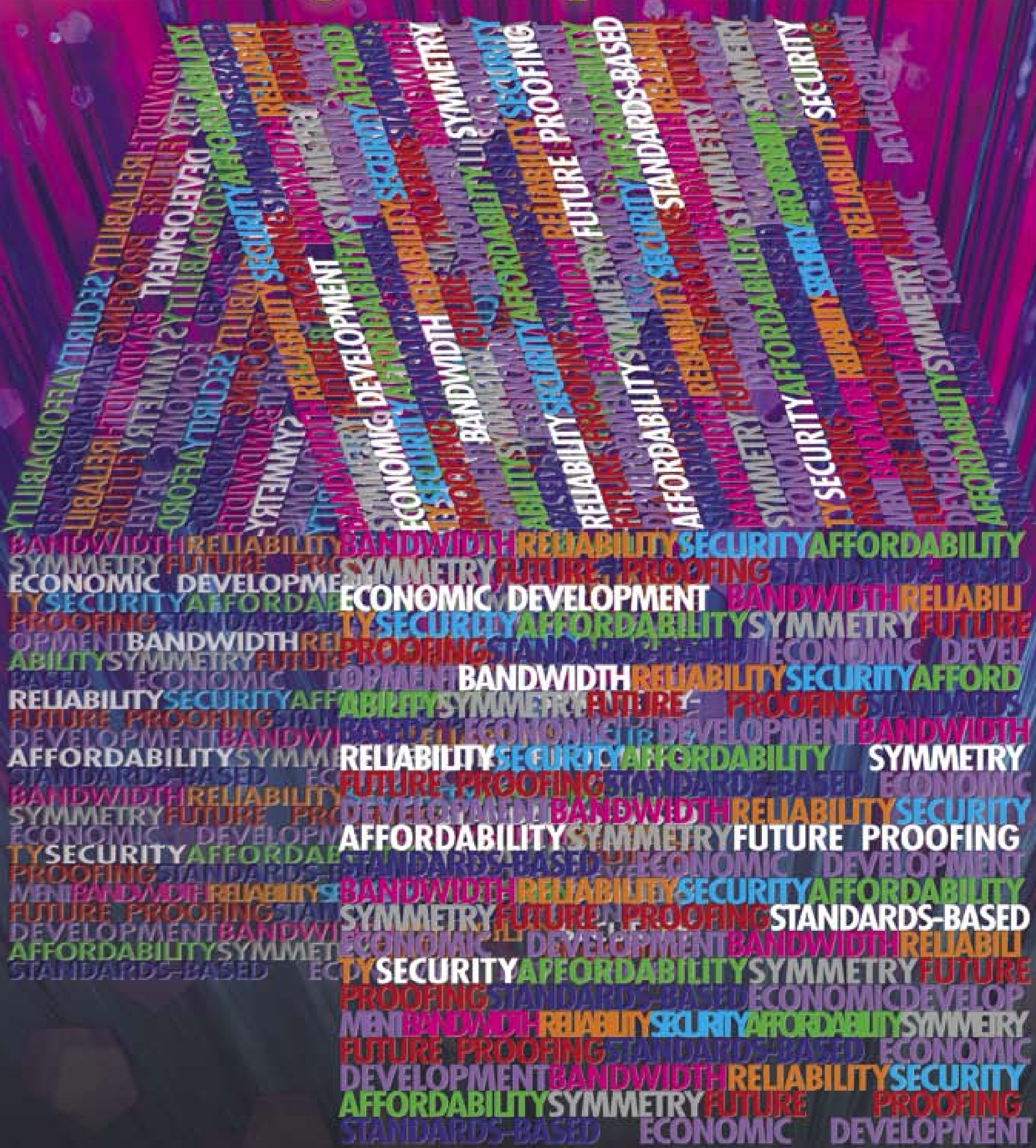
FTTH council | fiber to the home

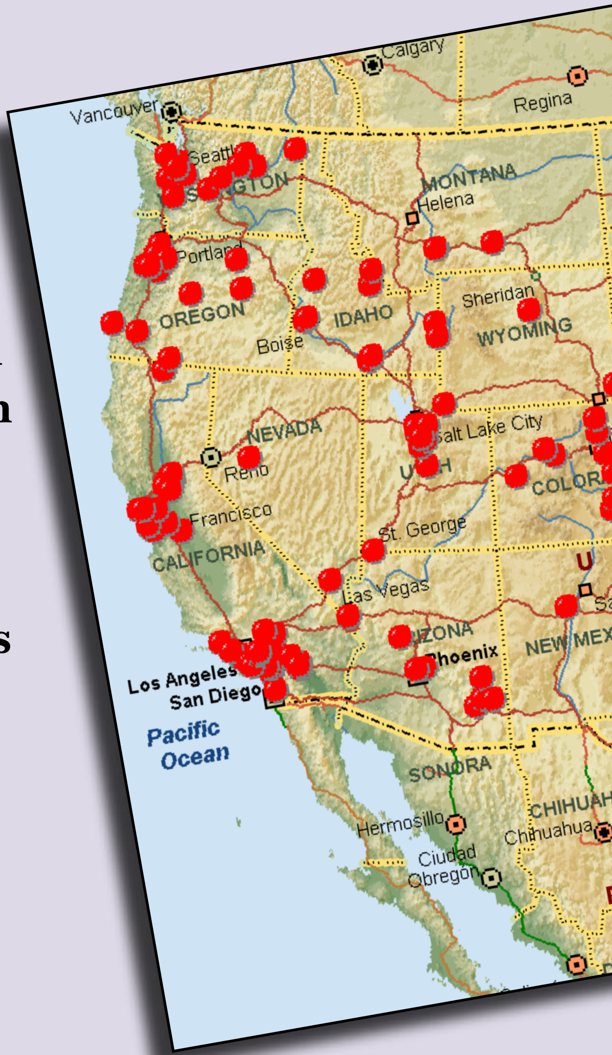
Fiber to the Home

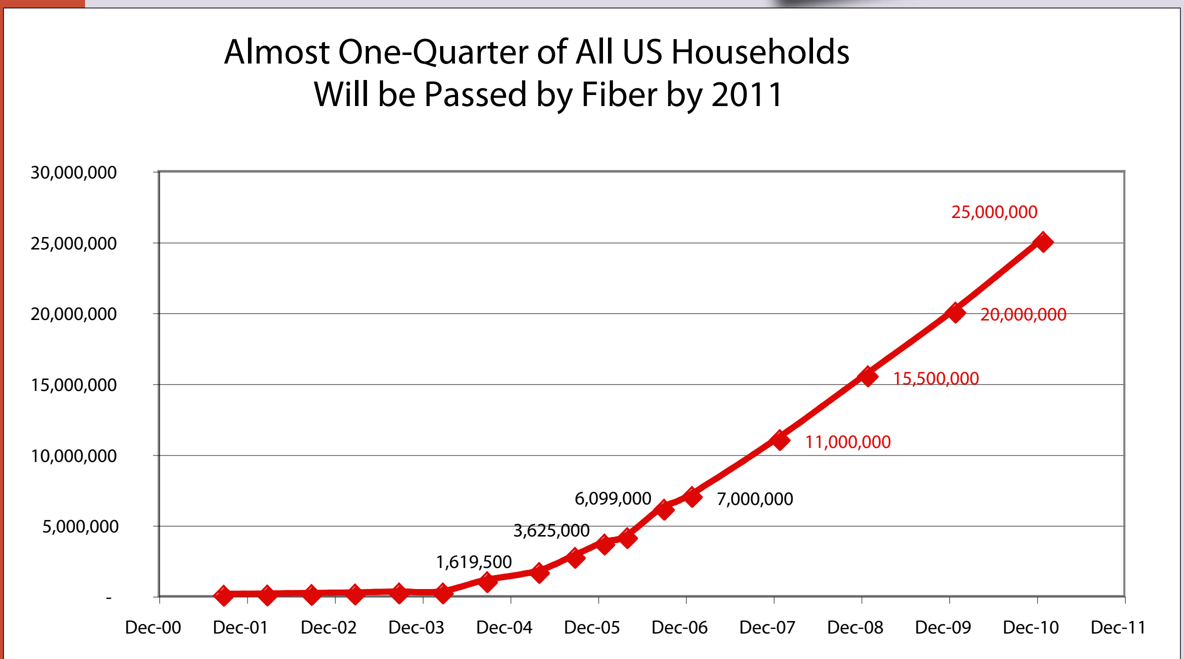
Advantages of Optical Access



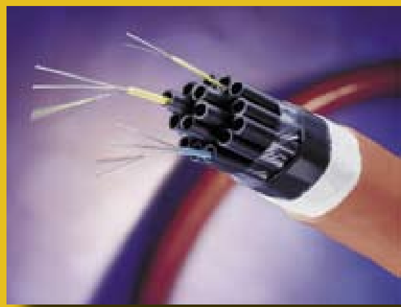
North American Deployments

As the number of Fiber-to-the-Home communities and real estate developments passed the 1,000 mark in spring 2006, every region in the country stood to share in the bandwidth capacity, reliability and economic benefits of this future-proof technology.





Source: BBP LLC



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Reliability... Bandwidth... Affordability... Future-Proofing... Standards... Security... Economic Development...

Why FTTH, Why Now?

Fiber-to-the-Home (FTTH) has become a reality. More than a million consumers now use direct fiber optic connections in the United States, more than 6 million in Japan, about 10 million worldwide.

FTTH is also widely recognized as the optimal solution for providing broadband to new and existing communities alike. In fact, hundreds of FTTH communities are flourishing here. Why? FTTH offers more bandwidth and more flexibility than alternatives, at a similar price. It cost $84 billion for the cable companies to pass almost 100 million households a decade ago, with a technology that offers far less than FTTH in every respect – lower reliability, lower bandwidth. For the same $850 a household – really less in today's dollars – the phone companies, public utilities, and even some cable companies have been installing future-proof fiber.

The basic technological and economic challenges of FTTH have been resolved. Based on the immense capacity of fiber – already the foundation of the world's telecommunications system – FTTH is now being deployed around the country and around the world. Almost all large developers are putting fiber in their new developments. Independent telcos are deploying it in rural America at an increasing rate. Municipalities in the U.S. and elsewhere are finding FTTH can be a feasible solution today that positions their communities for tomorrow's jobs and economic growth.

Wireless alternatives such as WiFi and WiMAX can't deliver HDTV – and in fact have trouble delivering standard-definition television. Variants of DSL, and even the latest cable and satellite links, can deliver HDTV only with difficulty, low reliability, and high operating costs. And that's today. What about the demands we see even five years down the road?

There's no problem for optical fiber. In fact, one bundle of fiber cable not much thicker than a pencil can carry ALL of the world's current communications traffic.

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So why should there be any confusion? Different types of people have different things in mind when they talk about FTTH.

- Engineers talk about bandwidth, as if raw capacity to move bits and bytes of data is an end in itself.
- Consumers think about the products and services that bandwidth can provide NOW. They can't demand services they don't know about, or that have not been invented.
- Political leaders, corporate economists and academics often have a third view: Bandwidth as publicly available infrastructure, a utility that makes it easier for people to develop new products or start entirely new businesses.

Public infrastructure also makes private property more valuable. A house, for instance, is generally worth much more if it has access to a public street, water, and sewer services, public schools and other "utilities" than if it does not.

Real estate ads in Korea carry from one to four stars to describe the bandwidth available. A four-star rating generally requires fiber.

Just as people argue about "how good is good" when it comes to roads and schools, we argue about "how much bandwidth is enough," in what form the bandwidth should be provided, and who might pay for it. Should it look like a "telephone" system, which historically uses a network technology that differs from, say, an Ethernet home or office network? Or perhaps it should look like the networks cable companies have developed for delivering TV channels and other video.

But if you are working in property development, building residential or business structures, why would you equip your building with 120-year-old copper technology that is already obsolescent, costs as much as (or more than) fiber, and will be totally obsolete in just a few years?

If you help run a telecom or cable TV company, why would you cede your competitive advantage to builders of fiber networks – networks that are cheap to run, reliable, and can deliver premium services you can't?

