Start thinking about 3 to 30 Gbps by 2030!

Today's networks can be designed to eventually carry that traffic; here's how

By John George ■ *OFS*

It's become crystal clear that not all broadband is created equal and that some technologies will soon be obsolete. Why? Bandwidth requirements have been growing at 42 percent per year. Video-based applications are saturating the Internet and will drive data rates to levels far beyond the capabilities of copper based networks such as DSL and HFC.

In parallel, the first cost of ultra-fast fiber to the premises (FTTP) networks is now competitive. The result is that more that 1 million subscribers[1] in the US now enjoy FTTP services, and the number is expected to grow to over 10 million in just 5 years[2]. With many developers, property owners, and service providers now considering broadband, here are four keys to successful deployment:

1. Plan for new video applications that drive bandwidth past copper.
2. Choose FTTP due to cost parity plus bandwidth demands.
3. Design the FTTP Network for bandwidth upgrades over many decades.
4. Leverage recent innovations to enable cost effective migration to the coming Gigabit era.

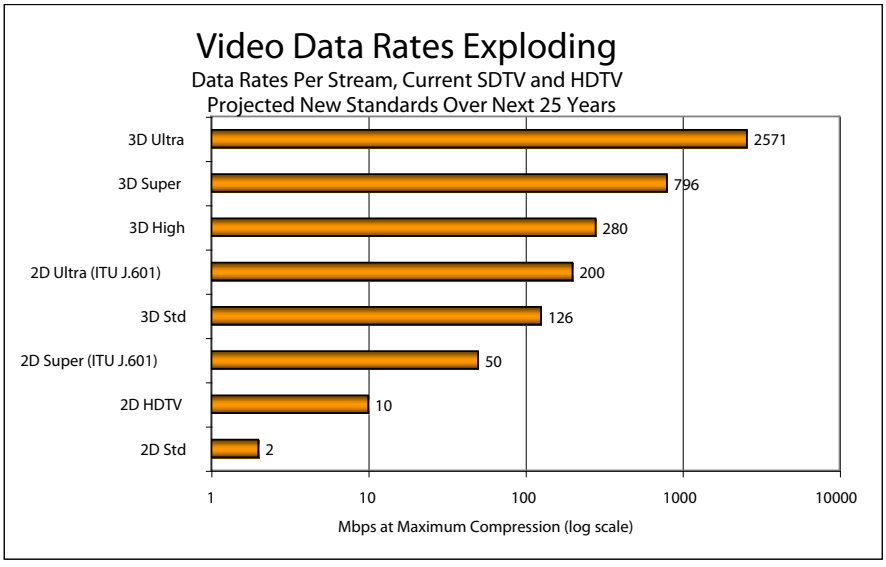

Figure 1 – Video data rates.

Video Applications Drive Demand

Entertainment, telecommunications, and workplaces are becoming dominated by video. Video ***enables*** several killer applications that will drive bandwidth growth at over 40 percent per year for decades. In the last century broadcast television sent the same few channels to all subscribers. Today it is enabling revolutionary new applications that are fast becoming customized and personalized for every user, driving up bandwidth demand both to and from homes. Here is a sample of the applications enabled by personalized and customized video:

- **OnlineVideoStores**–Thousands of titles, archives of everything, any time for instant viewing or download. Replacing bricks and mortar stores with video is a $16 billion opportunity. There are dozens of these Websites today, though the download takes about 1 hour with a fast DSL or cable modem.
- **Telemedicine** – HD video and imaging from individual to physician. Only 3 percent of the $1.5 trillion healthcare industry represents a $45 billion opportunity.
- **Gaming** – 3D versions in high definition may bring civilization to a halt!
- **Video Conferences and Learning** – HD and 3D enable the in-person experience.
- **Social Video** – Our kids are already loving it. Just consider the popularity of youtube.com with 100 million downloads and uploads a year, and other similar Websites.

