WHAT FIBER BROADBAND CAN DO FOR YOUR COMMUNITY

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A Fiber-to-the-Home Primer
from the Editors of
BroadbandCommunities

FTTH
FIBER TO THE HOME
COUNCIL
AMERICAS

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This primer was originally written by Steven S. Ross and updated by him and by Masha Zager, both of the ***Broadband Communities*** *staff. It summarizes research commissioned by the FTTH Council as well as independent reporting by the authors.*

Why Fiber?

Welcome to the Information Age – also known as the Fiber Optic Age.

The information and communications revolution was brought to you by glass – very long, thin, pure strands of glass called optical fibers. So much data zips around the world today in commerce, education, entertainment and personal communication that copper wires and radio waves could carry only a fraction of it. Because fiber optic cable has so much capacity, it now forms the backbone of the Internet, cable TV networks, telephone (including cellular) networks, private business networks and even data center networks. Without fiber optic cable, none of these systems would work.

Fiber optics was developed for communications in the 1960s. (The inventor received a Nobel Prize in 2009.) By the late 1980s, fiber optic cables were being strung across ocean floors. Then these fiber trunks grew branches hundreds of millions of miles in length and extended deep into most of the inhabited world.

The final step is to build fiber optic cables all the way to homes and businesses and replace the old copper networks entirely. Yes, many individual premises now send and receive so much data that their copper connections, built originally for telephone and analog cable TV, are struggling under its weight.

Worldwide, network operators agree that only fiber to the home,

52%
of FTTH customers are very satisfied with their service.

36%
of non-FTTH broadband customers are very satisfied with their service.

< 1%
of any cellular phone call actually travels through the air.

> 98%
of cellular calls are carried at least partially on fiber.

Photo courtesy of Adena Health System

One of the new services enabled by fiber networks is telemedicine, which can improve the health care available in smaller communities.

35-PLUS MILES
is the distance a gigabit signal can travel over fiber to a home.

300 FEET
is the distance a gigabit signal can travel over copper to a home.

196 FIBER STRANDS
each thinner than a human hair, in a bundle not much thicker than a pencil, could carry all the world's Internet traffic.

or FTTH, can meet the exploding demand for bandwidth and deliver next-generation services. Everyone agrees that fiber will meet the world's needs for the foreseeable future. The only debates involve the speed of the transition.

The reason for this striking degree of unanimity is simple: FTTH offers far more bandwidth, reliability, flexibility, security and longer economic life than alternative technologies, even though its price is comparable. On average, it is slightly more expensive to build, but it is far less expensive to operate and maintain than copper.

Consumers who subscribe to FTTH rate it as the fastest, most reliable broadband technology. They appreciate that fiber networks can deliver broadband services for medicine, education, home-based businesses, home automation, video and games.

Businesses are making a massive shift to cloud services. For economic efficiency and for redundancy, critical business systems now operate at huge data centers rather than on local computers. The speed, reliability and security of fiber connections make cloud services viable for consumers as well.

In the United States, about one-fifth of households have fiber connections available, less than the rest of the developed world. This year, American broadband providers have finally begun to catch up. The target is moving, however. China alone expects to have 70 million FTTH subscribers by the end of 2015, with gigabit speeds available in some larger cities.

1 OF 5
U.S. households have access to fiber-to-the-home services.

1 OF 11
U.S. households subscribe to fiber to the home.

46%
of U.S. households with access to FTTH sign up for services.

WHO IS BUILDING FTTH NETWORKS?

Most of the FTTH connections in the United States come from large telephone companies. Verizon, which started offering services on its FiOS network in 2005, was the first major company to deploy fiber to the home and now accounts for about two-thirds of FTTH connections. AT&T and CenturyLink have built FTTH in new communities for nearly a decade, and recently they announced gigabit FTTH deployments in multiple U.S. cities.

The large franchise cable companies have also experimented with fiber to the home, especially in new communities. As the demand for "gigabit services" grows, they seem likely to build FTTH on a larger scale in the next few years.

However, that doesn't tell the whole story, because more than 900 entities are providing FTTH services in the United States today, and most are small. Nearly all were in the telecommunications business to begin with – they are independent telephone companies, franchised and private cable companies, local Internet service providers, wireless ISPs and even satellite video companies.

In addition, new companies have formed specifically to build fiber optic infrastructure in underserved areas. RST Fiber in North Carolina and ValuNet in Kansas are recent examples of this phenomenon.

Local governments are attracted to FTTH because it positions their communities for tomorrow's jobs and economic growth. In areas where no private cable or telecom companies have taken the initiative, many communities reach out to nontraditional providers or even build their own systems.

In 2010, when Google announced that it planned to build one or more community fiber networks, more than 1,100 local governments proposed their communities as suitable locations. Several smaller software companies have been working with communities to build FTTH networks. Other nontraditional providers include cooperative electric utilities, property developers and even universities.

It makes sense for these forward-looking organizations to build FTTH networks. Most property developers can enhance the value of their real estate by putting fiber into new properties or upgrading existing properties. Some small electric companies built fiber optic networks to manage their own facilities and can extend these networks to serve their customers as well.

Some municipal governments build their own fiber networks or collaborate with neighboring communities to do so – there are now close to 150 FTTH projects of this kind, as well as about a dozen FTTH networks built by Native American tribal authorities. Some serve only businesses; most serve households as well.

1 OF 7

households worldwide can be served by fiber to the home or fiber to the building.

NO. 15

U.S. rank among 34 OECD nations in percent of broadband connections that are fiber

200 MILLION

Chinese households can be served with fiber to the home or to the building.

ESTONIA, SLOVENIA, SLOVAK REPUBLIC AND TURKEY

are among the 14 countries that outrank the U.S. in percentage of FTTH connections.

The copper and wireless last-mile connections to customer premises have inherently limited capacity, unlike fiber connections.

NO. 1
The amenity most desired in MDU buildings is fast Internet.

The newest model for FTTH deployment involves collaborations in which both public and private entities take significant ownership stakes in a network. This model has the potential to combine the best aspects of public and private ownership.

FTTH IS THE ONLY UNLIMITED BROADBAND TECHNOLOGY

As mentioned, most networks are already largely fiber-rich. Cable providers use fiber to get close to homes and then employ copper coaxial cable for the last 100 to 1,000 feet. Many phone companies also bring fiber to within a few thousand feet of homes and use copper wire for the rest of the trip. Fourth-generation wireless broadband, which is widely deployed today, usually requires fiber connections at cell sites.

But the copper and wireless "last miles" to customer premises still have inherently limited capacity. Tweaking more bandwidth from them becomes increasingly difficult and expensive as time goes on. This isn't true of optical fiber, whose capacity is effectively unlimited.

The technologies for transmitting data over fiber are well understood, and the upgrade path for the electronic components that send and receive signals has been defined for years into the future. If anything, increasing fiber

At the Noblis Center for Applied High Performance Computing, Danville, Va.'s fiber network enables always-on videoconferencing.

90%
of seniors who own MDU homes demand fast Internet.

bandwidth will become less expensive rather than more expensive.

THE PAYOFF

FTTH providers enjoy much greater revenue than traditional broadband providers. FTTH subscribers today often spend 30 to 40 percent more per month than DSL subscribers – not because basic services are more expensive (they aren't) but because more and better premium services are available.

For example, multiple simultaneous HD channels are difficult to implement well over any medium but fiber; the new 4K TV and high-definition video communications are even more challenging. Taking pay-TV services on the road (true TV Everywhere) requires high upstream bandwidth at home. On average, FTTH offers three times the upstream bandwidth of its closest competitor. Home energy management services, home security and medical monitoring services all benefit from fiber's high reliability.

In general, access to utilities makes private property more valuable, and FTTH is among the utilities that owners and renters especially value.

Fiber connections make single-family homes easier to sell and multiple dwelling units easier to rent – in fact, according to a recent survey by RVA LLC, buyers of houses and condominiums are willing to pay a 3 percent premium for a fiber-connected home, and renters are willing to pay an 8 percent premium.

Renters and buyers both know they can get the most attractive services available on the market today – and that if an exciting new service is introduced in a few years, they'll be prepared for that as well. In addition, working from home – either as a telecommuting employee or a home-based entrepreneur – is far easier with FTTH than with other types of broadband connections.

42%
is the annual increase in Internet traffic – year after year, for decades.

FTTH communities have an advantage in attracting everything from advanced manufacturing to contact centers to data centers. They can nurture the tech startups and home-based businesses that will provide tomorrow's jobs. They can provide better education and health care for residents, deliver government services more efficiently and engage citizens in government.

This publication explores these issues, and more, in detail. It's written in nontechnical language so you can understand the value of next-generation infrastructure – and what it means to you – without a degree in optical engineering.