If you are a municipal official, can you explain to voters and local businesses that your community will be bypassed by the successor to the Interstate Highway System, the Information Highway?

And if you are a consumer, can you afford to buy a home that will have to be modified in a few years to accommodate that fancy new TV or the phone system your job demands?

In this primer, we explain the technology, in a way you, the nonspecialist, can understand.

We want to communicate... The advantages of Fiber to the Home.

The Advantages of Fiber

This primer covers the key economic and technical issues surronding fiber to the home. It explains why we believe you will agree that:

- FTTH – that is, Fiber to the Home – is the only technology that will deliver enough bandwidth, reliably and at a low enough cost, to meet the consumer demands of the next decade.

- FTTH is affordable now, which is why hundreds of companies using hundreds of different business cases worldwide are racing to install it in thousands of locations.

- FTTH is also the only technology that will meet the needs of the foreseeable future, when 3D, "holographic" high-definition television and games (products already in use in industry, and on the drawing boards at big consumer electronics firms) will be in everyday use. Think 20 to 30 Gigabits per second in a decade. Copper can't do even 1/1000th of that bandwidth, and then not for more than a few hundred yards.

- FTTH will enable products that we have yet to conceive of, but that we are certain will become necessities for living well and working well in the decades ahead. Look what just the past few years has brought: Mobile video, iPods, HDTV, telemedicine, remote pet monitoring… and thousands of other products.

Fiber and Bandwidth

Q: What is bandwidth?

A: In a network, bandwidth is the ability to carry information. The more bandwidth you have, the more information can be carried in a given amount of time.

Q: How much bandwidth – or information – do we need?

A: A standard-definition television signal requires a bandwidth of about 2 Mbps – two million bits (zeros and ones) per second. HDTV requires as little as 4 Mbps if the image is rather static – a person being interviewed, for instance. But fast action, such as some sporting events, requires more – as much as 8 Mbps, even with new compression technology such as MPEG4.

Q: What about data?

A: Bandwidth requirements are exploding for many kinds of data. Most new digital cameras create images that contain 2 to 15 megabytes. At the upload speeds generally available to people using a cable modem or DSL, it takes well over a minute to transmit a 10-megabyte picture. That is, 10 megabytes = 80 megabits, which at 1 megabit per second (Mbps) equals 80 seconds. It normally takes even longer because the network sends extra bits to help route the network traffic and to provide security. At dialup speeds, it would take at least 20 minutes.

Q: Why is fiber preferred to copper? After all, copper has been around a long time.

A: Optical fiber is unique, in that it can carry a high-bandwidth signal enormous distances. Copper can support high bandwidth, 20 Mbps or more – but only for a few hundred yards. The longer the distance the signal travels on copper, the lower the bandwidth.

Fiber uses laser light to carry the signal. Under most circumstances, the signal can travel 15 miles (more than 25 kilometers) without degrading enough to keep it from being received.

What's more, the equipment necessary to send the light signals keeps getting better. So equipping an existing fiber network with newer electronics and with lasers that pulse light faster, or lasers using different wavelengths of light, can vastly increase the available bandwidth without changing the fiber itself. That's why fiber networks are said to be "future proof."

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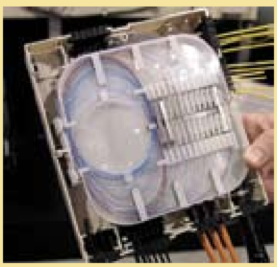


Q: That sounds like magic. But isn't fiber too new to trust?

A: Fiber has actually been used in communications networks for more than 30 years. But until 2002, it was rarely used to deliver a signal directly to a home. Instead, it was – and is – relied upon to carry communications traffic from city to city or country to country. Almost every country on Earth has some fiber, delivering services reliably and inexpensively.

In fact, if you have a cable modem, with broadband supplied by your cable operator, or if you have DSL, which converts your phone line into a data pipeline, you are already using fiber. The fiber carries the signal close enough to your home so that copper can carry it the rest of the way. But this approach requires expensive, hard-to-maintain electronics where the fiber meets the copper. The available bandwidth is far less than an all-fiber network. And these halfway approaches do not allow symmetrical bandwidth – existing cable and DSL systems can download much faster than they can upload information.

Q: Isn't that good enough?

A: That depends on what you want to use your bandwidth for. If all you want is to send simple text emails or receive an occasional photo of your grandchildren, the bandwidth provided by today's cable modems and DSL lines is good enough. But as soon as that photo becomes a video, you'll need more. And what about an adult monitoring an elderly parent?

Q: How close to the home does fiber come in DSL and cable systems, and why does that matter?

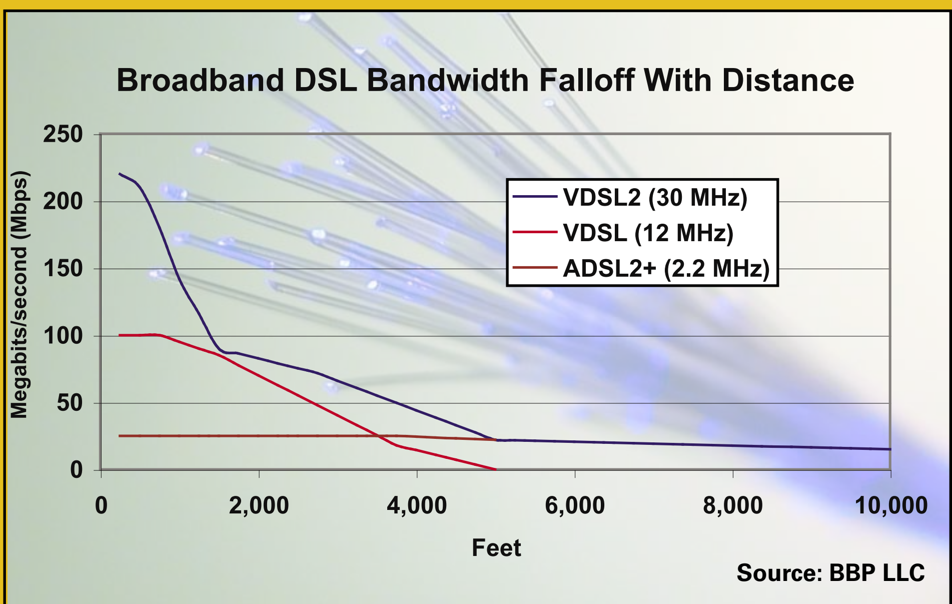
A: There is a marked relationship between the distance and the available bandwidth when you are using copper. The latest version of DSL is called VDSL2. It can carry a signal of more than 200 Mbps, but only for about 750 feet. At a distance of 1,500 feet, it can carry a signal of only 100 Mbps. Over a distance of a mile, it can deliver only about 30 Mbps. And that's the theoretical limit. In practice the real bandwidth is less.

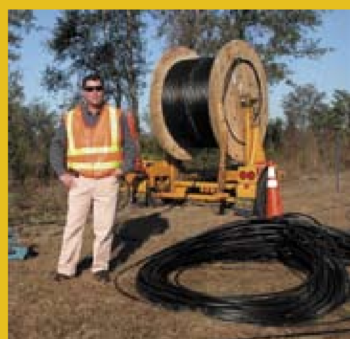
Q: Some telephone companies have been promising fiber to the home for a decade or more. But until recently there hasn't been any. Isn't that because the technology is difficult to master?

A: No, but until recently it was more expensive than other solutions that offer far less bandwidth, such as cable TV's DOCSIS and the phone companies' own DSL. Those older technologies were "good enough" until recently. But in the past few years, content that was expected, such as HDTV, and content that was not predicted, such as peer-to-peer video, have simply outrun the ability of these older technologies to handle the bandwidth needed.

> If you have a cable modem, with broadband supplied by your cable operator, or if you have DSL, which converts your phone line into a data pipeline, you are already using fiber, but not all the way to your home or business.

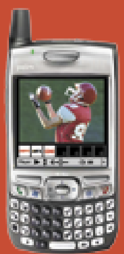
Now big cable companies advertise "unlimited" bandwidth. But in the fine print of their contracts with consumers, they reserve the right to shut off service when a customer uses an unspecified amount of bandwidth service in each month – 100 to 200 gigabytes. Some customers already use that amount of bandwidth for remote storage of their irreplaceable data files, videos, and images. A 100 GB hard drive is considered small today inside a home computer. Without FTTH, the cable companies can't deliver that much bandwidth to everybody.



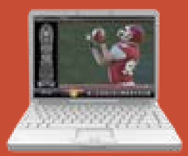


The Inevitability of Bandwidth Growth

All too often, we think of increased bandwidth as a matter of speed. It lets us do things faster. Send an e-mail message. View a Web site. But the real value of bandwidth is that it lets us do entirely new things with our computers, cameras, televisions – with our *network*.



What are these new things? We have the beginnings of glimpses of many of them. In the past few years, we have seen such new products and services as:



- Voice over Internet Protocol telephones. They're not only cheaper for the consumer, they are better. Many VoIP providers allow incoming callers to find the line you are on, and easily leave messages – text and video as well as voice – where you can easily pick them up.
- Video on the Web, and on mobile devices.
- Telemedicine, allowing the elderly and disabled to live in their own homes longer. Allowing doctors in larger communities to examine patients in remote areas of Alaska, from hundreds of miles away.
- User-created video so grandparents can see the children, or so a budding comedian or musician can develop an audience.

Entirely new and unforeseen product successes have dazzled, bemused and annoyed us. YouTube appeared in February 2005 – and quickly became one of the five largest users of bandwidth on Earth.

We have every reason to think the innovationwill continue and that our need for ever more bandwidth will grow. Only fiber to the home will be able to deliver it. In fact, only fiber can deliver that bandwidth now, to meet current needs.

We have absolutely no reason to think innovation will stop. When Thomas Edison built the world's first central-station electrical generating plants, electric lighting was the "killer app." Although Edison would later invent hundreds of products that use electricity, he was not thinking about air conditioning for private homes when he built the first electricity distribution network. Nor was he thinking about dishwashers, refrigerators, computers, or those rechargeable batteries for your iPod, mobile phones and cameras.

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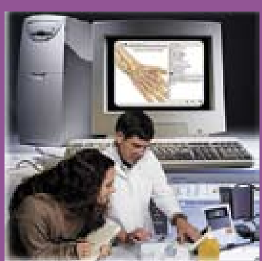


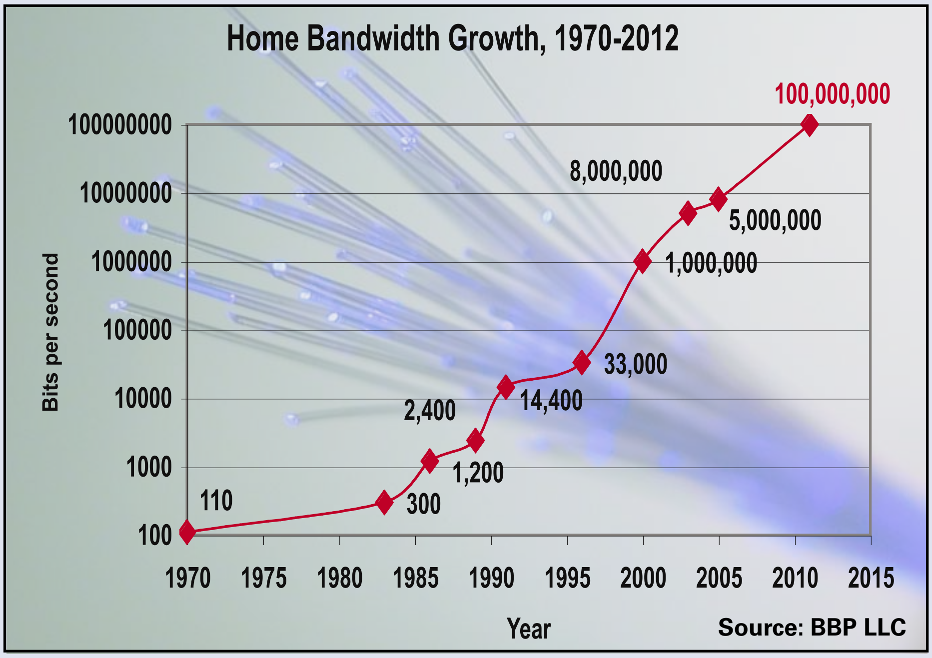
need the file space, they also need to send files of comparable size.

