

# Fiber to the Home Pays Back in Less than Five Years!

The business case for GPON easily beats copper, but only if you serve video

By Sunan Han, William Yue, and Stephen Smith ■ *Fujitsu Network Communications*

In this article, we review three competitive broadband access architectures and then analyze the economic perspectives including comparisons of revenue streams, free cash flows, cumulative discounted net present values, and respective payback years. The economic indicators are formulated incrementally; High-Speed Internet (HSI) service is added first and then overlay video and other services, such as voice over IP (VoIP), IPTV and video on demand (VOD), to show business impacts for various services.

We find that Fiber-to-the-home (FTTH) and fiber-to-the-curb (FTTC) using GPON technology has a slow start when only the HSI service is available to sell to customers. However, as other services are added, they become competitive architecture choices against the traditional asymmetric digital subscriber line (ADSL) over copper.

Telcos have discussed Fiber-to-the-Premises (FTTx) for many years. Of course, only recently has anyone really begun deploying fiber technology in volume. Service providers were deterred by economic considerations, including capital expenditure for new equipment and for laying the fiber, operational costs, the revenue from services that could be provided, and most importantly the payback years needed for the carrier to turn the investment into profit from such a fundamental build-up.

In this article, we examine a case

study to analyze the above-mentioned economic and financial aspects of the deployment of FTTx, adopting the most recent Gigabit Passive Optical Network (GPON) technology in comparison with the existing Asymmetric Digital Subscriber Line (ADSL) technology.

Consider a medium-to-large metro access network with 50,000 passed homes and premises. The target network architectures are FTTx using GPON with fiber all the way to the home or premises, FTTC/N (GPON with fiber to the curb or neighborhood) in the feeder plant and Very-high-rate Digital Subscriber Line (VDSL) with twisted-pair copper wire in the distribution plant, and the ADSL technology with twisted-pair copper wire or fiber in the feeder plant and twisted-pair copper wire in the distribution plant.

***Services are the most important differentiators of the business cases because they provide the revenue streams that are expected to dominate the cash flows for profitability.***

The services we imagine available are high-speed Internet (HSI), Voice over IP (VoIP), broadcast television (BTV) and video on demand (VOD). Different technology architectures can support the same services, but at different levels with respect to data rate, such as 3 Mbps versus 30 Mbps for HSI, and video resolution, such as standard definition (SD)

versus high definition (HD) for BTV and VOD.

This article shows that the services are the most important differentiators of the business cases because they provide the revenue streams that are expected to dominate the cash flows for profitability.

Capital expenditures (CAPEX) are usually the most important factor in taking up a new venture. Carriers consider it the initial cost they want to get paid back as soon as possible. We discuss the equipment and fiber cost based on the network designs for the three architectures, plus the carrier's core transport cost – required to deliver video content from Video Headend Office (VHO) to the local Video Serving Office (VSO) and HSI between hub offices and the VSO, costs that are frequently forgotten in calculations of this type.

Network operational expenses (OPEX) are functions of the installation and maintenance costs of the network facilities, including equipment in the central office, remote terminal and customer premises and the fiber. It is the consensus that the GPON technology brings about low OPEX to the access network.

Our results indicate that the FTTx

technologies have healthy cash flows in the business cases and the services that can be provided by the network are fundamental to prove in these new technologies.

**Broadband Access Architecture Alternatives**

The broadband access network architectures this article addresses are best described in figure 1.

The FTTx and FTTC/N approaches

provides access directly to a subscriber through the twisted-pair wire that also carries the telephone service.