In these pages you'll see... *the advantages of fiber to the home.* ❖

9X
The new fiber lines that Verizon used to replace the copper that Hurricane Sandy destroyed in lower Manhattan are nine times as reliable as the average for all New York State, which includes both copper and fiber.

900+
U.S. entities are deploying FTTH.

100+
U.S. entities offer gigabit FTTH.

150+
U.S. localities offer FTTH to residents or businesses.

Fiber and Bandwidth

Q: What is bandwidth?

A: In a network, bandwidth (what engineers call bitrate) is the ability to carry information. The more bandwidth a network has, the more information it can carry in a given amount of time. Networks with high bandwidth also tend to be more reliable because fewer bottlenecks disturb the flow of information.

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

A: The amount of bandwidth we need grows every year.

Worldwide Internet traffic roughly doubles every two years and has been increasing even faster lately because of smartphone use. The biggest growth has been for video – traditional pay TV, over-the-top or Internet-based video, and video communications. By the end of 2013, network equipment vendor Cisco noted that traffic had reached levels not expected until 2020 – seven years ahead of schedule.

Video requires not only extra bandwidth but also extra reliability. The smallest delay in data transmission can result in distorted views. More video is available than ever before, and people are watching video on more screens at once. In addition, video formats are becoming more bandwidth-intensive. HDTV can require 8 megabits per second (Mbps) or even more for fast action such as in sporting events, with MPEG-4 compression technology. So-called 3D immersive HDTV – already used in some academic and industrial settings for telepresence – requires between 50 Mbps and 300 Mbps. 4K video, which has four times the pixels of today's best-quality HDTV broadcasts, requires 16 to 32 Mbps even with the new HEVC compression, depending on how fast the screen action is and how much of the screen is taken up by fast-moving objects.

Q: What about other kinds of data?

A: Bandwidth requirements for many kinds of data are exploding. For example, think about uploading photos to a cloud storage facility such as iCloud. Digital cameras can create larger and larger images; 30 megabytes is not uncommon. And amateur HD video cameras use about 10 gigabytes per hour of video – the equivalent of 300 of those 30 MB still images.

In health care, the medical images produced by equipment such as CT scanners are a hundred times larger than camera images, and more. Business and science have both entered the era of big-data applications that collect and analyze data on massive scales. Today's big-data applications range from consumer pricing models to DNA sequencing to particle physics to control of electrical grids. Big data doesn't work without big bandwidth. A DNA sequencer produces enough data to monopolize a 2.5 Gbps connection.

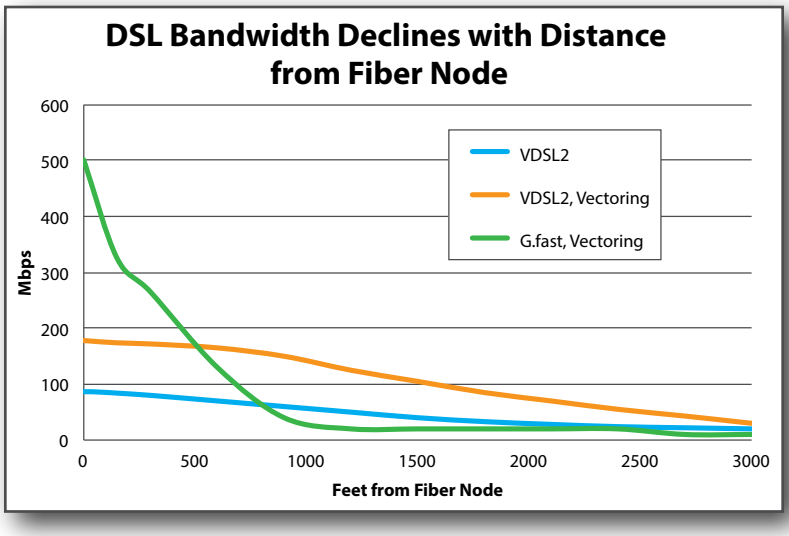
Q: Can't copper carry high bandwidth?

A: Copper's capacity is far less than fiber's. It can support high bandwidth for only a few hundred yards. The longer a signal travels on copper, the lower the bandwidth.

Optical fiber is unique in that it can carry high-bandwidth signals over enormous distances. Fiber uses laser light to carry signals. Under some circumstances, a signal can travel 60 kilometers (36 miles) without degrading enough to keep it from being received. The international minimum standard is 20 kilometers (12 miles). Fiber is also far better able to support upstream bandwidth – that is, from a user to the network.

Q: What's the difference between upstream and downstream bandwidth, and why is it important?

A: In the debate about FTTH versus copper-based broadband, people tend to argue in terms of downstream bandwidth because most users have needed more



The bandwidth of a DSL signal declines with distance from the fiber node. VDSL2+, the most advanced form of DSL in general use, can deliver about 30 Mbps download speed at 3,000 feet, depending on the quality of the copper. Vectoring and bonding (combining the VDSL signals among multiple copper wires) can increase the speed. G.fast, a new technology, can reach 500 Mbps for 100 feet when copper is high quality, dropping to 325 Mbps download speed and 325 Mbps upload at 150 feet. VDSL has very poor upload speeds (typically a fifth of download speed), but G.fast achieves symmetrical speeds by adding a sophisticated transmitter at the customer end.

The equipment used to send light signals over glass fiber keeps getting better.

downstream bandwidth than upstream – especially for bringing video entertainment into their homes. But emerging consumer uses such as home video uploads, cloud storage, distance learning, video communication and telemedicine may require as much upstream bandwidth as downstream. Small businesses, often home-based, may need upstream bandwidth as well – consider a wedding photographer sending proofs by email to clients. Businesses now often copy all their working data files for safekeeping to a remote computer center.

Q: What about wireless? I hear 4G wireless can provide 54 Mbps. In Singapore, there's a wireless carrier boasting 300 Mbps!

A: That's the potential bandwidth shared by all users connected to a cellular antenna. A wireless user might get high speeds for a moment or two if no one else is around, but average wireless speeds, even for 4G, are similar to those for DSL. Wireless broadband depends on fiber to move information to and from cell towers. Even so, each antenna can support only a finite number of cellular signals. Cellular data traffic grew 300-fold from 2006 to 2013 and will grow another sixfold by 2017.

Providers severely limit wireless data, encouraging or forcing customers to use Wi-Fi connections instead of cellular networks for data. Those Wi-Fi connections, in turn, work best when they can quickly offload data to a fiber network. A typical cellular data plan allows 3 or 4 gigabytes per month. Use your phone to view video, and you quickly run over the limit.

Q: What exactly makes fiber "future proof"?

A: The equipment used to send light signals over optical fiber keeps getting better. So

Fiber: The Light Fantastic

Fiber optic cable is made up of hair-thin (or thinner) strands of glass that carry information by transmitting pulses of light, which are usually created by lasers. (Copper cable, by contrast, carries low-voltage electrical signals.) The pulses are turned on and off very, very quickly. A single fiber can carry multiple streams of information at the same time over different wavelengths, or colors, of light. Fiber has many advantages over copper wire or coaxial cable:

1 **Great for rural areas.** Signals travel long distances inside fiber cable without degradation – 35 miles or more in some real-world networks and 65 miles or more in the laboratory.

2 **Easy to deploy.** Fiber cable is thin and flexible. An individual fiber can be thinner than a human hair. Thin fibers can be packaged in a narrow ribbon or inside a hollow plastic microduct less than 1/8 inch in diameter. Fiber cable can be hidden easily on the surfaces of walls in old buildings. There are even hair-thin fiber products that can be attached with adhesive and painted over.

3 **Future-proof.** Once installed, fiber is upgraded by changing the electronics that create and receive the light pulses, not by replacing the cable itself.

4 **Rugged and weatherproof.** Fiber cable has a longer life than copper because it does not corrode, is not easily affected by water and generates no heat. It isn't damaged by lightning. Nothing hurts it except a physical cut or the destruction of the building it is in.

5 **Low operating costs and high environmental benefits.** Fiber networks cost less to operate than copper. The most common FTTH network technology, GPON, uses no electronics – and therefore no power – between the provider's central office and the customer premises, which minimizes operating costs. Even optical networks that do require electronics in the field use far less power than copper networks do.

6 **Reliable.** Fiber is far more reliable than copper. Surveys by market researcher Michael Render of RVA LLC show that a typical DSL modem has to be reset by the user about once a week. For fiber, it is once a month or less. This is critical for telemedicine and for distance learning, but it is also important for businesses. We have all sought to pay for something by credit card only to find that the card reader is not working. This is usually because the DSL or cable modem connection has been lost. A few lost sales per month can cost a retailer more than the monthly fee for the connection!