Wall of LCD screens at University of California at San Diego allows worldwide "telepresence."

And what about those digital images? Users get annoyed when the network's speed doesn't come close to the speed at which their own computer handles things. Using your computer's USB port, it takes about half a minute to move a 2 GB memory card's worth of digital pictures (or an hour of TV-quality video) to your hard drive. At common DSL and cable-modem upload speeds, it would still take 5 to 10 hours. At the dialup speeds still used by many American households, it would take more than 90 hours to move those images to a remote location.

Think about the speeds fiber to the home (FTTH) makes possible. TV manufacturers have. New sets just coming onto the market in 2007 can display wide-screen high-definition video from the local cable or phone company – and also from the Internet. And users don't have to "think Internet" to get the TV show they want. They just check out what's available using their TV remote.

Think hundreds of thousands – even millions – of fiber-enabled TV "channels" from all over the world.



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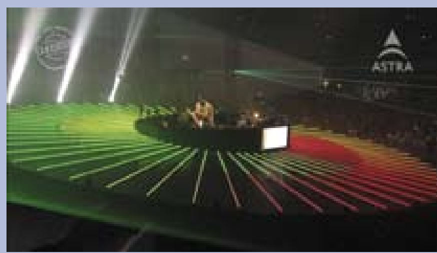


The Light Fantastic: Three Reasons

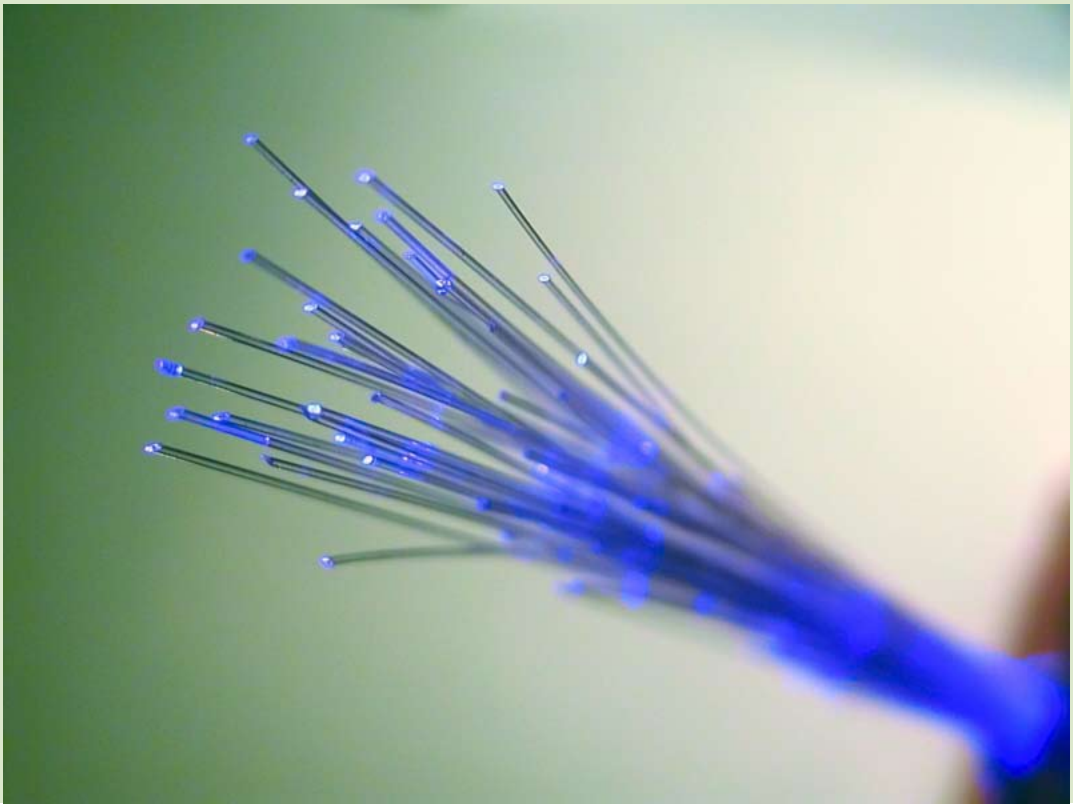
The key concept is this: Fiber optic cable carries information by carrying pulses of light. The pulses are turned on and off very, very fast. Multiple streams of information can be carried on the same fiber at the same time by using multiple wavelengths – colors – of light.

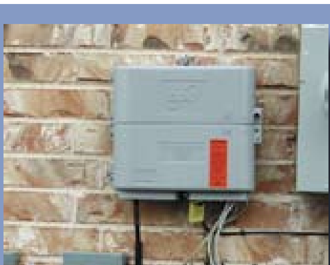
The pulses of light are created by lasers. The equipment to do that keeps getting faster, so the same old fiber can be used to carry ever more information. New equipment is just slipped in.

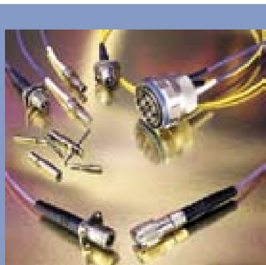
The ability to carry information is called bandwidth. Lots of bandwidth allows lots of information to be carried. Fiber has a lot of advantages over copper wire or coaxial cable, as it is easier to maintain and delivers far more bandwidth. Three of the biggest advantages are:

1 Signals travel a long distance inside fiber cable without degradation – 20 miles or more under some circumstances. In contrast, as the distance traveled by a signal in copper wire or coax increases, the bandwidth decreases. Short lengths of coax, for instance – the lengths typically found in a small building – can carry 1 Gbps.

That's a thousand times more bandwidth than typical broadband service using DSL over copper wire, and 200 times more than typical broadband over cable TV coax. But those speeds are impossible over longer distances. The closer fiber gets to a building, the faster the service that is available to the building's residents and businesses. Service providers have been bringing fiber closer and closer for years, and now they are bringing it inside end users' buildings.







2 Fiber cable is thin. It can, in fact, be made thinner than a human hair. It can be carried on a thin ribbon, or inside a "microduct" of hollow plastic only an eighth of an inch wide. One typical fiber cable configuration with about 200 superthin strands is about the thickness of a standard coax cable. That fiber cable could theoretically carry enough bandwidth to handle all the information being sent on Earth at any one time today. The bottom line: Fiber can be "hidden" easily on the surfaces of walls in old construction.

3 Once installed, fiber is upgraded by changing the electronics that creates the light pulses, and not by replacing the cable itself. The fiber is amazingly reliable. Nothing hurts it except a physical cut, or the destruction of the building it is in. Passive optical networks, or PONs, are the most common type of network. They use a minimum of electronics. In fact, there are no electronics at all between the provider's central office and users. This vastly improves network reliability.

Now, as we noted above, bandwidth providers are increasingly bringing fiber optics all the way to customer premises. That technology, FTTH or fiber to the home (also called FTTP, for fiber to the premises or FTTx for fiber to everyplace) is the "gold standard." But in cases where the population density is too low, or where high-quality coaxial cable or copper networks exist, it may make sense under some circumstances to bring fiber only partway to the customer. The fiber is then connected to the existing copper for the last jump to users' premises.

As time goes on, fiber is moved closer and closer to the customers, to provide more bandwidth. That approach is called FTTN for fiber to the "neighborhood" or "node" or (for greater bandwidth) fiber to the curb (FTTC).

Today, the looming bandwidth needs are so large, and FTTH construction prices so reasonable, that going straight to FTTH makes more economic sense.

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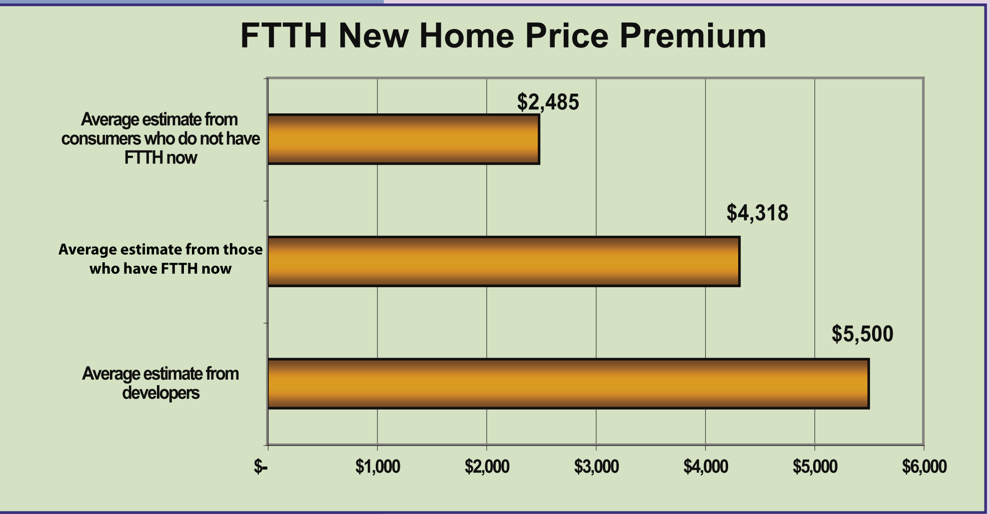
In the US until now, single-family homes have been the easiest to equip with FTTH. Apartment buildings and other multiple-dwelling-unit (MDU) structures in the US started to be served with FTTH in really large numbers only in 2006.

MDU fiber service is already common in Europe and Asia, however. Thus, there is no "technology risk" in specifying FTTH now, in any circumstance.

Builders, Real Estate Developers and FTTH

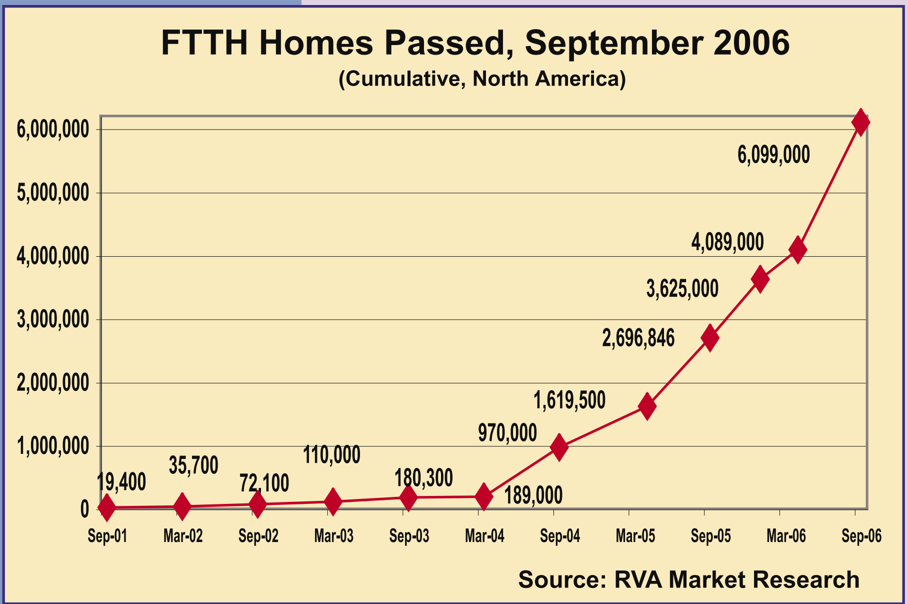


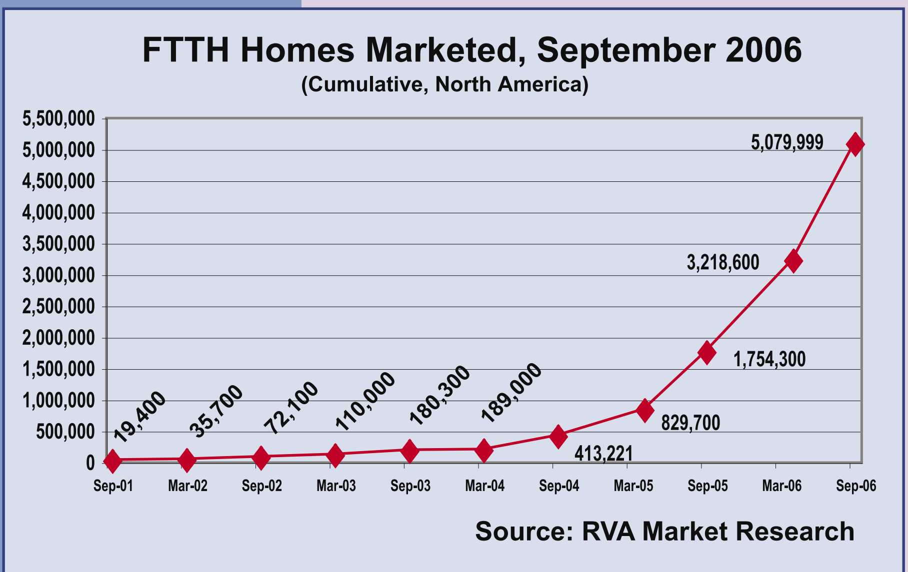
Virtually every large developer of single-family homes, condominiums and rental properties has an active program to add FTTH to new properties. Most are working on retrofitting older properties as well.

