and Published Industry Standards and Draft Standards – IEEE 802.3, SCTE RFOG, ITU-T.

Labor Saving Cables

Optical Cable Improvements such as fiber ribbons, fully dry cables, and micro cables can reduce costs per home while speeding deployment. Cables with fibers packaged in 12 fiber wide ribbons can reduce fusion splicing time. For a 144- fiber FTTH distribution cable, the reduced time to fusion splice 12 fiber ribbons versus the single fibers in a loose tube cable can save $190 per terminal. Much greater savings of about $2,000 are possible under the same scenario if the contractor charges a set price for each splice. Fully Dry cables can save $100 per terminal by eliminating the labor required to clean the gel from conventional cables prior to splicing. Super small diameter micro-cables can save $20,000 per mile by avoiding the need for burying new conduit. All of these cable innovations have been increasingly adopted in FTTH deployments, contributing to the cost reductions of the past five years.

New Technologies for Reaching MDUs

Fiber to terminals inside the residence is one of the last frontiers for access networks, and is becoming the preferred architecture by many carriers. Lower cost Optical Networking Units (ONUs), combined with the increasing challenges of remediating existing copper wiring to carry higher bandwidths, is pushing fiber into individual Multiple Dwelling Units and even homes. But installing fiber inside residential buildings using conventional methods can be slow, disruptive, and expensive. Unlike most commercial buildings constructed in the past 12 -15 years, residential buildings rarely have pathways and conduits in place designed to house conventional fiber optic cables and apparatus.

Newly available technologies speed and simplify MDU fiber installations in these unstructured residential environments. The first is a spooled plug and play system which can provide compact variable length pre-connectorized backbone cabling in a single component to reduce or eliminate fusion splicing, while fitting in compact spaces (Figure 3). To reach each unit, a new ultra bend, insensitive fiber (U-BIF) inside a rugged drop cable has been developed which can be quickly installed with low skilled copper cable like procedures using stapling and without the need for conduits or bend radius management. The new U-BIF, known as Resonance Assisted Fiber (RAF), offers up to 500 times lower bending loss than conventional single-mode fibers, yet is a fully solid fiber can use standard splicing and connector-mounting procedures. Additionally, a fusion splice-on connector can be reliably field mounted on the U-BIF drop cable to eliminate slack management and splicing protection boxes, Cost modeling has shown the spooled plug and play backbone with ultra bend insensitive drop cables can reduce installed costs by 33 percent to 66 percent compared to a conventional MDU cabling system.

Figure 3 – Spooled Plug and Play Hub, Combiner, and Terminal

Conclusion

Cost reductions and unmatched bandwidth potential are enabling FTTH to economically meet bandwidth demands, with room for many decades of bandwidth growth. Copper-based technologies may struggle to keep pace as theoretical limits slow improvements and increase plant maintenance costs. Leveraging key innovations in the relatively low cost passive plant can reduce the labor and electronics costs, resulting in overall reductions in total FTTH network costs. Efficient and optimized Network Design is often overlooked but can affect the cost per home passed by hundreds of dollars.. The capability of the optical path can have a large impact on current and future cost despite it's comprising only a few percent of the network's costs: Cable improvements such as fiber ribbons, fully dry cables, and micro cables can reduce costs per home while speeding deployment. Lastly, as fiber is reaching into multiple dwelling units, newly created pluggable and bendable MDU optical cabling are helping make fiber to each unit the preferred architecture for residential buildings. Click To access Footnotes