In a properly designed fiber network, users will always get the speeds that are advertised – or better.

equipping an existing fiber network with new electronics and with lasers that pulse light faster, or lasers that use different wavelengths of light, can vastly increase available bandwidth without changing the fiber itself.

New electronics are very cheap compared with the original cost of laying the fiber. At the customer end, the system can be designed so that customers themselves can simply pull an old unit out and plug a new one in. Therefore, once fiber has been deployed, network operators can keep increasing bandwidth as needed at very little cost.

Q: How long has fiber optic technology been in use?

A: Fiber optic cable is the foundation of the world's telecommunications system. It has been used for more than 30 years to carry communications traffic from city to city and from country to country. Almost every country has some fiber optic cable, delivering services reliably and inexpensively. The first time fiber delivered a signal directly to a home (in Hunter's Creek, Fla.) was more than 25 years ago.

Q: All providers seem to claim they have fiber networks. What's different about fiber to the home?

A: Don't be fooled! It is true that most cable and FTTN (DSL) networks use fiber. In these networks, the fiber carries the signal close enough to homes so that copper can carry it the rest of the way. However, this approach requires expensive, difficult-to-maintain electronics at the point where fiber meets copper. (These electronic devices use a great deal of power and are quite sensitive to lightning strikes. Even the cost of bringing electric power to them can be huge, depending on where they are located.) The available bandwidth is far less than in an all-fiber network. And most of these halfway approaches do not allow symmetrical bandwidth – cable and DSL systems generally can't upload information as fast as they can download it.

Q: Isn't a network with some fiber good enough?

A: It may be fine to send emails, download songs or share family photos. If you want to log on to the corporate LAN from home and work effectively, or run a home-based business, you'll need more. And what about uploading a high-def video of your child's football game, or sitting down to dinner virtually with family members a thousand miles away?

Q: Why does it matter how close to the home fiber comes?

A: With copper cable, bandwidth drops precipitously with distance. The most recent expedient, vectored DSL, allows 50 Mbps downstream for as far as 1,800 feet under ideal conditions. It won't work on very old copper wiring, its upstream bandwidth is limited and it requires expensive electronics. However, it is touted as an interim solution for network builders that cannot afford FTTH. A new technology, G.fast, is being field-tested now; under ideal conditions and with vectoring (crosstalk cancellation), G.fast is expected to provide 500 Mbps symmetrical bandwidth up to 300 feet from a fiber node. G.fast may prove to be an excellent solution for retrofitting apartment buildings with fiber to the basement (as long as those buildings already have good internal copper wiring), but it requires bringing fiber very close to customer premises and is still limited in comparison with true fiber to the home.

Q: With cable and DSL, there's often a gap between advertised and actual bandwidth. Is that true for fiber?

A: No. Cable, DSL and even wireless networks are usually heavily oversubscribed – that is, providers promise users more than the total amount of available bandwidth because they know all users aren't going full throttle most of the time. As a result, networks slow down during periods of heavy use, such as when teenagers come home from school. Copper networks are also more subject to speed degradation due to the condition of the wiring. Fiber has enough bandwidth and reliability that providers can guarantee high speeds with little or no oversubscription. If a fiber network is designed properly, users will always get the speeds that are advertised – or better. Data published by the FCC in June 2014 showed that, on average, fiber-to-the-home services delivered 113 percent of their advertised speeds.

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Is It Really Fiber To the Home?

When service providers advertise "fiber rich," "fiber deep" and "fiber optic" networks, how do you know whether you're really getting fiber to the home? In 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 as follows:

FIBER TO THE HOME (FTTH) A fiber optic communications path that extends from an operator's switching equipment to at least the **boundary of a home living space or business office space**. The definition excludes architectures in which the optical fiber terminates before reaching either a home living space or business office space, with the access path continuing over a physical medium other than optical fiber. Also called fiber to the premises (FTTP).

FIBER TO THE BUILDING (FTTB) A fiber optic communications path that extends from an operator's switching equipment to at least the **boundary of a private property that encloses homes or businesses**. The optical fiber terminates in the basement or, in larger buildings, in a closet on each floor, but not in home living spaces or business office spaces. The access path then continues over another access medium, such as copper or wireless, to subscribers. Only FTTH is truly unlimited, but FTTB can provide as much capacity as most households and small businesses can use today. Also called fiber to the basement. Often used in multiple-dwelling-unit buildings.

SOME "FIBER" NETWORKS ARE NOT FIBER TO THE HOME

Other network architectures, such as FTTN, FTTC, FTTdp and HFC, do not fit the FTTH Councils' definitions. Their capacity depends on how far users are from nodes and on the number of users on each node.

FIBER TO THE NODE OR FIBER TO THE NEIGHBORHOOD (FTTN) In an FTTN network, fiber is extended to a street cabinet or an on-pole cabinet an average of 1,000 to 5,000 feet from users. From there, copper, or occasionally wireless, serves users, typically through a variant of DSL.

FIBER TO THE CURB OR FIBER TO THE CABINET (FTTC) FTTC is similar to FTTN except that the fiber is brought closer to user premises – typically closer than 1,000 feet and often closer than 300 feet. Service continues over copper (rarely wireless), using a DSL variant or Ethernet.

FIBER TO THE DISTRIBUTION POINT (FTTdp) In this emerging architecture, fiber is brought very close to a building – sometimes right outside – and the fiber termination unit is placed along with a DSL modem in a small enclosure (the distribution point). Signals are carried using one of the newer variants of DSL – VDSL2 or G.fast – to anywhere from one to 16 subscribers. Distribution points may take their electric power from the customer premises.

HYBRID FIBER-COAX (HFC) This architecture is used mainly by cable TV companies and is common in community broadband networks built before 2004. In a typical HFC system, fiber runs to a node in each neighborhood, and coaxial cable running from the node serves between 100 and 500 users. HFC networks typically use DOCSIS (Data Over Cable Service Interface Specification) technology for Internet access. A new version of this technology, DOCSIS 3.1, has an option for the first time to use fiber all the way to subscribers or to the basement of MDU buildings without resorting to RFoG (which just moves the DOCSIS node closer to users). Starting in late 2014, we expect to see a few large DOCSIS 3.1 deployments, mainly in new buildings, that use this option, with the signal carried by EPON over fiber (there is also an EPON over coax standard coming). More deployments will come in 2015 as the standard is fully adopted.

Q: Is FTTH technology expensive?

A: In new construction, fiber costs about the same as copper to build, and it costs much less to operate and maintain. Building fiber to the home is expensive only when compared with *not* building a new network – that is, with making minor tweaks to an existing copper network. The problem is that these less-expensive solutions don't meet users' needs. In the last few years, the flood of video content has outrun the ability of older copper technologies to handle bandwidth demands. In many parts of the world, providers shut off or slow down service or impose prohibitive fees for customers who exceed monthly bandwidth caps. Customers don't like these restrictions, and they don't appreciate being called "bandwidth hogs" for using services they have paid for.

In addition, it's not clear that providers save money by failing to meet users' needs because limiting bandwidth means limiting revenue potential as well. ❖

Why We'll Always Need More Bandwidth

In a century of telephone communications, the bandwidth on voice channels changed very little. Today, however, Internet bandwidth needs are growing exponentially. Cisco Systems estimates that global Internet traffic in 2018 will be equivalent to 64 times the volume of the entire global Internet in 2005. Globally, Internet traffic will reach 14 gigabytes per capita by 2018, up from 5 gigabytes per capita in 2013.

To put that another way, global Internet traffic increased more than fivefold in the past five years and will increase at least threefold over the next five years, Cisco predicts. On the Internet, bandwidth drives innovation, and innovation drives bandwidth demand.

Sure, increased bandwidth lets us send email faster, but bandwidth's real value is that it lets us do entirely new things. In the past few years, we've seen Internet video evolve from a novelty to the standard way of accessing news, information and entertainment. We've seen a host of new Internet-connected devices – always-on smartphones and tablets that keep us connected with the world full time, smart TVs (and TV-connected devices such as Roku boxes and Chromecasts), home security devices that broadcast alerts and video images to our phones.

Who had heard of the "cloud" a few years ago? Today, consumers and businesses store their data, run their programs and even access computing power "in the cloud." More than 300 million people store files on Apple iCloud, 250 million on Microsoft OneDrive, 175 million on Dropbox and 120 million on Google Drive – to name just a few of the more popular cloud storage systems. The default storage location setting in the most recent version of Microsoft Office is OneDrive, not your own PC. Users no longer know or care exactly where their files are located or their programs are running – that's what makes it a cloud. All they need is fast, reliable Internet access.