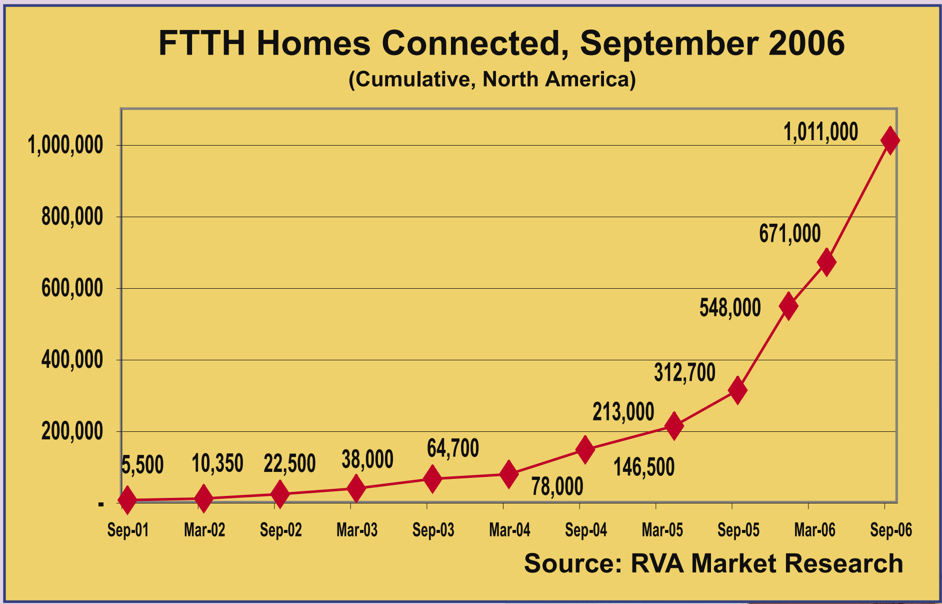
What do the major players know that not all smaller developers realize?

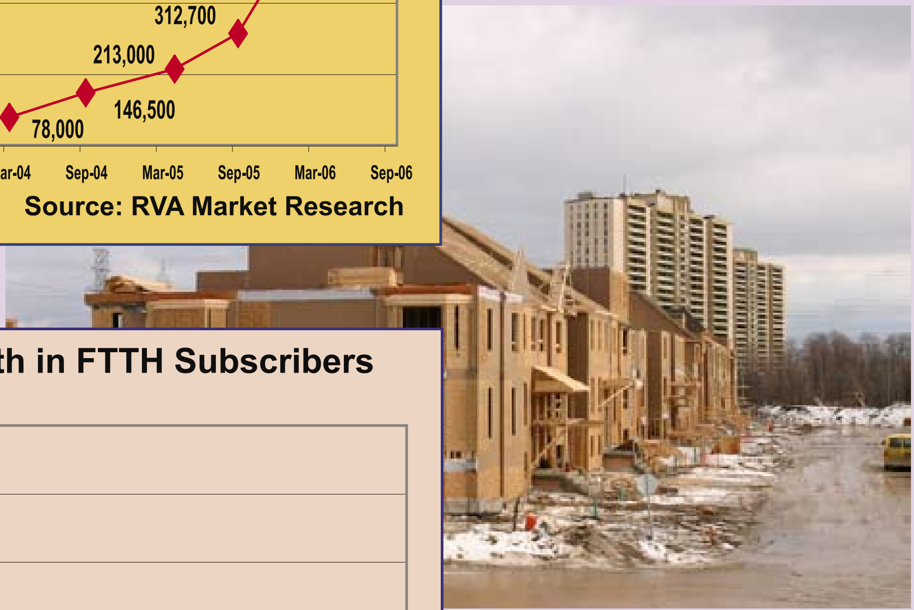
Michael Render of RVA & Associates estimates, on the basis of surveying home buyers and developers, that FTTH adds about $5,000 to the price of a home (see chart).

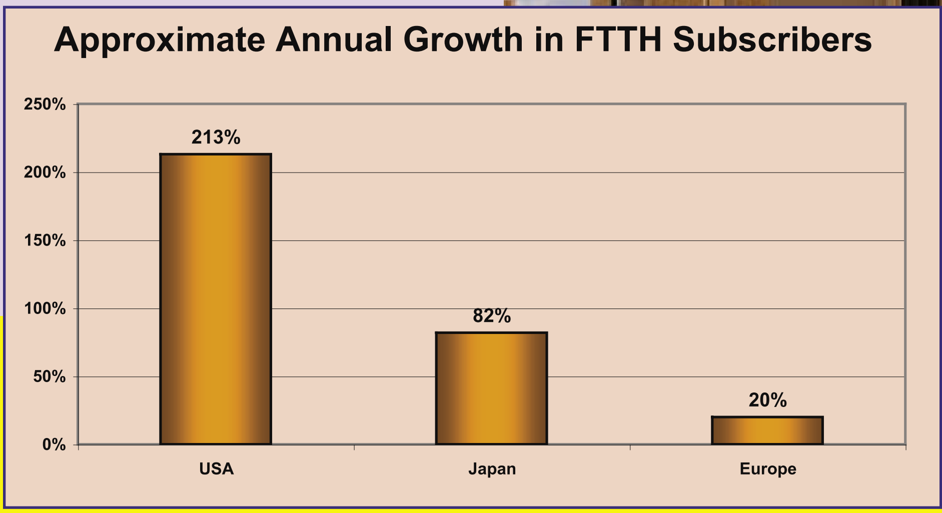
Nevertheless, some smaller developers were on the sidelines until recently. That's now changing. By mid-2006 it was clear that FTTH was economically viable in developments with as few as 100 single-family homes. As fiber costs have come down and copper costs have increased, the break-even point has sunk lower and lower. It now costs about $800 to pass a home with fiber.