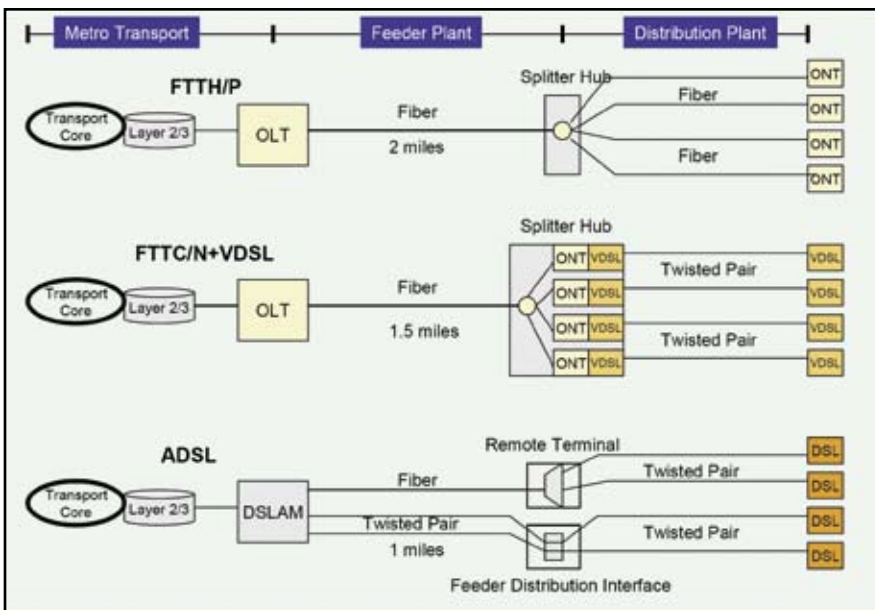
New deployment of the feeder plant may use fiber to reach remote terminals where signal from copper is multiplexed. The DSLAM is responsible for differentiating the (non-VoIP) voice signal, which is sent to a voice switch, from the data signal, which is HSI, IPTV or VOD and directed to a Layer 2 or Layer 3 switch.

range. The initial deployments of PON networks have focused on ATM-based Broadband PON (BPON) and Ethernet PON (EPON) but as HDTV service rolls out and BPON systems can only deliver 155- and 622-Mbps downlink streams while EPON systems are designed to deliver 1.25 Gbps connections only.

Many question whether those PON systems can provide enough bandwidth for the emerging high bandwidth applications. To address this concern, the ITU-T committee has defined the G.984.x specifications for GPON operation. GPON is the next generation, descended from the line of BPON and EPON technologies. GPON supports both ATM and Ethernet with Layer 2 data encapsulation, so it is clearly an attractive proposition, despite the overhead needed for the encapsulation process (mapping traffic into SONET-capable frames to achieve higher data rates over a reach of 60 km covering 32 to 64 users).

Due to these advantages and its cost efficiency, this article adopts GPON as the technology for the FTTH and FTTC architectures in the analysis.

On the municipal access network (MAN) side, the OLT or DSLAM communicates with a Layer 2 switch or Layer



**Figure 1. Metro transport feeder plant distribution plant; various broadband access network architectures for comparison.**

both use passive optical network (PON) technology. Every port from the optical line terminal (OLT) is capable of carrying 1.2 Gbps to 2.5 Gbps downstream (39 Mbps to 78 Mbps per subscriber depending on the split), and 622 Mbps to 1.2 Gbps upstream traffic demand – all on a single fiber. The fiber is split into 32 or 64 distribution fibers that each terminate on either an optical network terminal (ONT) at a home (FTTH), or on a remote ONT at the splitter hub where VDSL technology delivers the service through twisted-pair copper wire in the distribution plant (FTTC).

Most of today’s broadband access networks are built on ADSL technology. In that approach, the Digital Subscriber Line Access Multiplexer (DSLAM)

**New high bandwidth video applications such as HDTV require much higher bandwidth than the current generation of DSL or cable modems can provide.**

However, new high bandwidth video applications such as HDTV require much higher bandwidth than the current generation of DSL or cable modems can provide. The rollout of PON systems in the access market (that is, in the first mile) is viewed as the technology to provide triple-play services – voice, video, and data – to homes.