Figure 2 – 103" HDTV plasma monitor.

multiply bandwidth demands exponentially. Large screens not only provide a more lifelike experience but also enable viewing multiple videos on the same screen simultaneously. This is of great value to sports fans, who are typically the most willing to pay for entertainment. The monitor makers see increasing screen size as a market demand; One manufacturer just announced a 103" Plasma TV that will be on sale later this year [3]. Clearly, we will are headed toward the wall-sized video monitors that futurists have predicted. But one issue with large screens is that they require proportionately higher definition to

- **Video Mail** – Video clips of a child's birthday, a product presentation, detailed damage assessment for an insurance company, advertising, and lots more.
- **Video Telephony** – HD and 3D will finally make it real.
- **"Video" commuting** – using all of the above applications, saving $3 per gallon gasoline.

These applications in high definition and later in 3D might require greater than 1,000 Mbps per home. Copper technologies at best support 50 Mbps of assured bandwidth per home while fiber can support 10,000 to 100,000 Mbps.

Dedicated video streams plus the progression to higher definition and 3D video will soon drive requirements past copper. Super Definition and Ultra Definition video has already been demonstrated and 3D video is being developed today. As a result the bandwidth required for video streams is projected to increase over 100-fold in coming years as shown in figure 1.

Lifelike Displays Eat more Bandwidth

The trend to larger screens, higher definition, and 3D video will

Compression to the Rescue?

FTTx Cost vs Performance Comparison (Greenfield or Brownfield, Estimated)	Fiber to the Multiple Dwelling Unit		Building		Complex	
	Down	Up	Down	Up	Down	Up
Bandwidth (Mbps) with 2006 Equipment	70	35	30	30	25	1
Practical Bandwidth Potential (Mbps)	10,000	10,000	1,000	1,000	50	5
Relative Cost (2006)	1,200		1,100		1,000	
Relative cost for future upgrade to practical potential	600		400		200	
Relative Cost per Mbps 2006	11		18		38	
Relative Cost per Mbps Practical Potential	0.1		0.8		22	

Table 1 – FTT MDU Cost vs. Performance (worst case bandwidth)

Won't video compression save us from exploding video bandwidth demands? Compression has already greatly enabled bandwidth-limited networks but is quickly running out of steam. Transporting a single uncompressed HDTV signal requires 1.5 Gbps. HDTV has already been compressed by 75 times, down to only about 20 Mbps per stream today. Emerging standards might cut that in half to 10 Mbps, a compression ratio of 150. But with high compression, image quality suffers because there is only a finite percentage of redundant data in a video. Once the redundant data is compressed, excessive reliance on algorithms that predict motion and color changes increases the probability of errors. These can be manifested in pixilation, lower definition, and detectable color variations compared to the uncompressed original. Even so, the projections above assume an increase in compression ratio from 150 today to 600 in the future. In spite of increasing compression ratios, data rates are projected to grow at 40-50 percent annually to keep pace with video application demands. Big bandwidth requirements aren't just downstream to the home anymore. Data

➥

rate requirements will soon be symmetrical to support the growing personalized video files and video telephony that subscribers will transmit to the network. Sending video content and video communications from the home will drive "upstream" bandwidth requirements to new heights. Increasing symmetry in bandwidth demands is now exposing deficiencies in DSL and cable modem networks, which allocate upstream bandwidths of only 10 to 20 percent that of downstream.

FTTP is the Best choice

Why is FTTP the best choice? Quite simply, it provides much higher data rates at about the same price as copper, to support bandwidth demands for decades. As seen in the Fiber to the Multiple Dwelling Unit example on the previous page, running fiber to each unit lowers the cost per Mbps by 38 to 99 percent compared to networks using copper in the last 100 to 1000 meters.

maintain video sharpness.

In response, the International Telecommunication Union (ITU) is currently developing a standard for transporting super and ultra high definition video for large screen applications. This standard for "Large Screen Digital Imagery" can support both high definition large screen displays, and ultra high definition smaller displays. Within the current draft of the new standard, and the most optimistic compression, bandwidths of up to 200 Mbps per video stream will be required.