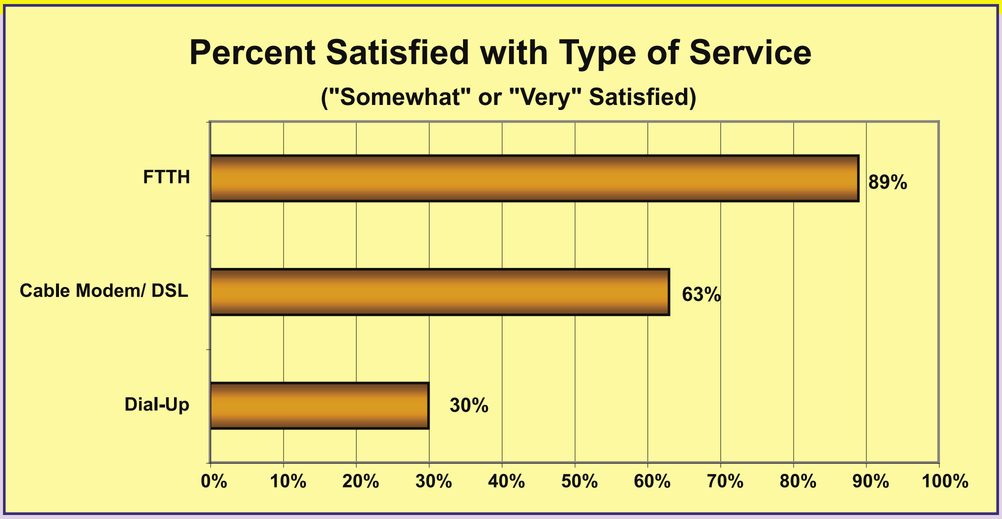








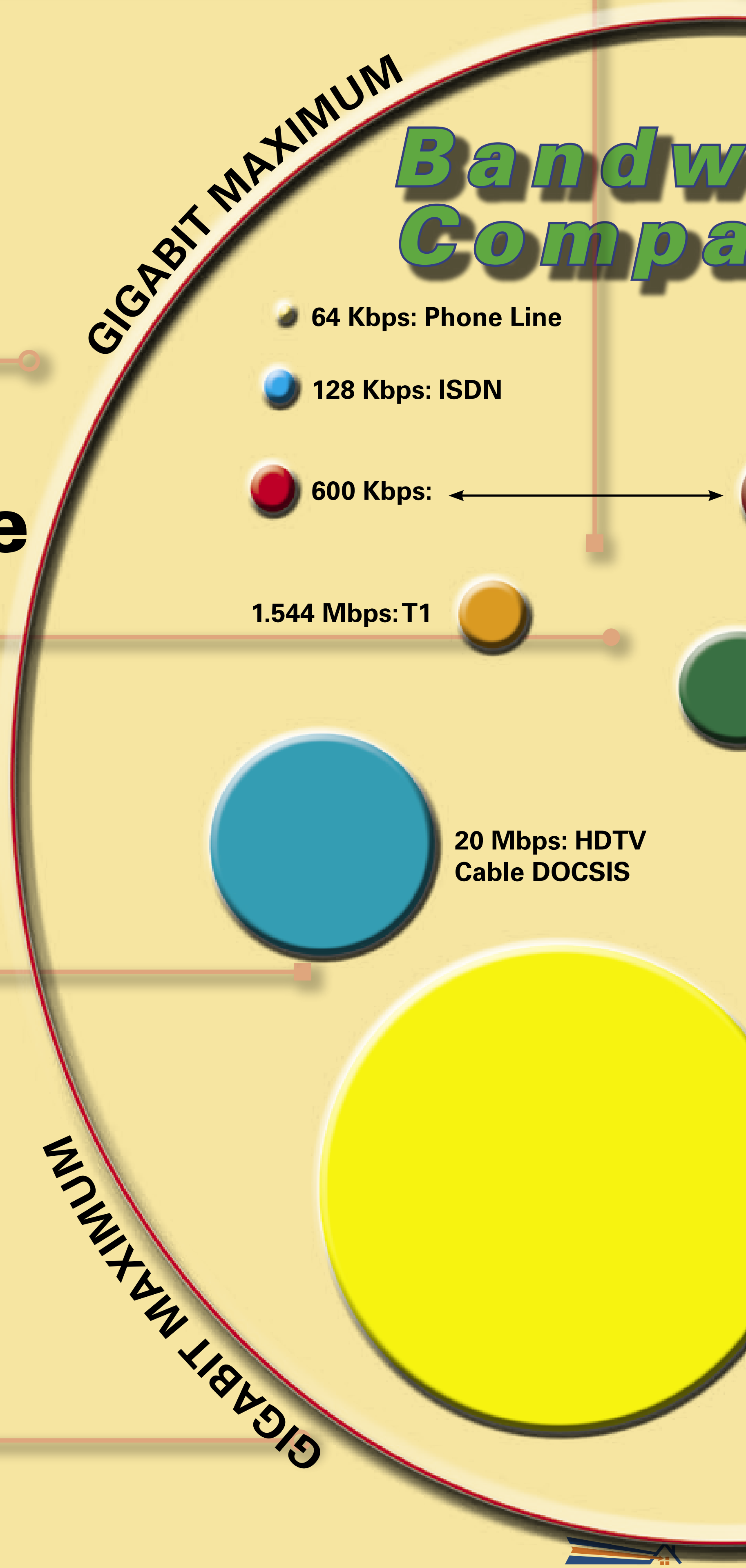
Source: RVA Market Research

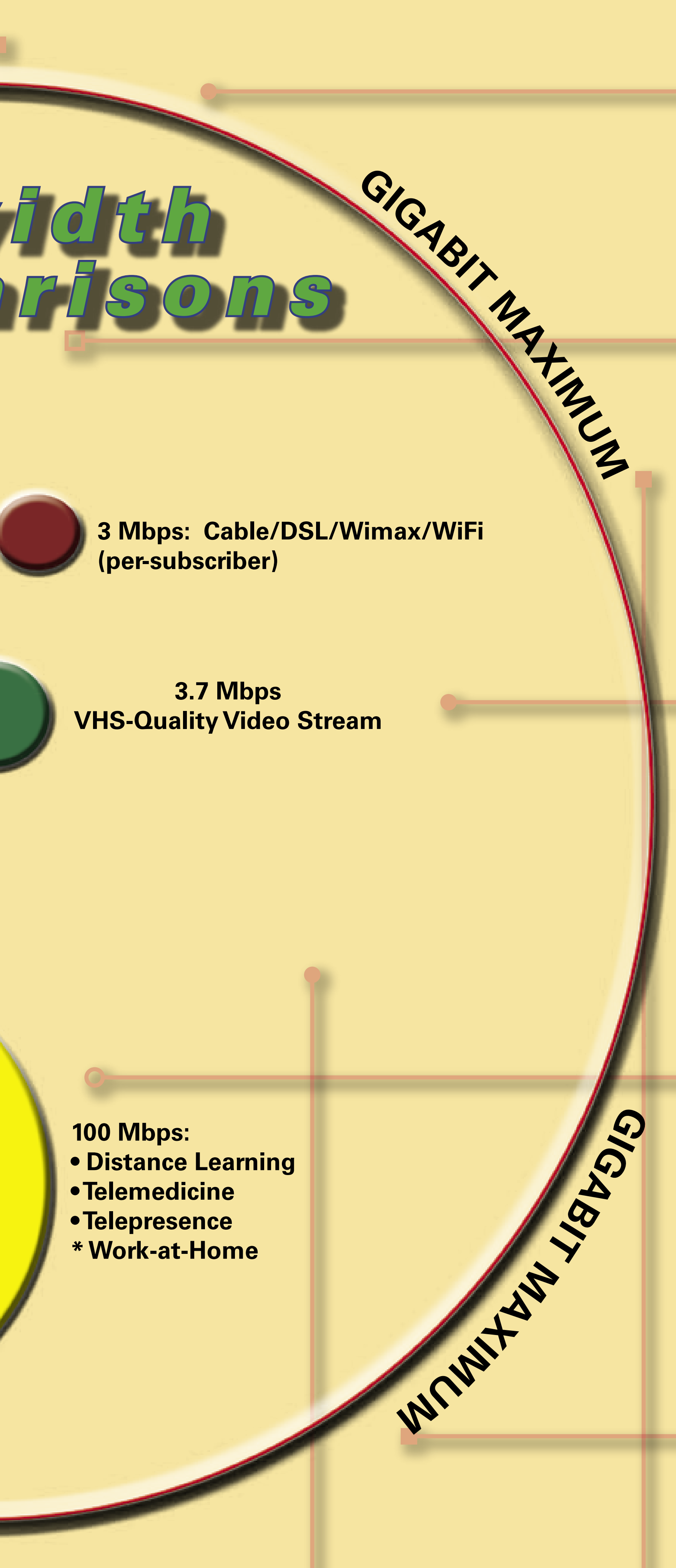


Source: RVA Market Research

Wanted: A Bigger Pipe

How big? Here's a graphical representation of fiber's bandwidth advantage over other technologies. It's a quantum leap.





Only the Beginning

A decade from now, even 100 Mbps or 1 Gbps will look small. By then, you'll be seeing 3D television on the market. It could require 2.5 Gbps or more.

Questions Real Estate Developers Ask About FTTH

Q: I and my architects, contractors, technicians and building managers are used to coax. At the point in construction that the coax should be installed, I call the guys up and they come and lay wiring. FTTH is new to them. I need to hire an engineering firm to design the installation, don't I?

A: Most FTTH systems up until now have been engineer-designed. But the balance appears to be tipping toward less formal design regimes thanks to increasing standardization during 2006 along with the growth of distributor-supplied design help and an expanding corps of qualified technicians. There were more than 150 colleges with courses for fiber technicians by the end of 2006. Overall, the various FTTH technologies differ only in detail, with one or another offering advantages in specific situations.

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Just as coax systems in very large apartment complexes need to be "engineered," that will continue to be the case for fiber. But smaller installations, as with smaller corporate LANs, will not need that kind of sophistication to work well.

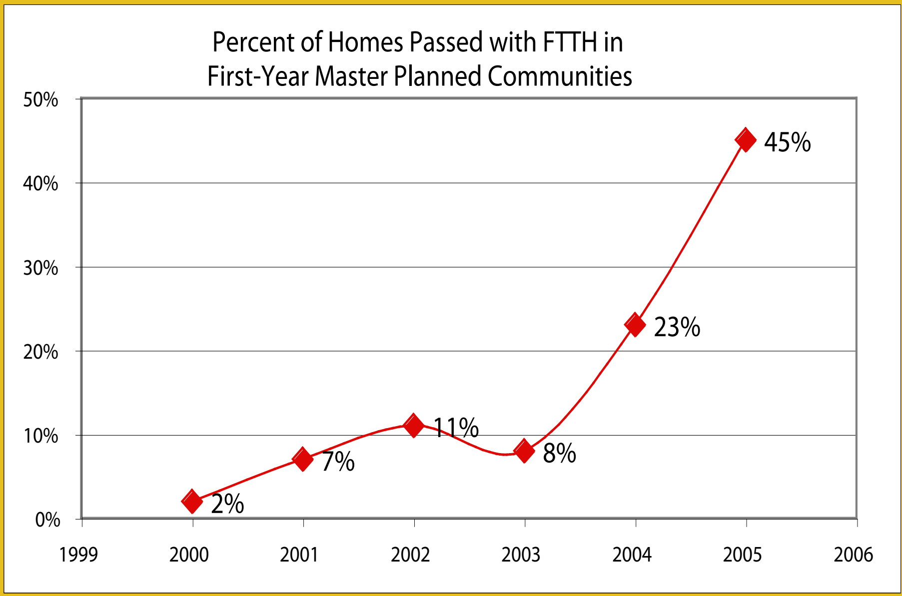
Q: What about other labor on my construction site? I hear that fiber is rather fragile and can be damaged before walls and trenches are closed.

A: The fiber itself is very, very thin – thinner than a human hair. But fiber vendors have evolved many ways to protect the fibers from harm. Cable can be armored to ward off cuts. Contractors can route inexpensive "microduct" – hollow plastic tubes as little as three-eighths of an inch in diameter – through walls before the walls are closed in with sheetrock or other materials. The microducts are easily repairable. After everything else is done, thin fiber can be "blown" through the microduct for hundreds of feet.

Q: Do any building codes pertain to fiber? The stuff seems inert.

Typical fiber distribution cabinet or "hub." It can be placed anywhere outside, because it needs no electric power.

A: Yes, all the regular fire and life safety issues apply. For instance, just as copper with PVC installation would be considered a life-safety hazard because of the combustion products produced when it burns, so would various plastics used in fiber that is meant for outside installation. Indoors, look for LSZH cables (it stands for Low Smoke Zero Halogen). If you are using thin plastic "microduct" that fiber can later be blown through, it should be labeled Halogen-Free Flame Retardant. You use a simple junction box to change from "outside" to "inside" wir-



Network connections built into the wall. This one is next to a kitchen counter in Loma Linda, California.

ing, just as you might with electrical cables.

And of course, check with your local building code inspector. Aside from fire issues, codes may govern where fiber ONTs (the boxes that convert pulses of light from the fiber into electrical signals for your computer or TV) are placed on the outside walls or in common areas. A few municipalities specify where in the home network connections should be placed.

Q: I'm building new single-family and residential MDU structures, and we've made the decision to add FTTH. Where should we put the users' network connections, assuming there is no specific building code or "guidance" document covering that?

A: You should expect users to desire broadband connections in virtually any room in the house – bedrooms, office-dens, the kitchen. That's because Internet connections these days accommodate telephones, televisions, electronic picture frames connected to your home computer, and of course the computer itself. You should also think about home security, monitors for fire, smoke, and your other household utilities. And, down the road, what about that telemedicine connection to your refrigerator or the alarm in your bathroom?

You should expect users to desire broadband connections in virtually any room in the house – bedrooms, office-dens, the kitchen. That's because Internet connections these days accommodate telephones, televisions, electronic picture frames connected to your home computer, and of course the computer itself.

Q: In a single-family home, I often see the ONT box hung onto the outside wall. Is that the only way?

A: No. In harsh climates, for instance – where heat or heavy snow could affect the outside installation - you will probably want to put the ONT indoors. In Japan, the ONT can be a small, portable unit, more like a cable or DSL modem, connected to the network with tough, flexible fiber that can be laid anywhere.

Q: I hear that ONTs require a backup battery. Why is that? When the power goes out, after all, the phone usually keeps working.

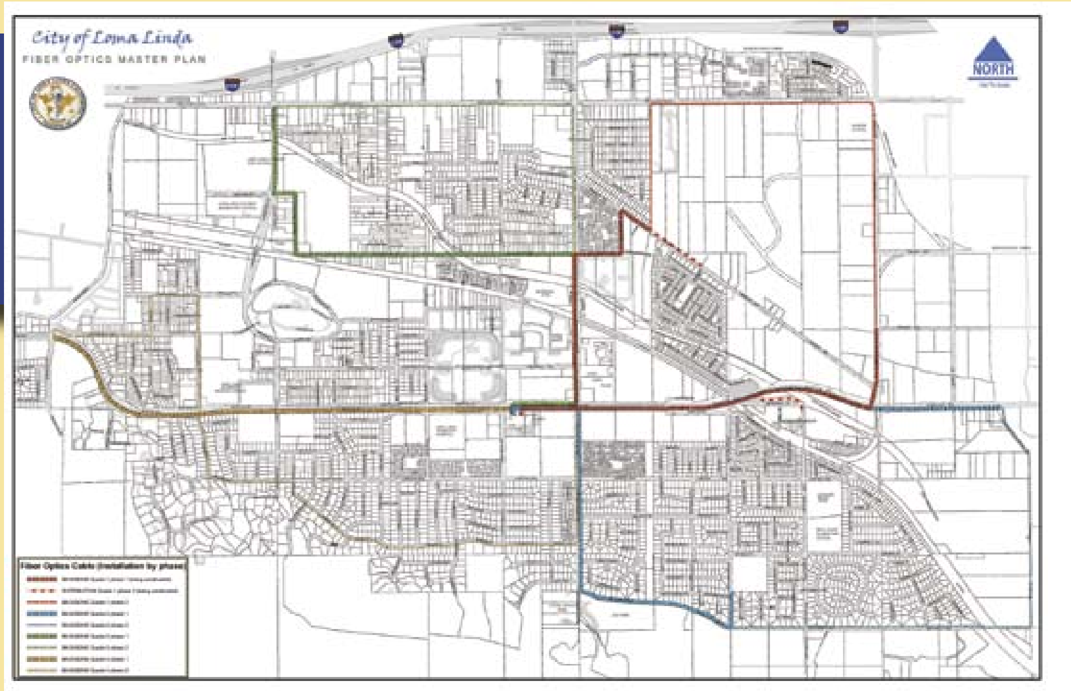
A: Optical fiber cannot conduct electricity. Thus, to keep the network connection running at times electricity has been cut, you need a battery at the user premises. There are many standard designs for in-wall between-stud boxes that hold the battery, ONT, and fiber connections.