Telcos are seeing PONs as a means to offer video services and compete with the cable companies. One of the main reasons is that the PON can push the downlink performance into the 2.5 Gbps

3 router, which ships the traffic to a transport core network. This core network can be built on directly connected fibers, Synchronous Optical Network (SONET), or Dense Wavelength Division Multiplexing (DWDM) technology.<sup>1</sup>

Although GPON technology does provide network protection mechanisms for broadband access networks,<sup>2</sup> our study does not model any protection for any of the three architectures.

**Economic Assumptions**

This article is based on a study that

***This article is based on a study that examines a broadband access network in a metro area of 50,000 homes and other premises. The three network architectures are used to derive comparative results financially and economically.***

Service Technology	High-Speed Internet (HSI) (Dn/Up)	Tariff (Monthly)	Voice	Tariff (Monthly)	Video	Tariff (VOD: per view Other: Monthly)
FTTH/FTTP	5M/2M	\$35	VOIP	\$30	Overlay TV	\$50
	15M/2M	\$45			IPTV (SD Only)	\$40
	30M/5M	\$180			IPTV (SD+HD)	\$50
FTTN/FTTC + VDSL	5M/2M	\$35	VOIP	\$30	VOD (SD)	\$3
	15M/2M	\$45			VOD (HD)	\$5
	20M/3M	\$80				
ADSL	1.5M/1M	\$20	VOIP	\$30	IPTV (SD Only)	\$40
	3M/1M	\$30			VOD (SD)	\$3
	6M/1M	\$40				

**Table 1. Services and tariffs for FTTH, FTTC and ADSL. High-speed Internet charges are dropping for a given bandwidth, but across the board.**

examines a broadband access network in a metro area of 50,000 homes and other premises. The three network architectures surveyed in the previous section are being used to derive comparative results financially and economically. Table 1 lists revenue-generating services that can be provided by FTTH, FTTC and ADSL respectively, and the tariff for each service.

A five-year business case is the target of this study. To model the revenue generated by each technology, we have to assume the take rate for each of the services. When a broadband access network is deployed to pass all 50,000 homes in the metro area, there will only be a percentage of homes that actually take a service from the service carrier. The take rate of a service is the percentage of homes that actually subscribe to the service.

The take rate directly relates to the total revenue. For high-speed Internet (HSI), we assume a starting take rate of 25 percent in month 6, growing into 56 percent in month 60 (year 5). The mix

of the HSI is 72 percent low bit rate (1.5 Mbps for ADSL and 5 Mbps for FTTx), 25 percent intermediate bit rate (3 Mbps for ADSL and 15 Mbps for FTTx) and 3 percent high bit rate (6 Mbps for ADSL, 20 Mbps for FTTC and 30 Mbps for FTTH). But by year 5 the mix becomes 49 percent, 40 percent and 11 percent for low, intermediate and high bit rates respectively.

VoIP has a take rate of 11 percent initially and 29 percent in year 5. IPTV, with or without HD, starts with 8 percent take rate in year 1 and grows into 19 percent in year 5. VOD, including SD and HD, adopts a peak-hour take rate of 5 percent in the first year and 24 percent in the last year. The split between SD and HD users and programming for both IPTV and VOD is about 9:1 at the beginning and 5:5 at the end.

RF (radio frequency) overlay TV is provided only by the FTTH architecture. It is carried in a separate optical channel, or wavelength, overlaid with the data channel in a GPON access network.

Once the home is connected and wired correctly, the broadcast video is available to the subscriber through GPON overlay just as it is through cable. The take rate for overlay TV begins with 10 percent and grows into 32 percent in year 5.

The network is built in year 1. Thus much of the capital expenditures are spent in year 1 when the equipment is deployed to pass all 50,000 homes. Incremental cost is incurred only for homes that subscribe to one or more services, in the year they subscribe. Thus the network cost is divided into three major portions: home passed, home connected and core metro transport.

Cost for home passed mainly includes the cost to deploy the fiber and twisted pair copper wire in feeder and distribution plants, and the cost for passive fiber splitters. Our calculated per passing home total cost is \$893 for FTTH, about \$500 for FTTC and \$156 for ADSL where distribution copper wire is considered free and one third of the feeder plant is fiber.