> Hundreds of millions of consumers store their data files in the "cloud," using services such as Apple iCloud, Microsoft OneDrive, Google Drive and Dropbox..

Families now stay in touch via social media and video calls – Facebook, Skype and Twitter have become household words. Businesses use video communication whose quality is good enough to bring the illusion of "being there" to teleconferencing. It's called telepresence. High-definition video communication has even reached the home market; telecommuting workers can send telepresence robots in their offices to sit in for them at meetings while they participate via their home TVs.

Today, people visit doctors from home or work, saving a trip to the doctor's office or emergency room if they don't need to be seen in person. (Home telehealth is a great way to reduce hospital readmissions.) They take classes from home – MOOCs,

Photo courtesy of UC2B

Fiber ambassadors sign up their neighbors for a new FTTH network.

19 MILLION MILES
of fiber were laid in the U.S. in 2011, a record year.

44 MILLION MILES
of fiber were laid worldwide in the second quarter of 2014.

32%
Growth of busy-hour Internet traffic from 2012 to 2013

1.0 PETABITS PER SECOND
Busy-hour traffic forecast for 2018, the equivalent of 335 million people streaming HD video continuously

or massive open online courses, give anyone and everyone a taste of what the country's leading universities have to offer. The most popular MOOC platform, Coursera, boasts more than 22 million enrollments in its courses.

Telecommuting and home-based businesses are on the rise, too. A quarter of all owners of home-based businesses say they could not operate without fiber to the home, and telecommuters say their employers would be less likely to let them work from home without fast, reliable fiber broadband. There appears to be a pent-up demand for working from home at least part-time – in a recent survey of federal employees, 93 percent said they valued the option to telecommute.

There is every reason to believe that innovation will continue, that bandwidth needs will keep on growing – and that only fiber to the home, with its superior reliability and vastly superior upstream capacity, will be able to keep delivering the goods.

Here are a few of the new applications emerging now:

- Ultra high-definition video with four times the pixels of conventional HD creating massive bandwidth requirements. (With the new home video cameras that can shoot in Ultra HD format, the demand will be as great for upstream bandwidth as for downstream.)
- E-jamming and rehearsal applications for musicians and music teachers requiring perfect synching of multiple remote audio streams.
- Remote operation of complex equipment, such as medical robots, electron microscopes, radio telescopes and even nuclear power plants.
- Interactive classes where students can not only watch their professors but also participate in real-time, video-based discussions.
- 3-D videoconferencing.
- Virtual-world environments. ❖

Services:

Beyond the Triple Play

More than a decade ago, cable companies introduced the triple play of voice, video and data. Fiber's greater bandwidth and reliability allow FTTH providers to think beyond the triple play and offer services tailored to communities' specific needs. Some of these services help differentiate fiber-to-the-home communities; some generate additional revenue streams (often with high margins) or help retain customers; still others are used by providers or property developers to manage their assets more efficiently. Many do all three.

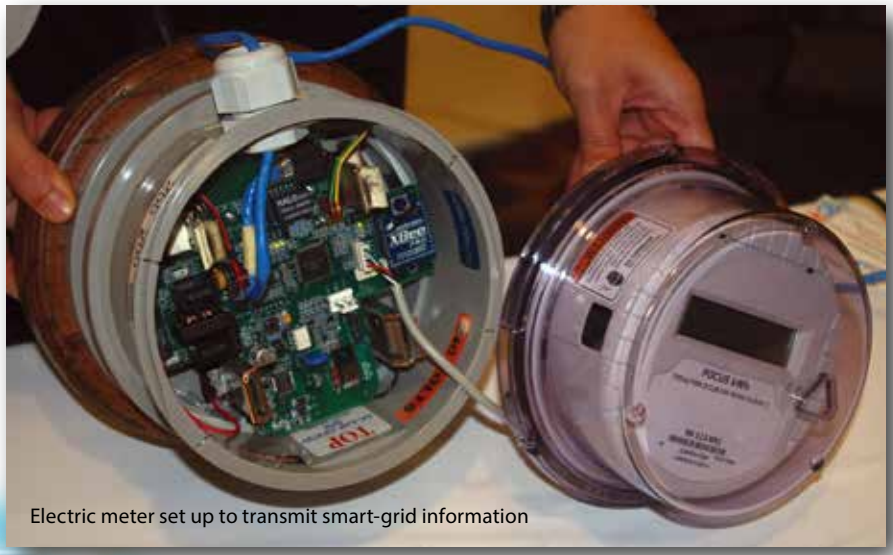
Telehealth allows instant access to medical specialists via videoconferencing from a home or community center. The videoconferencing may be integrated with Internet-enabled diagnostic devices (blood pressure cuffs, respiration measurement and so forth), sensor-based home monitoring, electronic medical records systems, online prescription services and online appointment scheduling. Telehealth helps keep older adults living independently for longer, offering tremendous savings for payers and families. It is a boon for members of the "sandwich generation," who are responsible for caring for both their children and their elders.

> The services that fiber to the home supports can make your community a more appealing place to live, enable efficient asset management and generate new revenues.

Social applications build a sense of community. They range from community-focused social networking sites to intranet sites that feature local news and events to video channels that broadcast local athletic contests, artistic productions and political meetings. Because these offerings can be interactive, they easily trump conventional cable public-access stations.

Home-automation and concierge services make residents' lives comfortable and convenient. Cameras that recognize cars when they enter a community can alert parking attendants and security personnel and then turn on lights and heating or air conditioning at home. Residents can view the laundry room, connect to community services or schedule a dry cleaning pickup, pizza delivery or home repair. These applications also help owners control energy use.

Mobility is easier to accommodate with a robust fiber-to-the-home network. Using the backhaul afforded by fiber, providers can offer Wi-Fi connections to residents in indoor and outdoor public spaces without overloading the network. Residents can bring their laptops or tablets to a pool area, check email from a laundry room, check the laundry status from a community room or listen to Internet radio in a gym.



Electric meter set up to transmit smart-grid information

ADD NEW REVENUE STREAMS

Because fiber-to-the-home networks have virtually unlimited capacity, unparalleled reliability and remote service monitoring, fiber providers have a wide choice of applications for resale.

The smart electric grid is expected to radically improve the business case for fiber to the home. Connecting electric meters to fiber enables automated meter reading at frequent intervals, providing massive data for analysis and planning.

Automated meter reading is usually the first smart-grid application that utilities deploy because it is relatively straightforward to implement and has an immediate payback. Though most

FTTH deployers that have installed smart meters are public or cooperative electric utilities, a few telcos install and read smart meters for utilities.

Beyond automated meter reading, such smart-grid applications as demand-response programs, SCADA and outage detection greatly reduce electric utilities' operating costs. Smart-grid applications are major reasons that electric utilities across the country have long been connecting their own equipment with fiber networks.

Mobile backhaul is another enormous revenue opportunity for fiber deployers. The exploding demands for mobile bandwidth are prompting wireless providers to upgrade the connections from their cell sites to the Internet (traditional connections are usually copper T1 lines with 1.5 Mbps bandwidth; the latest fiber connections are a gigabit per second, more than 600 times the bandwidth). Half of cell sites are now served by fiber, and more are added every day. In addition, the next generation of wireless architecture (LTE-Advanced, which is now in field trials around the world) will move all baseband processing from cell sites to the cloud; cell sites will have to be connected via fiber to the hubs where processing takes place.

Broadband providers offer many other applications through Web portals or set-top boxes, often at lower prices than customers could obtain by purchasing these services directly. In addition to creating new revenue streams, these applications reduce customer churn, and they lower expenses by keeping more traffic in-network.

Business services have become a major new revenue source for FTTH deployers because the cloud computing revolution has moved storage, applications and computing capacity from the desktop to the Web. Service providers now supply managed

Telehealth

Fiber is the technology of choice for in-hospital networks and for consultations between local clinics and off-site specialists, which help improve the standard of health care outside major metropolitan areas. Until recently, however, regulatory requirements limited the opportunities for home-based telehealth.

That's now changing. A new Apple initiative, in partnership with the Mayo Clinic and dozens of other health care providers, could be on the verge of helping to solve one of the biggest problems in the U.S. economy – one out of every six dollars spent in the U.S. is spent on health care. This is far more than any other country on Earth spends, yet results are meager: The U.S. ranks 26th in life expectancy, right behind Slovenia.

To start, Apple is releasing programming interfaces that allow any interested parties to create a wide range of personal health and activity monitoring apps. The company has also improved upon inexpensive sensing chips that can be embedded into a wide range of products, from iPhones to watches to home exercise machines – thus potentially kickstarting a slowly growing field.