What is next after super HD and ultra HD video? Three dimensional video will create true lifelike moving images, and it is being developed today. While is difficult at this time to predict exactly what type of technology will be used to record and display 3D video, the many proposals under investigation share a common requirement: More bandwidth. The projected bandwidth required to transport future 3D video over the FTTH network seems incredible – 2.5 Gigabits per second (Gbps) for each video stream.

While video streams are projected to require very high data rates, this pales in comparison to what might be required to support such video integrated into entertainment, business, and personal applications. This would require huge increases in the bi-directional access bandwidth provided for each home and business, as shown in Figure 3.

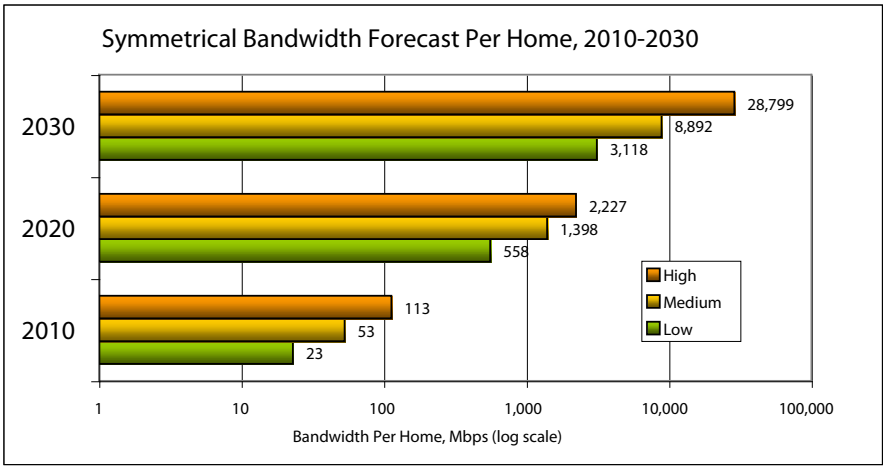

Figure 3 – Projected access data rates per home required in 2010, 2020, and 2030, assuming three video and voice streams, one gaming stream and one data/email stream per home simultaneously.

The increase in video bandwidth per stream is understandable given increasing definition and 3D video. The surprising increase is projected for Internet and e-mail access data rates. In 2020, a presentation or recording of a child's birthday party might include 10 minutes of standard 3D video. Even compressed by a factor of 300 the file size would be 10 GB! To send this file in 60 seconds with no oversubscription would require 768 Mbps. The same in 2030 with super 3D video would require 4.9 Gbps. Do these projections seem high? At the current bandwidth growth rate of 42 percent per year, we will need 2,000 Mbps per home in 2020, and 67,000 Mbps per home in 2030! Even if bandwidth demand slows to 25 percent per year after 2010, the required rates will be over 300 and 3,000 Mbps respectively.