Cost for home connected is for the necessary equipment and installation expense to connect a home and put it on service. This includes the cost of OLT, DSLAM, ONT, xDSL modem and installation materials and labor. The per-connected-home cost turns out to be \$746 for FTTH, \$386 for FTTC and \$118 for ADSL. These costs are extremely close to what AT&T, Verizon, and others spent for these purposes in 2006.

The annual churn (erosion) rates are 11.6 percent, 9.8 percent and 5.5 percent for FTTH, FTTC and ADSL, respectively.

The core transport network architecture is not discussed here. But delivery of Gigabit Ethernet (GE) circuits from a VSO, where the subscribers are located, to a hub for Internet access or the VHO for video services, is not free. We assume the metro area is covered by two 5-VSO transport rings that are connected to the same hubs and the VHO. Per-subscriber core transport cost varies from \$31 to

\$77, depending on the mix of services in a specific scenario, and the transport technology adopted.<sup>2</sup>

VOD-HD subscribers use the most network bandwidth, at 10 Mbps per video stream with MPEG-4 encoding. VOD-SD subscribers use 2 Mbps for each video stream. Broadcast TV is most economic to transport because of its nature and can be multicast in the network. Only one GE circuit is needed for each TV package for all the subscribers covered by the network.

High-speed Internet is a “best effort” service. In our calculations here, we apply a 50:1 oversubscription for low bit rate, 40:1 for intermediate bit rate and 25:1 for high bit rate HSI services. For example, a 5 Mbps HSI connection constitutes only 0.1 Mbps of transport network bandwidth. So, HSI does not contribute as much traffic as VOD to the core transport. VoIP for each phone line is allocated a constant bandwidth of 64 Kbps.

**“Straight” Free Cash Flows**

FTTH needs revenue from video to be competitive.

Let’s first look at a simple or straight business case analysis, in which the revenue is directly against the network capital cost over a five-year period. This analysis does not include other intangible costs such as maintenance, advertisement, sales, taxes and so forth, as well as capital depreciations and net present values.

It is interesting to just apply only HSI services first to the three architecture scenarios to watch how well the FTTH performs, because it requires the most capital. We would expect FTTH to perform worse than the other two technologies with only HSI even though it provides the highest bit rates. It’s then also interesting to see how it improves when the overlay TV services are added. Note that overlay TV can only be provided by FTTH with real digital quality pictures over the fiber. It can be used to compete directly with the incumbent cable tech-

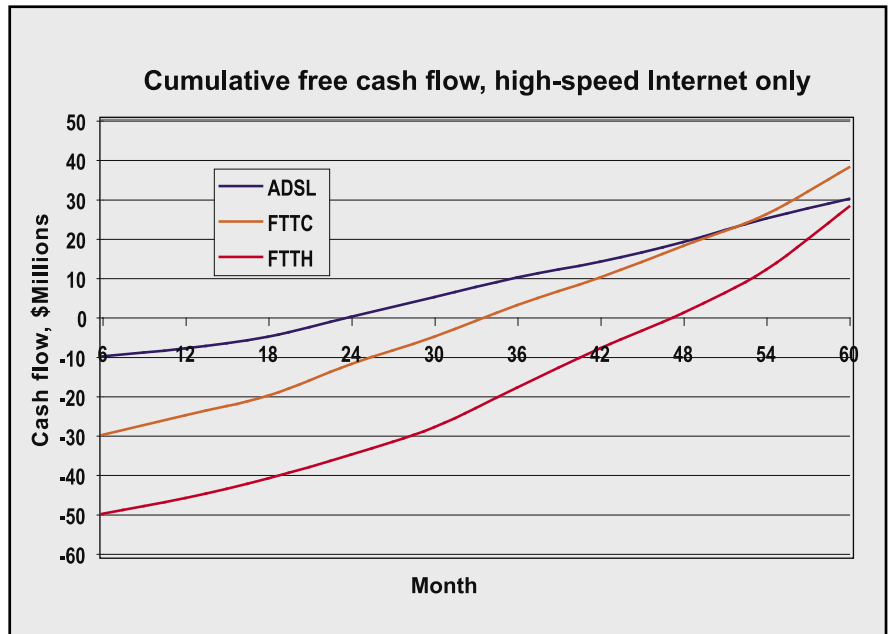


Figure 2. Straight free cash flow serving high-speed Internet only.