While the Apple initiative is aimed at younger individuals, NewCourtland, a senior services provider in Philadelphia, has been operating its LIFE telehealth program, modeled on the Medicare/Medicaid Program of All-Inclusive Care for the Elderly (PACE) initiative, since 2007. In August 2014, it doubled its service area. PACE serves individuals age 55 or older who are certified to need nursing home care, are able to live safely in the community and reside in a PACE service area.

In the LIFE program, remote monitoring helps substitute a $125 per month technology cost per person for $225+ per day in nursing home costs. By employing remote monitoring over broadband, NewCourtland enabled 33 residents to move safely from traditional nursing home care to less restrictive environments, realizing an annual savings of more than $1.8 million. Fiber providers, whose networks rarely suffer outages, have a huge advantage over DSL or cable providers in supporting programs like this one. Some 104 providers in 31 states had received Medicare and Medicaid waivers to operate PACE programs as of summer 2014.

"Keeping even one person out of the hospital can pay for all systems for a PACE program for a year," said Jim Reilly, then director of Courtland Health Technology. The NewCourtland program could be copied by many local network providers under current regulations. Some continuing-care providers are now using similar approaches, backed by fiber-to-the-unit networks, to keep residents from escalating to higher levels of care.

Remote monitoring also promises to reduce the cost of treating patients who have chronic diseases. A U.S. Department of Veterans Affairs review of its home telehealth program found a 25 percent reduction in the average number of days hospitalized and a 19 percent reduction in hospitalizations for patients using home telehealth. For some patients, the cost of telehealth services in their homes averaged $1,600 a year – much lower than in-home clinician care costs.

Several innovative telehealth applications are being developed and tested in gigabit communities today under the aegis of the US Ignite program. Some of these include video-based support for caregivers of dementia patients, a solution for home-based psychological counseling and 3D video interaction for physical therapy.

services to business customers that until recently were provided only by corporate IT departments. Hosted PBX services are rapidly replacing on-premises PBX equipment, and online backup, storage and disaster recovery services are replacing the tape libraries of earlier days. Unified communications, managed Wi-Fi, transparent LAN and email exchange services are also popular offerings. In addition, many fiber network deployers derive revenue from allowing business customers to colocate servers in their data centers or central offices.

Home security, like many other technologies, is migrating from analog to digital. Digitally based home security allows residents to control settings, receive alerts and view their homes via PC or cellphone. Digital security systems also support a wider range of sensors – not only traditional motion detectors but also cameras, water detectors, carbon monoxide monitors, smoke detectors and many others. With FTTH's high upstream bandwidth, home surveillance cameras can even upload video footage of home intrusions to owners' cellphones, police departments or security monitoring companies. Because digital security uses wiring already installed for broadband, it is inexpensive to install and makes economic sense for renters as well as homeowners.

Over-the-top video (delivered via the data service, not the video service) may be offered as either an adjunct to or a substitute for traditional pay TV, and it may be delivered through either a Web portal or a set-top box. The business models, technologies and legal status of provider-delivered OTT video are evolving rapidly – a fact that demonstrates the enormous amount of interest in this application. If OTT video eventually displaces traditional pay TV, fiber-to-the-home providers are well-positioned to benefit because they can guarantee the quality of user experience.

Videoconferencing or video chat is universally available through free or low-cost Web-based services, but the quality of low-end services is often poor. Fiber to the home, with its high upstream bandwidth and its reliability, presents opportunities for providers to make high-quality videoconferencing available through TV screens.

Targeted advertising represents an important potential revenue stream. In IP-based networks, ads can be sent to households or specific TVs or other devices based on demographic criteria or viewing patterns. Another potential source of advertising dollars is T-commerce, in which television viewers click on ads – or even product placements in television shows – to see more information about products or order them.

MANAGE ASSETS MORE EFFICIENTLY

Broadband enables property owners to manage their assets efficiently and allows them to avoid costly upgrades or replacements of proprietary asset management systems, such as fire protection systems. The addition of broadband – especially the high-capacity, high-reliability broadband that fiber enables – turns "smart" buildings into "genius" buildings. Internet-enabled sensors and applications automate work that was once done by maintenance crews – and get it done it more quickly and accurately. Broadband applications also help owners communicate with tenants and employees.

- Guarding buildings and construction sites can be managed inexpensively and intelligently through IP-based video surveillance.
- Videoconferencing allows construction managers to make virtual site inspections more frequently than they can make physical inspections.
- Online work order scheduling helps property managers be more responsive to their residents while reducing operating expenses.
- Residents can request repairs at any time – not just when the office is open or they can find the superintendent – and management personnel can deal with problems that require personal attention rather than routine requests.
- Residents can be automatically notified when work is completed.
- Proprietary building management networks, such as fire protection systems, can be replaced by standards-based systems that are less expensive.
- Energy management and water management can be broadband-enabled.
- Motion sensors, intelligent thermostats and automated ventilation equipment can keep public spaces and unoccupied units at appropriate temperatures; applications that monitor and analyze usage help property managers and residents find opportunities to shift loads to nonpeak times and reduce their overall usage. ❖

Rural telco BEK brings local sports events to its video customers; this is the mobile studio.

Education Goes Broadband

When it comes to education, can communities afford not to assure high-capacity broadband for residents? Today's fiber-connected schools demonstrate how broadband enhances students' educational opportunities. Though most schools now have Internet access, adequate school broadband is still rare. But over the next few years, fiber-connected schools should become more common, thanks to the federal government's new ConnectED initiative. One big issue that is taking longer to solve: ensuring that all students have access to broadband after they leave the school building for home.

The Forsyth County school district in Georgia uses a business Ethernet connection from Comcast to support streaming video, interactive whiteboards, mobile devices and digital content for its 40,000 students. A next-generation learning system provides individualized learning plans based on students' needs, preferences and performance, helping to keep this Atlanta suburb's district among the state's top 10.

> "Every time you increase the speed of the network, you are enabling incredible educational opportunities."
>
> – Bailey Mitchell, CTO and CIO, Forsyth County (Ga.) Schools

The system takes into account learning interests and learning style to increase student engagement and boost academic performance. Students can learn at home on their own or at school, using high-speed Internet connections, and be rewarded by their teachers in collaborative settings.

Forsyth County's Bring Your Own Technology (BYOT) program lets students use their individual Internet-capable tablets, laptops, netbooks and cellphones to work in classrooms. Other schools around the country have substituted standard equipment – iPads, Chromebooks and so forth – vastly cutting their maintenance costs while creating new learning environments.

In Forsyth schools, for instance, students participating in the NOBLE Virtual World project interact in a digitally created world where they can create anything they imagine. Students develop creativity, data analysis and problem-solving skills by working in teams and creating plans and solutions.

Forsyth County Schools reduced its textbook costs by about 85 percent using interactive online content, including streaming video, simulations and other digital resources that, unlike physical textbooks, are kept always up to date. Administrative offices also benefit from fast, efficient data transmission as well as from file sharing and document storage via the district's central server.

"Bandwidth is the key. The only way to have access to all that digital content is to connect the technology and infrastructure in support of it," said Bailey Mitchell, chief technology and information officer for Forsyth County Schools. "My view is that every time you increase the speed of the network, you are enabling incredible educational opportunities."

Connected schools offer students the opportunity to take interactive field trips to museums and historical sites, study specialized subjects with teachers at other schools, and watch activities ranging from neurosurgery to Himalayan expeditions in real time.

School districts with superior broadband capabilities use "flipped classrooms," in which teachers record lessons as videos on YouTube or similar sites and students study the lessons at home. In school, students solve problems based on the previous night's lesson and get individual help from teachers.

Photo courtesy of Belen Jesuit Preparatory School

Students at Belen Jesuit Preparatory School in Miami began using iPads in the classroom during the 2011-12 school year. In this picture, sixth-grade students use iPads during a Spanish class taught by Alicia Fariñas.

FTTH for Communities

By summer 2014, the number of public and public-private fiber networks in the U.S. reached about 145 – and many of these serve multiple communities. Many communities are expanding the networks they started building in earlier years, thanks in part to stimulus funding, and are upgrading them to offer gigabit-speed service.

In 2012, Google launched gigabit Internet service in Kansas City, Kan., and Kansas City, Mo. – locations it chose in large part because the city governments were willing to collaborate with it. In 2013 it expanded to Austin, Texas, and acquired the municipal FTTH network in Provo, Utah. It also announced that it would negotiate with localities about expansion in nine other metropolitan areas with 34 communities.

All this activity has made municipal officials keenly aware of the potential for using ultra-broadband to promote economic development and enhance the quality of life in their communities. They are looking for new ways to encourage private providers to build FTTH networks, new partnership arrangements with telecom providers and new ways to leverage such municipal assets as conduit, utility poles and existing fiber. And they are finding takers – there are more than 100 networks offering or soon to offer gigabit services. Many are operated by small telcos, some of which have partnered with municipalities.