Design FTTP for Bandwidth Upgrades over Many Decades

Wall-sized video, higher definition, and 3D will likely drive bandwidth

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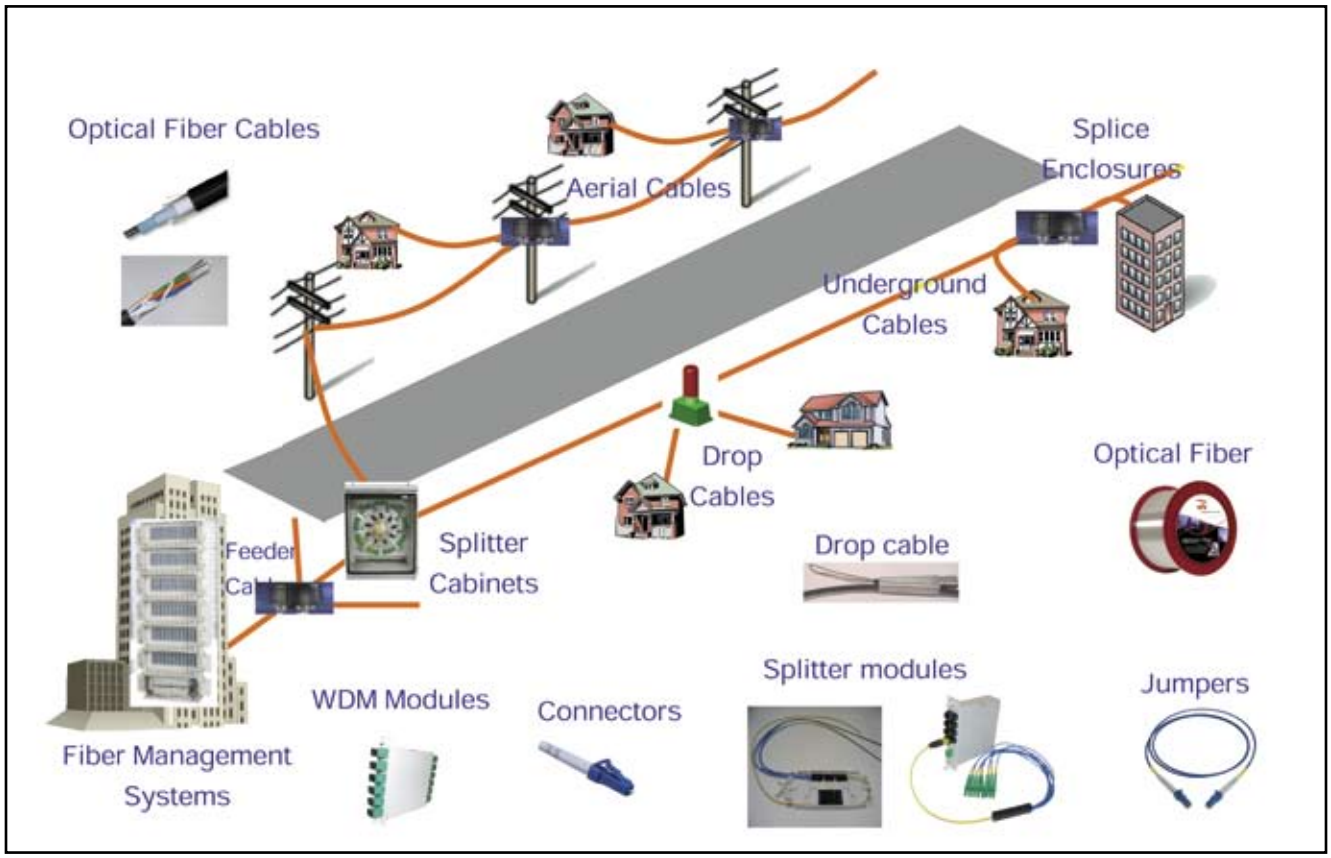

Figure 4. A view of a typical Optical Distribution Network and its elements; the ODN is the optical path that must support many generations of applications and upgrades 25 to 40 years into an uncertain future.

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per home well into the Gigabits per second. Symmetrical bandwidth pipes will be a necessity. But will the network be capable of providing that kind of bandwidth for each home? Can access network speeds economically keep pace with exploding video bandwidth demands? The answer is a resounding yes, if the network is fiber to the home and designed to support 25 years of bandwidth growth, without expensive replacement of cabling infrastructure.

First-generation FTTP networks provide up to 70 Mbps per subscriber, assuming a GPON with a 1:32 split ratio. By reducing split ratios, PON speeds can be quadrupled to 280 Mbps. Work has begun in standards bodies on a 10,000 Mbps PON capable of 280 to 1,125 Mbps per subscriber.

Another step in speed is the WDM-PON, which can increase data rates to 1,000 or even 10,000 Mbps per subscriber. WDM-PONs add more wavelengths to each fiber to increase the data rate, and can use existing economical technology. What is the best way to be prepared for such upgrades?