Q: Is lightning a problem with fiber?

A: No. In fact, because fiber does not conduct electricity, lightning strikes do not affect fiber at all.

Focus on Municipal Priorities

Municipal officials face many issues with FTTH. Should they build their own network, or invite corporate providers in? Should they go for FTTH, or settle for something less? And what about wireless? Should they just ignore the whole issue and hope it will go away?



Key Questions Municipal Officials Ask

Q: Nearby towns and new housing developments are beginning to install FTTH, and local real estate agents say that property values in my town suffer because homes and businesses do not have access to FTTH. But the franchise cable operator offers 8 Mbps and says 40 Mbps will be available in a few years using something called DOCSIS 3.0. And the local phone company says it will be bringing in FTTN with VDSL. Isn't that good enough?

A: It may be good enough for the next few years, but it sounds like it will be installed just as broadband needs will increase beyond what DOCSIS and FTTN can deliver.

Q: But they tell me both use fiber. Is that true?

A: It is true, but not fiber all the way to the home. The last 1,000 to 5,000 feet from the fiber's endpoint to the home is handled with copper – coaxial cable in the case of DOCSIS, plain copper wire for VDSL. That limits bandwidth, reliability and versatility.

Q: But my town's residents are just like others in the region, and maybe have even slightly higher incomes. Why aren't they considered attractive customers for FTTH?

A: They may be, but they may run into overall corporate policy. A few cable companies are installing FTTH. Many telephone companies and independent broadband providers are doing the same. But the companies operating in your town may be following an overall policy they think will work for them.

Q: The telephone company that operates here is installing FTTH in the new development just 10 miles up the road. Why not here?

A: It is usually easier to install fiber in new developments than in existing ones. The fiber goes into the same trenches that have to be dug anyway for water, electricity and sewer service. In fact, copper wiring can't

The telephone company that operates here is installing FTTH in the new development just 10 miles up the road. Why not here?

be run that way, so fiber is usually cheaper. Also, the new residents are not already tied to a cable or phone provider, so whoever installs a FTTH network in a new community has an easier road to signing up customers.

That's why about half of all new, large housing developments are equipped with fiber.

Q: Would installing fiber require that my streets be dug up?

A: It depends. Many network builders use "aerial" fiber, installed on poles along with existing telephone, electric, and cable wiring. In areas where trenching is impractical, contractors can often use horizontal drilling, or pull fiber through existing ducts, water pipes, sewers and gas lines rather than digging up streets and sidewalks. In addition, many cities already have usable fiber under their streets, fiber that is not being used to its limit.

Distribution box for fiber lashed to existing aerial cable; this method is quick and inexpensive.

Q: What might I do to get fiber to my residents, without building my own network? My town has too much debt now to borrow more, and we have no experience operating a municipal utility.

A: You might try lobbying the incumbents – the cable and telephone companies serving your town now. You could offer such incentives as a reduced franchise fee, access to public property, or an accelerated permitting process. You might also invite outside companies to consider bringing FTTH to your residents. In Europe, public-private partnerships are common, and are the norm for the biggest projects such as the bringing of fiber to all homes in Amsterdam and Vienna. In such partnerships, the municipality and private enterprises own the new fiber network together. There's no reason it can't be done in North America, but it rarely is. Many states already subsidize broadband to libraries, schools and colleges; the existing broadband networks can be starting points for adding fiber to the home.

Q: Are we giving something up by allowing one utility to run a network and provide content at the same time? What about open-access networks?

A: There is no clear answer. Open-access networks, where the network builder (either a municipal or a private entity) "rents" bandwidth to a potentially unlimited number of content providers, have worked in many locations. They are more common in Europe and Asia than in the United States. But they have worked here as well. At present here, they tend to be municipal networks, or networks built by companies that specialize in bringing fiber to new buildings and subdivisions. When the same organization provides content and maintains the network – as is more typical in the US – the network tends to be more reliable and the interfaces for choosing programs more consistent and easier to follow.

Q: What about WiFi or WiMAX? Some companies will even come in and provide basic wireless service free to residents. Isn't that a good substitute for fiber?

A: WiFi and WiMAX are important public amenities. But they are not substitutes for FTTH. They complement and extend a fixed fiber network. They can't replace it, however. No new businesses or other economic activities are generated by wireless, and wireless networks covering wide areas are not reliable enough to deliver video and other broadband services that are emerging – although serving individual homes in rural areas with point-to-point wireless, where running fiber might still be too expensive, can work well.

Q: Where could I go to find out more? I can't tell my voters the advantages of fiber, except to support higher property values, unless I have examples.

A: There are several conferences and academic organizations you could try. They include: The FTTH Council, www.ftthcouncil.org, which has an annual meeting and monthly webinars.

WiFi and WiMAX are important public amenities. But they are not substitutes for FTTH. They complement and extend a fixed fiber network. They can't replace it, however.

Understanding the Technology in Greater Detail

In FTTH, much of the alphabet soup of acronyms has to do with devices that convert electrical signals that travel in wires, to pulses of light and back again. Here's what you might want to know so you can understand the technical jargon. Let's start at the beginning of a fiber network.

OLT stands for Optical Line Terminal. OLTs put the pulses on the fiber in the first place. Because they are located in telephone exchanges and other network "central offices," residents and property owners rarely see them.

ONTs are Optical Network Terminals. They are also sometimes called ONUs, for Optical Network Units. They are the devices at the consumer end that turn the light pulses back into electrical signals. Usually, customers will have equipment such as computers that expect an Ethernet connection. This is a standard way of networking that's used around the world. Your computers, and perhaps your little home WiFi system, all use Ethernet. Ethernet connectors are built into virtually all computers that have been sold in this decade. So a typical ONT turns the light pulses into Ethernet signals.

In the United States the ONTs are typically inside cigar-box sized enclosures on the outside walls of houses or apartments. But they can be made smaller than a deck of cards, and can be used inside customer premises as well.

You'll also hear about the point of presence, or **POP**. That's the point at which the signal from multiple customers joins the rest of the extended network.

Hybrid fiber coax, or HFC, is the cable com-

pany's coax, with fiber bringing the signal fairly close to the building, or even into the basement or a central area on your property. A **DOCSIS node**, fed by fiber, then distributes the signal to individual households over coax. One node typically feeds 100 to 500 homes.

Pedestals and larger **Fiber Distribution Hubs** are enclosures close to the user premises. They can hold the beam splitters that take the signal from one fiber that extends back to the central office, and divides it (typically 8:1 up to 32:1 but as much as 64:1) among fibers that go to individual dwelling units.

Pedestals and hubs can be below ground, above ground (they often look like short posts or squat air-conditioner-size boxes), or attached to buildings. Connections and splits can also be made in boxes hung under roof eaves, in attics or basements, on telephone poles, or on what look like power lines or phone lines. For best reliability, many contractors bring two fibers into each dwelling unit from the pedestal, not one. The fibers leading from the hub or pedestal to the user premises is called the **drop cable**.

Network Standards

There are many standards-setting bodies that serve the networking industry. Foremost among them is the Institute of Electrical and Electronics Engineers, or IEEE. This group, international in reach but American-based, worries about the ways signals are sent, managed, interpreted and kept secure from intruders.

The common WiFi standards (802.11b or 802.11g, for example) are from IEEE. So are most of the standards for Ethernet. The standards do not cover everything. So many vendors have to add their own "extensions" to make everything work smoothly. That's a necessary evil. But avoid vendors who ignore the standards entirely, and use their own proprietary methods and software in place of IEEE standards.

Physical standards – the ones that ensure that plugs will mate property – are mainly the realm of the TIA, which stands for the Telecommunications Industry Association. This is a trade association.

But what about durability, or ability to withstand high temperatures or moisture? The technology has been moving so fast that standards-setting bodies can't entirely keep up. Many independent groups, such as Telcordia (a private company) have developed their own testing standards to assure reliability. You will see them show up as references in contracts.

There's nothing entirely unusual about any of this. Property is subject to standards from the National Electrical Code, building and fire codes, Underwriters Laboratories, and so forth. But the organizations that are responsible for fiber may be strange to you. Get acquainted with them on their Web sites.

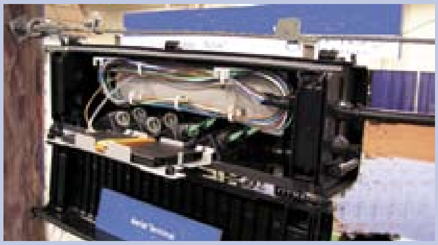
Companies that may wish to gain access to your property, or to joint venture with you, are often nervous about the technology themselves. Thus, they sometimes deal with fiber optic network vendors that offer "end-to-end" technology. That is, they guarantee that everything will work together, reducing risk.

The need for "end-to-end" technology has diminished in recent years due to standardization. But there are often some advantages. The key point to keep in mind is that the technology risk is low. More important is the business sense and commitment to service of the people with whom you will be dealing.

Delivering Services to End users

All pulses of light look the same to fiber, and to consumers' equipment. At the user premises, the pulses get converted to **Ethernet** signals that move over copper Ethernet wiring (typically Category 5 or Category 6 wiring, **Cat5** or **Cat6** for short).

Many companies make special equipment that converts the cable company's coax, or your building's electrical wiring, so that it can carry an Ethernet signal. The standard for carrying Ethernet over coax is called **MoCA** (for Multimedia over Coax Alliance; see www.mocalliance.org). The standard for using electrical wiring is called **HomePlug**, and generically **BPL** (for Broadband over Power Line).



Aerial distrbution housing.

Such setups may require that the same company's equipment be used at both ends of the wire – that is, one "box" turns the signal into "Ethernet" over coax and the other turns the signal back to something customers' TV sets understand. These devices tend to offer an interim solution, but some companies' technology is so robust that it can be depended upon for many years.

Microducts into which fiber can be blown.

Zeros and Ones

If all pulses look the same, what's the difference between video, voice, and data? Theoretically, there is no difference. But each requires special skills on the part of providers. Voice, for instance, does not require much bandwidth; 100 Kbps per second will carry a high-quality phone conversation over Ethernet. A regular "analog" phone line uses as little as 8 Kbps. But the voice signal must be very clean, with no noticeable delay and no static. That's difficult to do on a network such as the Internet, which is used for many purposes at the same time.

Technical people thus describe voice as requiring a high **QoS** (quality of service and low bandwidth). Telephone service over digital data networks is called **VoIP** for Voice over Internet Protocol. Cable companies have been offering both VoIP and switched telephone services (similar technically to regular telephone company services). But they are now transitioning quickly to VoIP.

Video also requires good QoS, but not as good as voice. Small delays and a bit of static will often go unnoticed by viewers. But video requires a lot of bandwidth – 2 Mbps for standard-definition TV, and 4 to 8 Mbps (and as much as 20 Mbps) for the new high-definition TV, or HDTV.

But the video world is changing. Part of that change is already obvious: Cable companies are offering video on demand, or **VoD**. To deliver, they have to send extra signals down the coax, to individual customers. This increases the need for high quality service.