Questions Municipal Officials Ask About FTTH

Q: Will a fiber network help bring new business into my community?

A: There's growing evidence that fiber connectivity encourages businesses to stay, helps businesses grow and become more productive, and attracts new businesses, particularly in high-tech industries. FTTH supports home-based startup businesses and helps workers telecommute. It makes a community a more attractive place to live – especially for young people – which can stem the population loss that many small communities experience. If inadequate health care resources hamper economic growth, fiber connections permit local health care providers to call upon specialists in regional health centers. And if an unprepared workforce is a hindrance to business expansion, fiber connectivity can enable cost-effective distance learning.

FTTH is only one component of an overall economic development strategy – but it's a vitally important one.

> Fiber to the home is only one component of an overall economic development strategy, but it's a vitally important one.

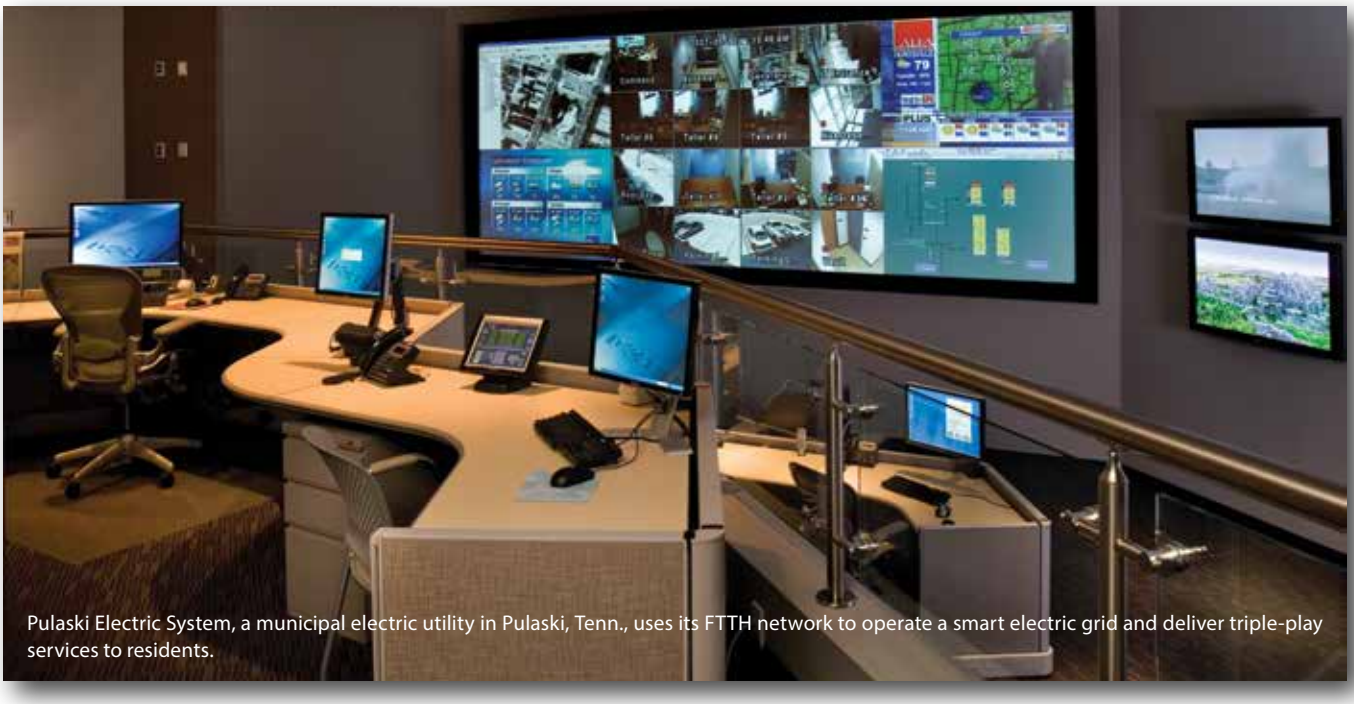
Q: How can I get fiber to my residents without building my own network? My town has too much debt now to borrow more, and we have no experience operating a municipal utility.

A: Lobby the incumbents – the cable and telephone companies that serve your town now. Lobby competitive providers or even local businesses that need more bandwidth and have the capability to undertake such a project. Offer such incentives as reduced franchise fees, access to public property or an accelerated permitting process.

If you own an institutional fiber ring that connects municipal buildings, schools and libraries, or if your traffic lights are connected by fiber, you might be able to propose fiber swaps to a potential provider. Take a fiber inventory to find out whether there is abandoned or unused fiber in your town that might either revert to the locality or be donated in exchange for a tax exemption.

Educate residents about the value of FTTH, and encourage them to commit to taking fiber services if and when a provider offers them. Start a community fiber campaign on CrowdFiber.com or a similar site so you can document the extent of subscriber interest in fiber broadband.

Alternatively, enter into a partnership to build a fiber network jointly with a private partner. In Europe, such partnerships are common, and the approach has begun to gain traction in the United States. A variety



Pulaski Electric System, a municipal electric utility in Pulaski, Tenn., uses its FTTH network to operate a smart electric grid and deliver triple-play services to residents.

of arrangements between the public and private parties are used, depending on legal requirements and on each party's assets and capabilities.

In 2011, a group of university communities banded together to invite both incumbent and competitive providers, as well as nontraditional providers, to build advanced networks. This project, called Gig.U, has given rise to several FTTH projects.

Q: Wouldn't it be better – and cheaper – to put in a community wireless network?

A: Wireless services are important public amenities, but they are not substitutes or replacements for FTTH. Rather, they complement and extend fixed fiber networks. Many wireless access points and cell sites are already fiber-connected, and most of them will be soon. Wireless service can thus be considered an application on a fiber network rather than a separate type of network.

Wireless access alone cannot attract new businesses to a community or enable businesses to grow. Wireless networks that cover wide areas are not reliable enough to deliver video and other emerging broadband services with high quality of service. Wi-Fi is highly desirable in targeted areas such as commercial shopping streets and common areas, but no one has developed a compelling business case for a municipalitywide Wi-Fi network.

Q: Don't all wired broadband networks use fiber?

A: They use fiber, but not all the way to the home.

Generally, the last 1,000 to 5,000 feet from the fiber's endpoint to the home is copper – coaxial cable in cable networks, plain copper wire in telephone networks. That limits bandwidth, reliability and versatility.

Q: How do I know whether my community is underserved?

A: Without a fiber network, your community is underserved – or it will be very soon. Even with upgrades, your non-fiber network won't be able to handle the ever-increasing bandwidth demands placed on it. Be sure to consider the needs of the business community in addition to those of residents – many economic development officials believe that affordable, symmetrical 1 Gbps access is needed to lure new businesses to a town.

If you can't get site selection committees to look at vacant commercial properties, or if your residents have trouble selling homes due to their poor Internet connections, your community is underserved.

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

A: Installing fiber in new developments is usually easier than installing it in existing neighborhoods. The fiber goes into the same trenches that have to be dug anyway for water, electricity and sewer service. In fact, copper wiring usually can't be run that way, so fiber is usually

Start preparing for fiber now by adding underground ducts whenever you or a utility repair a street or open it to excavation.

cheaper. Also, the new residents have not yet subscribed to cable or phone service, so whoever installs an FTTH network in a new community has an easier time signing up customers. That's why most new, large housing developments are being equipped with fiber.

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

A: It depends. Many network builders in North America use aerial fiber installed on poles along with existing telephone, electric and cable wiring. 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.

When there is no good alternative to trenching, new microtrenching techniques may allow fiber to be laid with less disruption to traffic. In microtrenching, a deep groove is cut quickly into the pavement or road with a large circular saw on wheels, and fiber is laid into the groove. Finally, many cities already have usable fiber under their streets – fiber that is not being used to its limit or that has been abandoned altogether.

Q: What can I do to make installing FTTH less expensive?

A: Start preparing for fiber now by adding underground ducts whenever you or a utility repair a street or open it to excavation. You can also adopt an "open trench" policy that gives telecom providers the opportunity to install ducts any time a street is opened. When it comes time for the city or a private provider to install fiber, the cost will be much lower if the fiber can simply be blown or pulled through ducts.

Q: Is it better for the same company to run the network and provide services, or should we consider an open-access network with multiple providers?

A: Both methods have been successful. Open-access networks, in which the public or private network builder "rents" bandwidth to a potentially unlimited number of service and content providers, are more common in Europe and Asia than in the United States. However, they have succeeded here as well. At present, most open-access networks in the United States are either municipal networks or networks built by companies that specialize in bringing fiber to new buildings and subdivisions.