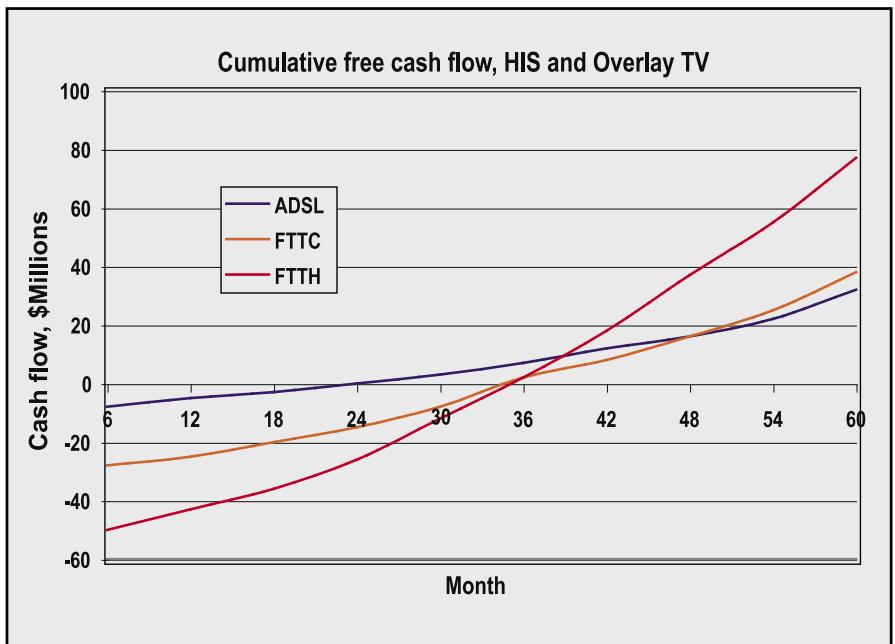


Figure 3. Straight Free Cash Flow with high-speed Internet and overlay TV services.

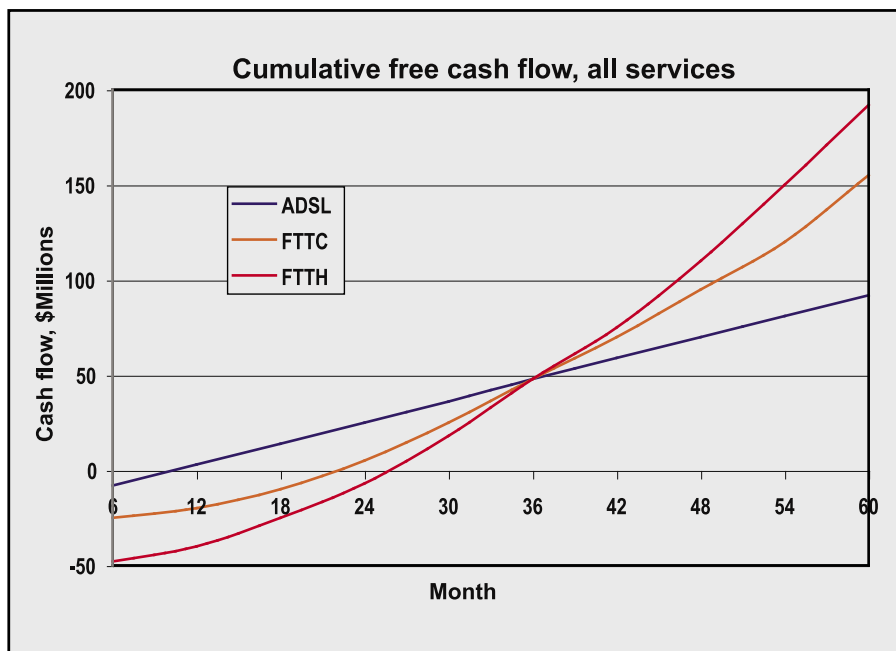
nology that the subscribers have been so used to.