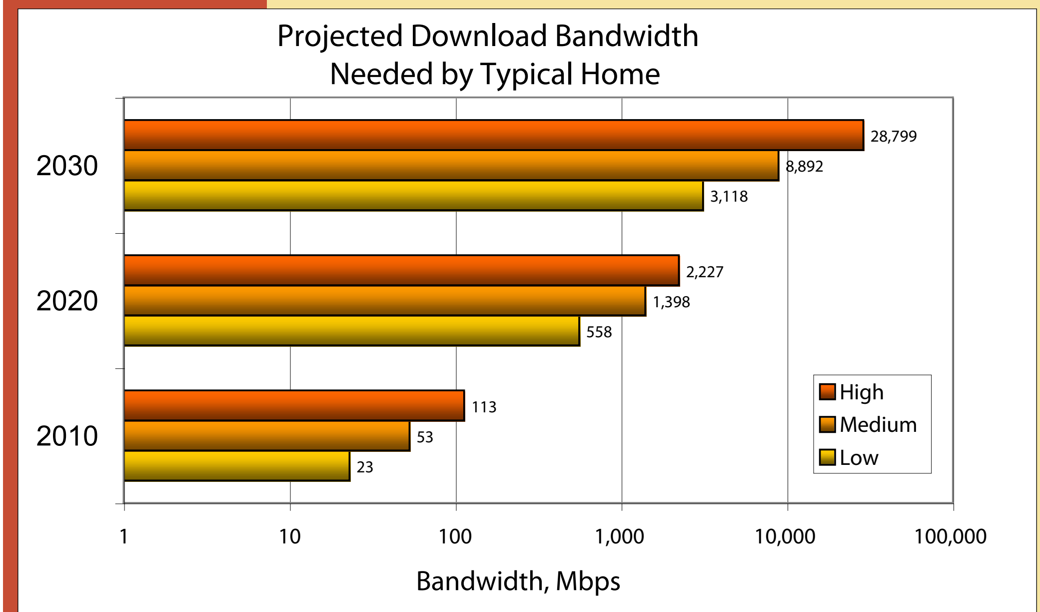
Today, almost all of those signals arrive as **RF** (radio frequency or analog) signals. Even when the signals move over fiber, they are often treated as if they are RF.

This is changing. The new technology is **IPTV**. In IPTV, the video moves as data, using the same Internet Protocol (hence IP) as any other data. As IPTV develops over the next few years, expect thousands, even hundreds of thousands, of channels, mainly sending video on demand to consumers who will be able to view the video on computers or portable devices (think iPODs) as well as on conventional TV sets.

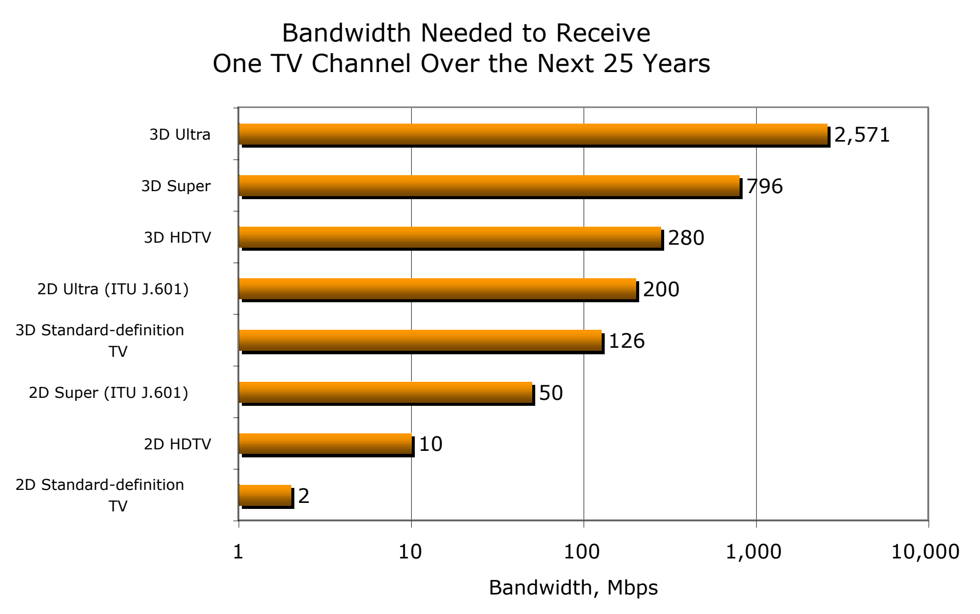
The video service for Verizon's FiOS is mainly RF (for the time being), with IPTV for program guides, numerous HDTV channels, and VoD.

Satellite TV vendors, who now count almost a fourth of American households as subscribers, cannot directly compete with VoD, because they can only send signals one way – from satellite down to subscribers. But some video providers are supplementing the satellite feed with VoD through a terrestrial network, fiber or coax or both. They can also package personal video recorders (think TiVo) with their services.

Projected download bandwidth needed by typical home in 2010, 2020, and 2030, assuming three video and voice streams, one gaming stream and one data/e-mail stream per home, simultaneously. The highest estimates for 2030 are close to 30 Gbps because of 3D HDTV.



Data is requiring more and more bandwidth to meet consumer needs, although 1 to 5 Mbps is typical. QoS needs are not as great as for voice or video, because the Internet Protocol automatically splits up data streams into "packets" each containing many thousands of zeros and ones, and reassembles them when they arrive at their destination. They do not have to arrive at the same time, as long as they arrive within a short period



Standards for 3D video are already being formulated. The technology already exists and is used in industrial settings.

– typically a few fractions of seconds but sometimes much more.

Providers of all of these services have been used to thinking about consumers' bandwidth needs as **asymmetrical**. That is, the bandwidth has to be higher in one direction (the inbound direction to consumers) than the other. Few consumers create video now, for instance, but almost all view it from elsewhere.

Likewise, most users download more data than they upload. But those patterns have been changing. In much of Europe, where providers have offered **symmetrical** bandwidth, users have tended to upload more data, and even to create their own video.

In the US, service providers have started to talk about being allowed to charge different users of the network different fees, depending on QoS as well as on bandwidth.

It is unclear how American policymakers will handle this issue, which has come to be called "net neutrality," while being fair to all sides and while maximizing economic potential. But so far, the issue, despite the publicity it has received, has not proven to be an obstacle to building new, faster fiber-based networks.

The issue is complex, and cannot be solved if people resort to slogans without understanding the underlying issues. Phone and cable companies, for instance, are upset that third-party VoIP companies "ride free" over their networks, as long as end users pay for the bandwidth in the first place. Phone and cable companies are also worried that IP video will reduce the need for conventional cable services.

But if regulators were to allow them to block such services, or charge too high a price, innovation would be squelched and the rest of the world could harbor most of the innovation happening on the Internet. A "quality-priority" based pricing scheme would differ from the usual approach elsewhere in the world, where most governments are simply pushing for universally high bandwidth and QoS. But overseas, direct and indirect government subsidies to network builders tend to be higher. In Asia, governments have developed national policies to push for bandwidth to all residents and businesses, with the ultimate goal of using FTTH to deliver it.

All light pulses – whether voice, video, or data – look alike, and travel over a single glass fiber.

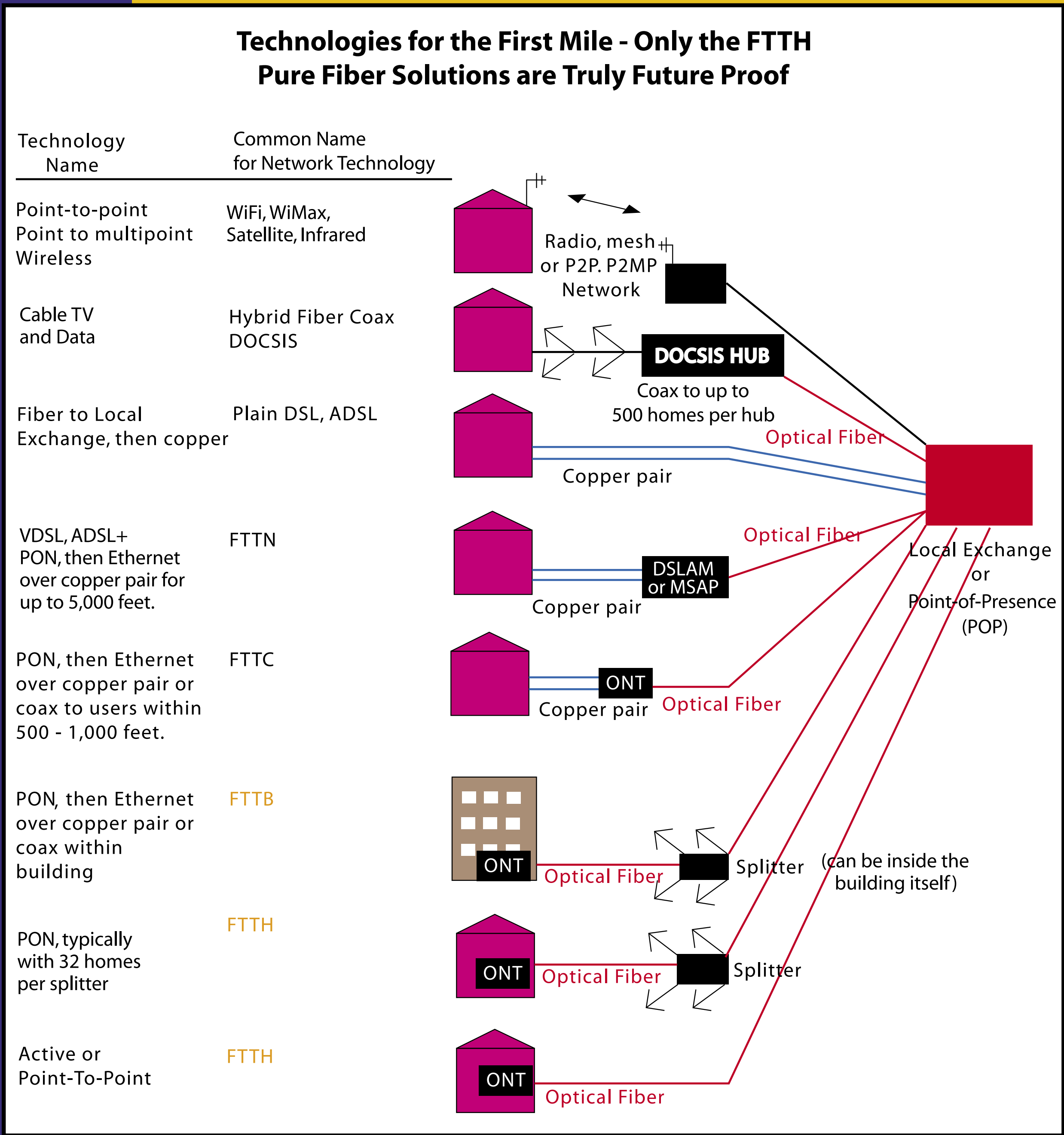
But providers need special skills for each.

FTTH Versus Other Types of Fiber Networks

In September 2006, the FTTH Councils for Europe, Asia and North America standardized the definitions for Fiber-to-the-Home and Fiber-to-the-Building (also called Fiber to the Basement). They are:

Fiber-to-the-Home (FTTH)

A fiber-optic communications path that extends from the operator's switching equipment to at least the boundary of the home living space or business office space. The definition excludes those architectures where the optical fiber terminates before reaching either the home living space or business office space and where the access path continues over a physical medium other than optical fiber.



Fiber-to-the-Building (FTTB)

A fiber-optic communications path that extends from the operator's switching equipment to at least the boundary of the private property enclosing the home(s) or business(es). In this architecture, the optical fiber will terminate before reaching the home living space or business office space. The access path will then continue over another access medium – such as copper or wireless – to the subscriber.