Municipal utilities sometimes prefer to provide services directly, at least at the outset, for two reasons: First, being the service provider gives them more control over the quality of user experience; second, they may have difficulty attracting third-party providers to new networks. The downside of a closed network, however, is less variety in content and services. Many public broadband advocates believe that opening networks to innovative service providers is the best way to maximize the networks' value for their communities. Networks built with broadband stimulus funds are required to allow open access.

Q: There seem to be advantages to running closed and open-access networks. Why not both?

A: Some network operators, especially smaller ones, are doing just that. Networks built with funds from the 2009 stimulus program must offer access to third-party providers. These have often taken the form of infrastructure-sharing arrangements. Some use local data centers as "managed service providers" that package outside content for local carriers. A network operator could also provide voice, video and data. Third parties – either content providers, or managed service providers handling multiple types of services – would add the variety of services customers expect. This is the same arrangement that all cellular phone providers use. The cell phone company provides voice, video and data. Users then customize their smartphones with third-party apps. ❖

Danville, Va .'s use of its own utility poles for the nDanville network saved the city time and money.

Gigabit to the Home

A gigabit (1 Gbps, or 1,000 Mbps) will soon be the standard for both downstream and upstream bandwidth. Only fiber to the home can support symmetrical gigabit speeds.

Google Fiber made "gigabit" a household word, but Google was hardly the first to offer these speeds. Many providers now offer gigabit – or even 10 gig – speeds to businesses. Among residential providers, EPB Fiber Optics (the municipally owned network in Chattanooga, Tenn.) was the first to offer 1 Gbps access throughout a large service area. It was followed by other network operators, both public and private. By mid-2014, residential gigabit speeds were available in more than 100 communities, a number that is expected to double and redouble by the end of 2015. Large companies such as AT&T, CenturyLink and Bright House Networks have now begun offering gigabit FTTH service in selected locations.

More than three dozen American research universities are collaborating on Gig.U, a program to bring 1 Gbps fiber access to the communities surrounding their campuses. Multiple Gig.U projects are already underway, usually with both private and public participation.

WHAT WILL YOU DO WITH A GIG?

When it announced its Fiber initiative, Google offered several scenarios.

"Imagine sitting in a rural health clinic, streaming three-dimensional medical imaging over the Web and discussing a unique condition with a specialist in New York," its statement said.

"Or downloading a high-definition, full-length feature film in less than five minutes. Or collaborating with classmates around the world while watching live, 3D video of a university lecture." Once Google began building the network, the two Kansas City governments began working closely with the private sector and local foundations to make sure the community derives maximum benefit from the new infrastructure. The scenario was repeated in Google's second major deployment, Austin.

In Chattanooga, Harold DePriest, CEO of EPB, called his city's FTTH network "the basis for creating the products and services of the Internet of the future." In 2012, 2013 and 2014 the city sponsored summer programs in which entrepreneurs and students competed to develop gigabit business ideas, tested them with customers on a live network, and won startup money and mentoring to help commercialize their ideas.

US Ignite, a public-private project launched with leadership from the National Science Foundation, chose Chattanooga, Lafayette and other gigabit communities as test beds to develop the applications of the future. The project focuses on new applications in health care, education, workforce development, energy, advanced manufacturing and public safety. Mozilla Ignite, part of the US Ignite project, is an open innovation contest that awarded $500,000 to 22 developers of applications that range from remote process control to collaborative learning to public transit planning. The teams are busy fleshing out their applications.

EARLY GIG ADOPTERS

A survey by Telecom Thinktank and RVA LLC found (not surprisingly) that 1 Gbps subscribers are heavy Internet users – or even households with several heavy Internet users. They are online an average of eight hours per day, compared with the overall average of 2.5 hours, and they have many networked devices. Some may be streaming movies and chatting on Facebook while participating in multiple online games through multiple consoles.

In addition, many are content creators. Traffic measurements by Hong Kong Broadband, which provides 1 Gbps service in Hong Kong, show its gigabit subscribers use three times more upload bandwidth than download bandwidth. Upload speed is critical for distributing HD photos and videos, efficient cloud computing and virtual-presence videoconferencing.

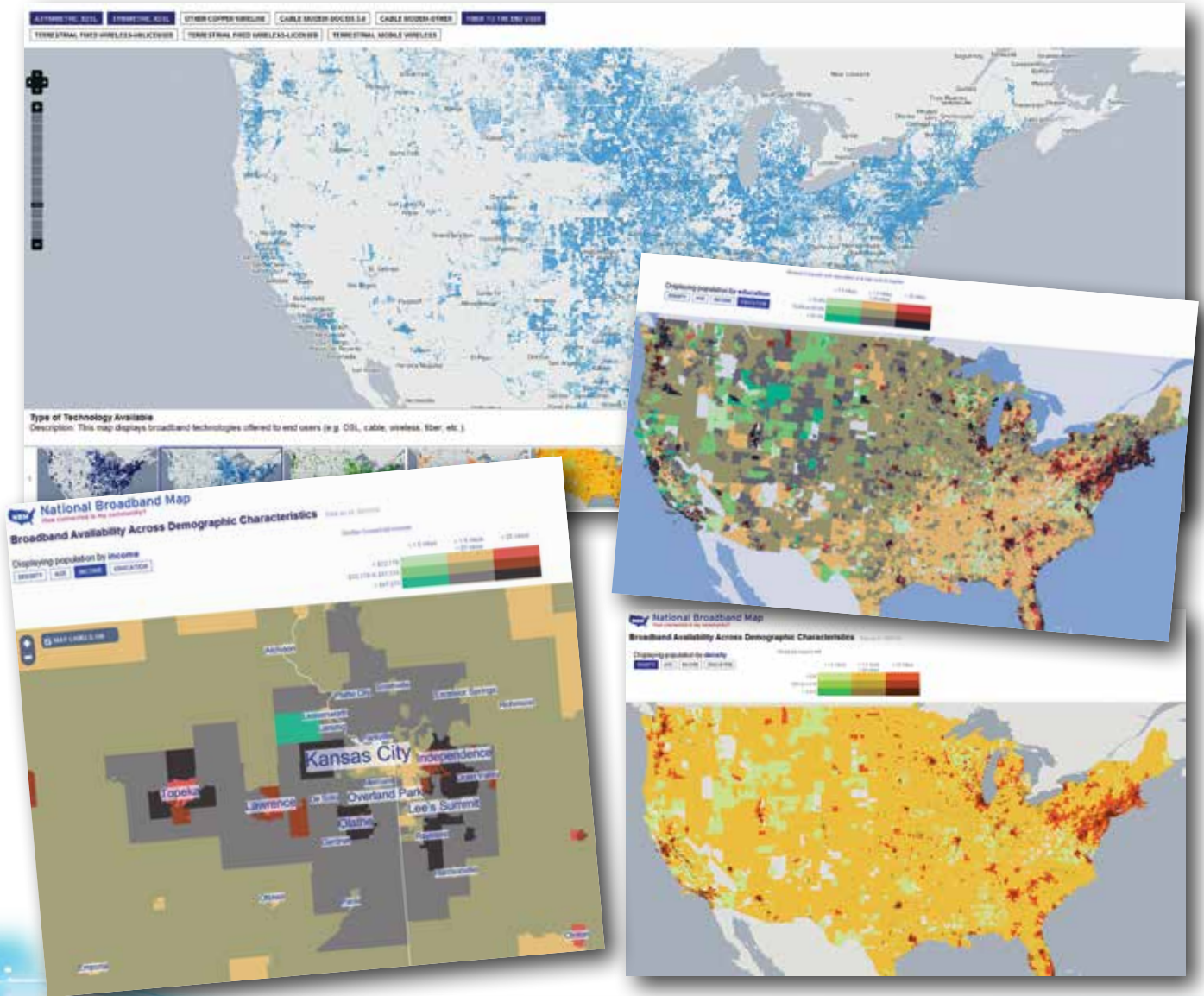
Finally, superfast connectivity also appeals to work-at-home professionals who need low latency and rapid file transfers. ❖

More Information for Community Leaders and Small Network Providers

Interested in fiber to the home? Start with a visit to www.bbcmag.com. **Broadband Communities'** municipal portal, www.bbpmag.com/MuniPortal/FTTHLand.php, can direct you to additional resources, and its FTTH deployment database at www.fiberville.com shows all FTTH deployments by municipalities and others, including small telephone companies.