Figure 2 shows straight free-cash flows with HSI services only, and Figure 3 shows cash flow with HSI and overlay TV services. A straight free-cash flow is the difference between total revenue and cumulative capital cost over a period of time.

With only HSI service, the FTTH

cash flow becomes positive at month 48, or year 4. It is always below other curves in the entire five-year period. When overlay TV service is added to FTTH, the business case turns cash flow positive in only about 36 months and outperforms other scenarios from then on.

Figure 4 shows the three free-cash flows with all services, HSI, VoIP, IPTV and overlay TV, being provided through



**Figure 4. Straight free cash flows with all broadband services. ADSL cannot provide HD video services for IPTV or video on demand.**

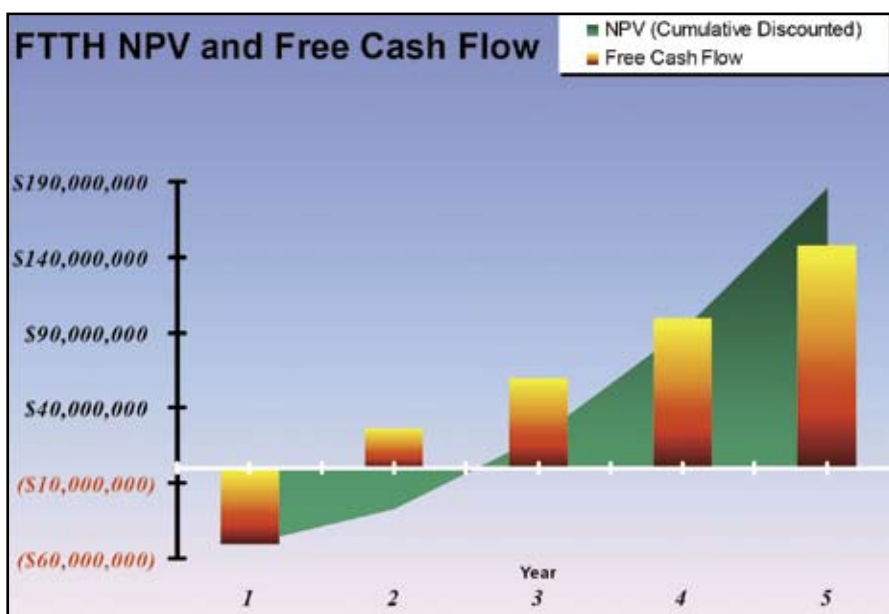
the broadband access network. Note that ADSL technology does not have the capability to provide HD video services for IPTV or VOD. With the network loaded with all broadband services, the cash flows all accelerate, FTTH accelerating at the highest pace.

The straight free cash flows give us an intuitive view of the business cases of the three architectures using different technologies – carriers adopting FTTx, with GPON technology, invest heavily in the initial stage, but get rewarded by its capability to provide more bandwidth to each subscriber through high bit rate HSI services and high definition video services. Especially for FTTH, GPON requires high deployment investment to reach each home through an optical medium.

At the same time, the exclusive overlay TV can serve as a short-term helper to turn the cash flow around, not to mention the potential to carry more advanced, more revenue generating services that can only be made available through high bandwidth access technologies, such as GPON.

**A Full Business Case Analysis**

A full business case can be built for



**Figure 5. NPV and free cash flow for FTTH with all services.**

FTTH, FTTC or ADSL based on the straight cash flows obtained above. A full business case analysis includes other factors such as net present values (NPVs), network management and maintenance cost, network engineering and equipment installation (E&I) cost, sales, general and administration (SG&A) cost, income taxes, depreciation of capital cost

and interest for loans, if any. One of the main objectives of a business case is to understand the payback period after the investment is put into place for the build-up of the business infrastructure.