Pay attention to the Optical Distribution Network and design it with the future in mind from day one. The ODN is the optical fiber pathway between the centralized electronics in the network, and the electronics at the subscriber's premises. Well designed ODNs can support the fantastic video, data, and voice services enabled by fiber optics, for many decades through many generations of electronics, without expensive replacement of outside optical cabling system. The ODN consists of the optical fiber cable, connectors, splitters, jumpers, and WDM multiplexers and de-multiplexers (Figure 4).

Enabling Cost-Effective Upgrades

The ODN design guidelines and products to support FTTP with low first-cost, low life-cycle cost, and economical upgrades are simple, available from multiple sources. Following are ODN guidelines for a 40-year future-proof ODN.

Full Spectrum Optical Path

☆ Elements

- G.652D Full-Spectrum or Bend-Insensitive Full-Spectrum fiber. Note: There is no practical benefit from special high power fiber.
- Full-Spectrum Splitters loss-rated for 1260 nm to 1620 nm.

☆ Benefits

- Cost-effective upgrades to 10 Gbps per home (symmetrical).
- Insurance against re-cabling to support future upgrades.
- Enables lower cost Full Spectrum CWDM options.
- Greater revenue potential and flexibility.
- Enables all WDM PON upgrade possibilities.
- Enables CWDM PON overlay option.

Low-Loss Optical Path

☆ Elements

- Low-loss optical fiber cable over the Full Spectrum from 1260 to 1620 nm
- Low-loss connectors, splitters, and jumpers.
- 50 percent reduction in signal loss vs. conventional components.

☆ Benefits

- Lower cost - 1.5 to 3 times longer reach reduces electronics locations and allows maximum split ratios and port use.
- Greater reliability margin to maintain services with aging and stress on ODN elements.
- Lower optical power and lower cost support of legacy analog video.

Easy to install and upgrade

☆ Elements

- Low labor to install cables (dry with no filling compound).
- Modular splitters upgradeable to lower split ratio or WDM.
- Easy to provision cabinets and patch panels.
- One feeder fiber for every 8 homes.

☆ Benefits

- Lower first cost
- Less opportunity for error
- Low cost /less disruptive upgrade to future xPON or WDM PON.
- Lower cost upgrade to 1:8 split ratio PON and/or CWDM-PON.

Reliable Optical Path

☆ Elements

- Fusion splicing where possible, vs. OSP connectors.
- Bend Insensitive fiber.
- Standards compliant products from reputable manufacturer.

☆ Benefits

- Lower life cycle cost by reducing costly truck rolls for repair and maintenance.
- Splicing proven for 20 years in backbone networks, cost effective today for FTTH.
- Bend insensitive fiber can prevent network failure from inadvertent tight bends that can occur anywhere.
- Increased revenues through improved service reliability and subscriber retention.

Conclusion

Video applications offering increasingly lifelike experiences will continue to drive 42 percent annual growth in household bandwidth (data rate) demands. Choosing FTTP maximizes the potential to realize greater revenue through new video based services.

Well designed ODNs can support the fantastic video, data, and voice services enabled by fiber optics, for many decades through many generations of electronics, without expensive replacement of outside optical cabling system. The ODN consists of relatively low cost elements that are expensive to install and disruptive to replace. Service providers need to understand how to design and deploy ODNs today that provide reliable and cost effective support for the variety of current and future architectures that must be supported over the potential 40 life of the ODN. The ODN should be capable of economically maximizing revenues for future video applications with reliable service to maximize subscriber retention. Specifying an ODN providing Full Spectrum, low loss, and reliable performance in easy to use packaging is a cost effective key to maximize the return on investment and value of FTTH networks. **BBP**

About the Author

John George is Director, FTTX Solutions at OFS. You can reach him by phone at 770-798-2432 or email at johngeorge@ofsoptics.com.

References

[1] "FTTH/FTTP Update" presentation by RVA to FTTH Council, June 2006

[2] "Worldwide Markets for Fiberoptics In Broadband Access Networks", KMI, August 2006

[3] "The New King of Big TV's Is Queen-Size" - By DAMON DARLIN, NY Times, July 24, 2006