There are also other definitions commonly used by people in the industry:

Fiber-to-the-Node or Fiber-to-the-Neighborhood (FTTN)

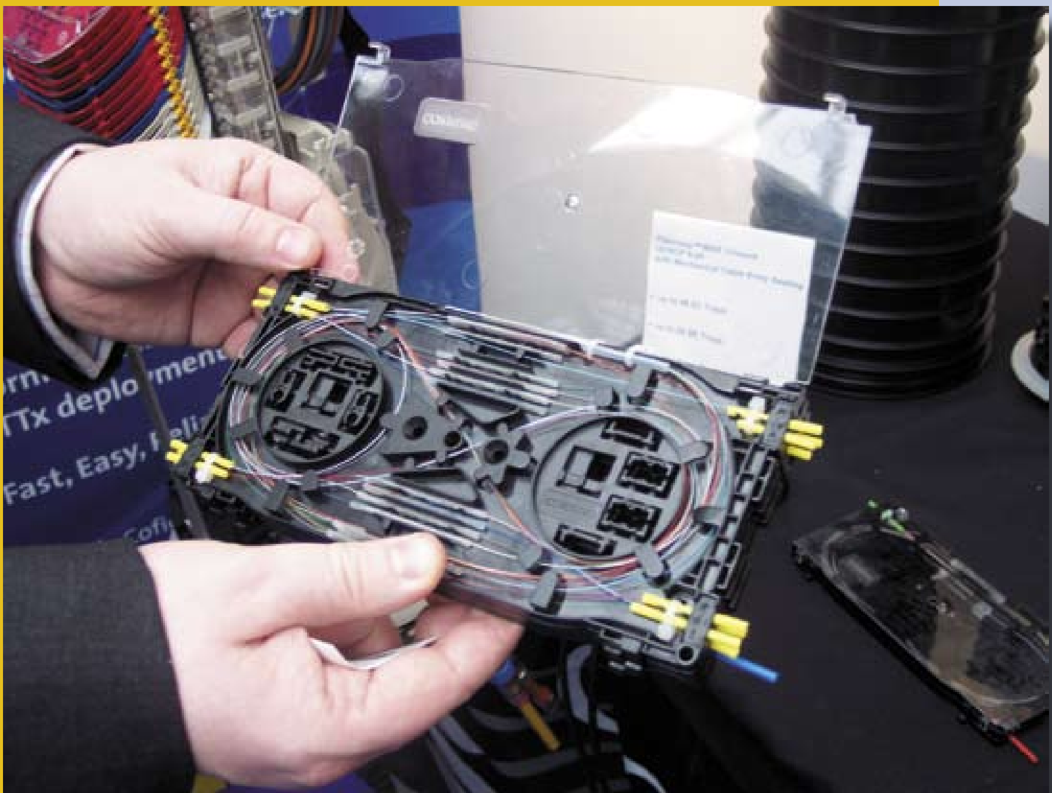
FTTN is not defined by the FTTH Councils. But in general it refers to a system where fiber is extended to a point – typically a street-side or on-pole cabinet – to within 1,000 to 5,000 feet of the average user. From there, copper or wireless serves the user. Typically, the service is through a variant of DSL (Digital Subscriber Line).

FTTN should not be confused with Hybrid Fiber Coax (HFC), used mainly by cable companies to implement DOCSIS, the standard that allows data to be transmitted over cable TV systems. Each DOCSIS node, typically served by fiber, with coax extending to users, passes 100 to 500 homes.

Fiber-to-the-Curb (FTTC)

Like FTTN, except that the fiber is brought much closer to a user premises – typically closer than 1,000 feet and often closer than 300 feet. In addition to DSL, FTTC installations may use Ethernet (over copper cable or wireless) to bring the signal from the fiber termination point to the user. Point-to-point wirelesss is sometimes used in rural areas simply to bring a signal from the roadway to a home that could be a mile or more away.

GPON OLT.



Simple cassette holds fiber.

FTTH and FTTB Network Architectures – A Little History

The "family" of optical networks has two major branches – PON and AON – and many technical variants within those branches.

PON stands for "passive optical network." It refers to the fact that there are no active electrical devices between the central office and the end user. All the handling of the light beams that carry the signal are done with mirrors, prisms and fiber. There are no electrical devices needed.

AON stands for "active optical network." As the name implies, there are electrical devices between the user and the central office. These devices are routers and switches, almost always using the Ethernet standard. But these days, the "active electronics" are not in a remote cabinet; they are in the central office itself. Thus, the industry has begun to call active networks "point-to-point" or P2P networks. This refers to the fact that each end user gets a dedicated fiber (or several dedicated fibers) extending from the central office.

Because each fiber requires its own laser, P2P networks require more power and space within the central office. But because they do not require fiber distribution hubs (containing optical splitters) in the field, they tend to be simpler to operate.

Standard	Name	Year Finalized
BPON ITU	G.983	2001
GPON ITU	G.984	2004
EPON IEEE	802.3ah	2004
GePON IEEE	802.3ah	2005

Evolution of PON Standards

Within the general category of passive optical networks, there are two branches. One is based on Ethernet, the same standard that is used in home and corporate local-area networks. The Ethernet branch has been standardized by IEEE – the Institute of Electrical and Electronics Engineers. The other is based on "carrier" standards, from the ITU – International Telecommunications Union – and are more "telephone-like."

The ITU Family

You may occasionally hear about an early member of the family, **APON**. It stands for "ATM" PON. Just as end users have Ethernet-based networks, telephone companies and other long-range data carriers used ATM.

BPON (for "Broadband PON") replaced APON. It also is based on ATM, with a top speed to users of 622 Mbps and upstream speed of 155 Mbps. But it allows the use of a separate wavelength of light to support video services.

In North America, the first large Fiber-to-the-Home network deployments used **BPON**. This version is being replaced by **GPON**, which allows 2.48 Gbps downstream to the user and 1.24 Gbps upstream.

GPON supports ATM, Ethernet, and TDM (the protocol phone companies use for ordinary telephone service) by "wrapping" or "encapsulating" the data packets with some extra bits. This is called **GEM**, which stands for "GPON Encapsulated Mode."

The GPON standard was finalized early in 2004, but it was not until early 2006 that inexpensive electronic chips to implement it became widely available in volume.

The Ethernet Family

There is another branch of the family tree, the Ethernet branch. Ethernet is also used for "active" P2P networks.

The first Ethernet PON (EPON) standard was released by the IEEE a few months after the GPON standard in 2004. The standard was quickly upgraded to 1.25 Gbps, twice the original bandwidth, as new electronic parts became available. Networks using that speed are sometimes called EPON and sometimes called GePON (for Gigabit Ethernet PON).

A point of confusion: Although P2P networks are said to be "active," the typical implementation is also Ethernet. And in an Ethernet P2P, there are usually no active electronics between the end user and the central office. In that sense, there's no difference between P2P and PON. But in a P2P network, each customer is served by at least one dedicated fiber. Each fiber (and thus each customer) has its own laser to generate the pulses of light. In a "passive" optical network, one central-office laser might serve up to 64 customers.

FTTH and Economic Development

Common sense suggests that communities with plentiful, reliable bandwidth available will do better than those without. FTTH-powered bandwidth is essential for:

- Hometown businesses competing in a global economy.
- Professionals and others who work at home.
- Quality of life provided by online entertainment, education, culture and e-commerce.
- Special services for the elderly and for shut-ins.

FTTH thus helps define successful communities just as good water, power, climate and transportation have defined them for millennia.

That's obviously so for greenfield developments – the data, in previous sections of this report, show that fiber-equipped homes and offices sell faster, and command a price premium over real estate developments without fiber.

But what about existing communities? Direct comparisons are admittedly difficult because FTTH has not been widely available until recently, but virtually all of the real-world economic studies have borne out the predictions; none has suggested otherwise. By far the most comprehensive look at broadband's impact is a 2005 study by William H. Lehr, Carlos A. Osorio, and Sharon E. Gillett at the Massachusetts Institute of Technology, and Marvin A. Sirbu, from Carnegie Mellon University. It was funded by the Economic Development Administration of the U.S. Department of Commerce and by the MIT Program on Internet & Telecoms Convergence (http://itc.mit.edu).

The study found that broadband enhances economic activity, helping to promote job creation both in terms of the total number of jobs and the number of establishments. Broadband is associated with growth in rents, total employment, number of business establishments, and share of establishments in IT-intensive sectors. There are also numerous case studies, comparing specific communities before and after public investment in broadband.

A few examples:

- One early study, of a municipal fiber network built in 2001 in South Dundas, Ontario, showed substantial benefits. It was prepared for the UK's Department of Trade and Industry.

- A 2003 study by D. J. Kelley comparing Cedar Falls, Iowa, which launched a municipal broadband network in 1997, against its otherwise similar neighboring community of Waterloo. Cedar Falls bounded ahead of its neighbor.

- More recently, Ford and Koutsky compared per capita retail sales growth in Lake County, Florida, which invested in a municipal broadband network that became operational in 2001, against ten Florida counties selected as controls based on their similar retail sales levels prior to Lake County's broadband investment. They found that sales per capita grew almost twice as fast in Lake County compared to the control group.

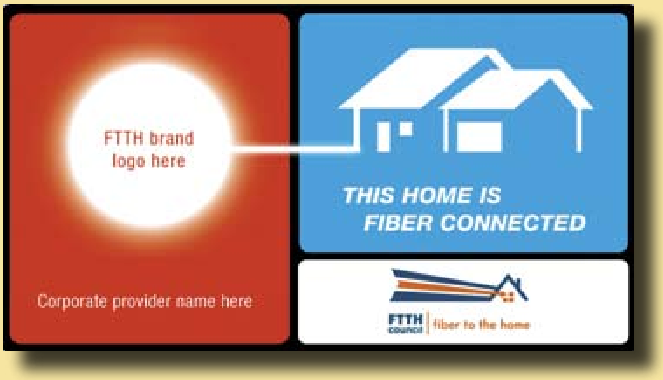
Similar patterns have emerged for communities using FTTH provided by private enterprise. Fort Wayne, Indiana, has taken good advantage of a Verizon FiOS investment there, for instance. And in February 2007, two big studies of housing sales in Massachusetts – where FiOS is coming on line in numerous communities – show a startling recovery. Sales are up, and prices are down only slightly (after a decade-long rise that makes housing there among the most expensive in the United States).

The data are clear and consistent: FTTH, whether provided by private or municipal organizations, is an economic plus for all communities, and an outright boon for many.

FTTH helps define successful communities just as good water, power, climate and transportation have defined them for millennia.

The FTTH Council Certification Program

The FTTH Council will certify any home installation that meets its standard – fiber optic cable that extends all the way to the boundary of the home premises. Certified projects may display the program's badge in its advertising.



Certification is important because companies like to claim they have fiber networks, even when the fiber does not go all the way to the home. This can lead to consumer confusion. Consumers sometimes think they are getting the full benefit of 100 percent fiber broadband, when in fact they are not. Once constituents understand the benefits of fiber, they will embrace it:

- **Consumers** will understand the difference between FTTH and other "fiber networks" that aren't as good, and will embrace the superior experience of FTTH.
- **Communities** will understand the benefits that broadband brings in terms of jobs, wages, and direct benefits such as medical and education services – especially when delivered in the best possible form – FTTH.
- **Investors** will understand the benefits to companies that make the effort to build fiber to the home networks – in terms of increased customer loyalty, competitive advantage, return on invested capital, and revenue.

Details and an application form can be found on the web at **www.FTTHCouncil.org**.

1. FTTH or fiber-to-the-home identifies a telecommunications architecture in which a communications path is provided over optical fiber cables extending from the telecommunications operator's switching equipment to (at least) the boundary of the home living space or business office space (the side of the building or unit). This communications path is provided for the purpose of carrying telecommunications traffic to one or more subscribers and for delivering one or more services (for example Internet access, telephony and/or video-television).

2. For the FTTH Council to certify any service provider's network as operating over fiber-to-the-home access; and to grant that service provider use of the Fiber-Connected Home badge, that service provider[, and their network,] must identify the location, size, and equipment being used in sufficient detail for the Council to effectively certify those deployments. The service provider must also confirm that commercial services are currently being delivered to revenue-paying subscribers.

3. The service provider must exhibit a high level of commitment to network-wide FTTH deployment as indicated by its "Strategic Commitment" to FTTH in its network. "Strategic Commitment" is defined as the ratio of:

Total number of residential households in Service Provider's serving areas to whom services can be marketed over an FTTH access network (Homes Passed), divided by Total residential households, subscribed to voice, data or video services, served by Service Provider's entire Wireline network (Total Residential Communication Subscribers)

This ratio must be 10 percent or higher.

FTTH council | fiber to the home

To learn more about fiber to the home:
FTTH Council
www.FTTHCouncil.org
503-635-3114
info@ftthcouncil.org