Our study assumes a 10 percent management and maintenance charge out of the total capital cost in each year for FTTH and 15 percent for FTTC and ADSL. This is because the FTTH option uses GPON technology in all feeder and distribution plants so that there are no active electronic components in the field. Active components require power support all the time and have a higher rate of failure than passive components.

We allocate 5 percent for the E&I of the annual incremental capital cost. SG&A is approximated by a percentage of the total revenue; the greatest spending is in the first few years. We assume

a 20 percent SG&A in the first year, 10 percent the second year, and down to 5 percent for each of the following three years. Income taxes are totaled at 40 percent. A five-year straight-line depreciation is assumed. A 12 percent discount rate is used in calculating the NPVs.

Figure 5 gives a graphical description of the cumulative free cash flow and

NPV of the operating cash flow for the FTTH scenario. When loaded with all the broadband services, as indicated by the diagram, the payback period is 2.6 years. The payback period becomes 4.3 years if the network carries only HSI services, and 3.4 years if it carries HSI and overlay services. Similarly, the FTTC and ADSL business cases show payback period of 2.3 years and 1.5 years, respectively, with all services being loaded.

### Conclusions

In examining the economics of deploying a broadband access network using GPON and twisted pair copper technologies, some interesting discoveries came to light. Several outcomes met with general expectations: ADSL technology delivers a quicker payback period, and GPON technology delivers faster growth in cash flow. However, the payback time difference between the two technologies is smaller than expected.

***We were surprised to observe that the overlay TV service improves the payback period by almost a whole year for the FTTH scenario: It contributes over a fifth of the total revenue.***

We were also surprised to observe that the overlay TV service improves the payback period by almost a whole year for the FTTH scenario: It contributes over a fifth of the total revenue. To take the full bandwidth advantage of the GPON technology, more services, such as business grade, service level agreement (SLA) based services can be provided to small or home-based business customers through the broadband access network. This will further strengthen the business case for

the FTTH and FTTC architectures.

As carriers migrate their networks to deliver multiple broadband services over a single integrated technology platform, GPON will be a powerful and efficient way to bridge the first mile of these networks. GPON architectures scale well across all services and across residential and business requirements.

GPON architectures can increase revenue through the delivery of new services over a single connection to both businesses and residences with reasonable payback period. We also truly believe that GPON will play a fundamental role in the convergence of a packet-based network with unified network management.<sup>3</sup> **BBP**

### About the Authors

*Sunan Han, William Yue, Stephen Smith are all at Fujitsu Network Communications, 2801 Telecom Parkway, Rich-*

*ardson, TX 75082. This article was adapted from a paper delivered at the FTTH Council meeting in Las Vegas in October.*

### References

1. Sunan Han and Sam Lisle, "Triple-Play Transport Architecture Alternatives and Economic Considerations," submitted to IEEE Network Magazine for the special topic of Convergence of Internet and Broadcasting Systems to be published in March, 2007.
2. Stephen Smith, "Business Class Services over a GPON Network," Proceedings of OFC/NFOEC, Anaheim CA, March 5-10, 2006, Section/Page: JThB96.
3. William Yue, "How GPON Deployment Drives the Evolution of the Packet-Based Network," Digest of the FTTH Conference, Las Vegas, NV, October 2-5, 2006.

**Killer App Conference** attendees will learn about broadband applications and their real-world impact from panels that include FTTP community representatives, applications developers, thought leaders and working professionals in:

**TELEMEDICINE  
DISTANCE LEARNING  
GOVERNMENT  
TELEWORK  
ENTERTAINMENT**

AND MORE...

Join us at the

**Killer App Conference**

to find out *What can we do with  
all this bandwidth?*

The **Killer App Expo** will provide a showcase for applications that are making use of broadband and ultrabroadband connectivity.

**For more information visit  
us online at [www.killerapp.com](http://www.killerapp.com)**