Broadband Communities has also created investor feasibility models and monthly cash flow models, available free at www.bbcmag.com/FTTHAnalyzer/. The models are easy to adapt to your specific situation – whether you are in an urban or rural district, or you are a property owner looking to investigate the business case for FTTH.

The FTTH Council (www.ftthcouncil.org) holds quarterly meetings and monthly webinars and offers other information for fiber deployers. See especially its Community Toolkit



(toolkit.ftthcouncil.org) for resources for municipalities.

Note the council's advice on organizing your community by identifying fiber champions, forging partnerships, and building consensus. Develop a business case by identifying your assets, estimating demand, building a financial model and finding the money to build. Once you are ready to build, the site offers advice on developing an RFP, finding a provider and managing the deployment.

The Baller Herbst Law Group (www.baller.com) offers links to many groups working on broadband issues and to discussions of laws and regulations covering FTTH.

The Blandin Foundation (www.blandinfoundation.org) is aimed at helping rural Minnesota communities thrive, but it has a national outlook when it comes to FTTH. The site includes multiple case studies.

What makes a smart community? The Intelligent Community Forum (www.intelligentcommunity.org) has an annual "smart community" competition and publishes numerous reports and studies showing what communities worldwide can do with broadband. The ICF is associated with New York University.

The Institute for Local Self-Reliance is a nonprofit research and educational organization that provides technical assistance and information on environmentally sound economic development strategies. It is a great source of information about community broadband networks, and its broadband advice and newsletter (www.ilsr.org/initiatives/broadband, www.muninetworks.org) have helped many communities.

The National Broadband Map – a continuing, nationwide collection of broadband availability and usage (www.broadbandmap.gov) – can help communities deploy FTTH networks where they are most needed and use them to best advantage. Though the data are still being refined, the map has already been used by:

- **Industry** to site new facilities.
- **Service providers** to target new opportunities.
- **Municipalities** to monitor broadband adoption.
- **Policymakers** to target broadband grants.
- **Native American tribal authorities** to reveal broadband training needs. ❖

FTTH Success Stories

Almost every new FTTH community offers a success story – young people or businesses that didn't leave town or new businesses that arrived. However, economic development doesn't occur inevitably as a result of investment in fiber infrastructure. Bankers have to be sold on investing in local businesses. Existing business operators have to learn how broadband can help them. Government agencies, local health care providers, educational institutions and builders all have to be brought up to "speed" on what broadband can do.

The good news: Broadband offers more "bang for the buck" than any other major infrastructure category – and it can be built faster.

Kansas City, Kan., and **Kansas City, Mo.**, showed the way when they became the first Google gigabit cities. Yes, small tech companies streamed into town as soon as Google launched. But the homegrown Kansas City Startup Village, an entrepreneur-led, grassroots initiative encouraged by municipal officials, established several startup neighborhoods into which young software writers streamed. Local business groups and the mayors of both Kansas Cities offered startup help. Now the growth is expanding into underutilized office buildings downtown.

San Leandro, a city of 85,000 residents across the bay from San Francisco, has long had good transportation, civic infrastructure and a history of manufacturing. Now its businesses have better-than-gigabit fiber, thanks to a private-public partnership that's attracting a new generation of employers and keeping existing employers in town. Lit San Leandro is the brainchild of Dr. J. Patrick Kennedy, a San Leandro resident and president and founder of OSIsoft, one of the city's largest employers. Mayor Stephen Cassidy met with Dr. Kennedy in 2011. Nine months later, the San Leandro City Council unanimously approved Lit San Leandro to install a fiber optic loop through the city's existing conduit. Businesses get up to 10 gigabits per second.

1.1%
is the increase in per capita GDP for U.S. cities with widely available gigabit services.

The city then won a $2.1 million U.S. Economic Development Administration grant to expand the system from 11 to over 18 miles, with connections to Oakland. More than 950 businesses are now within 200 meters of 10 gigabit fiber. One site, a future mixed-use development project, will help attract broadband-hungry office tenants.

As for Dr. Kennedy? His business got the bandwidth it needed to stay in San Leandro.

Danville, in south-central Virginia, suffered from the decline of tobacco and textiles. Unable to attract businesses without affordable fiber services, local leaders began a development program centered on advanced telecommunications infrastructure, technology education and workforce training, and targeted downtown revitalization projects. Today, companies that require sophisticated new technology are moving to Danville. The city became the second site globally for a next-generation Cray XMT supercomputer.

IKEA chose Danville as the location for its first U.S. manufacturing facility in large part for its access to

Revitalization projects in downtown Danville have been undertaken along with the buildout of the nDanville network.

fiber. CBN, which produces all the driver's licenses for Virginia, located in Danville in part because of the security of its fiber connections.

Corrie Teague of Danville's Office of Economic Development notes the network's success in inducing technology companies to start up or move to the area, creating a positive spiral effect. "High-tech companies attract other technology companies," says Teague.

Chattanooga saw the same thing. It attracted as many as 2,400 jobs – at a new Volkswagen Passat factory and an Amazon distribution center, among others – because of its fiber-based broadband and the reliable power that its fiber-enabled smart electric grid guarantees. But perhaps even more important, its pioneering gigabit network is attracting a new generation of entrepreneurs and gaining a reputation as a place to start and grow businesses. Even companies based in Knoxville, 100 miles away, now look to Chattanooga when they want to expand.

Powell, Wyo., is located 500 miles from the nearest metropolitan area and has more than 1,000 of its 5,500 residents below the poverty line. After it spent $4.9 million connecting each home to a fiber optic network, Alpine Access, a contact-center outsourcer that uses home-based agents, opened a virtual call center there.

Auburn, Ind., retained key employers by providing fiber connectivity.

Palm Coast, Fla., needed extra capacity for its communications network. In 2005, the city began connecting its 21 sites with a fiber network that would provide more bandwidth and reliability and cost less, too. By 2010, all but one site was connected. The city decided to offer its system to private businesses as well. It followed the model of **Leesburg, Fla.**, which began installing fiber in 1987 and now serves county schools, Leesburg Regional Medical Center and area businesses.

The business model is simple for Palm Coast – like San Leandro and many others, it rents access to providers of broadband service to businesses. By 2013, it had revenue of more than $500,000 a year, more than three times its expenses.

Auburn, Ind., went with fiber in 2005 when Cooper Industries, a Fortune 200 company whose global data operations were located in Auburn, Ind., was at a crossroads – it had to either expand its Auburn facility or relocate. The company's most critical requirement was for fast, resilient and reliable broadband.

Auburn Essential Services, a municipal broadband provider, worked with Cooper to craft a business-class broadband service and thereby preserve $7 million in annual payroll for the community. In addition, the city has retained a number of Internet-dependent, small but growing businesses.

There are now hundreds of examples. When it comes to highways, the Information Highway is the one to be on, to attract and keep businesses. ❖

Builders, Real Estate Developers and FTTH

Most large developers of single-family homes and many developers of multiple-dwelling-unit (MDU) communities add FTTH to new properties. Many are retrofitting older properties as well. By mid-2006, FTTH was economically viable in new developments with as few as 80 MDU living units or 100 single-family homes. That number has continued to fall based on improvements in deployment technology.

FTTH adds value. Since the mid-2000s, the market research firm RVA LLC has surveyed home buyers and developers. Through boom, recession and recovery, surveys have noted that FTTH adds more than $5,000 to the price of a single-family home. The most recent survey indicates that fiber access adds between $5,000 and $6,000 to the value of a $300,000 home. RVA's 2014 survey of MDU residents found that condo buyers were willing to pay a 3 percent premium for an FTTH connection, and renters would pay an 8 to 15 percent premium for FTTH.

The reason fiber adds value is that subscribers are more likely to be very satisfied with their broadband and video services and much less likely to consider moving from their current homes. According to RVA's most recent survey of MDU residents, good broadband is now the No. 1 amenity, beating out even in-unit washers and dryers.

Q: How can I justify increasing my construction cost by adding fiber?

A: First, don't assume that fiber is more expensive to install than copper – that's not necessarily the case. Second, homes sell for higher prices when they are wired for high bandwidth and provide access to fiber. And because FTTH homes sell faster than non- FTTH homes in the same market, this may translate into a greater profit. This is even more important in bad times. When few homes are sold or rented, you can bet that homes with high-bandwidth amenities sell faster. This is equally true for rental properties. Developers of MDU communities say their new buildings lease up faster if they can advertise them as fiber-connected.

91% of students demand fast Internet or broadband in their housing.

44% of students want cable TV.

Q: Do buyers and renters really care about fiber to the home? How many of them have heard of it?

A: They really care about fast, reliable broadband. Survey after survey shows that FTTH customers are more satisfied with their broadband and TV service than cable, DSL and wireless customers.

Q: Do I need to hire an engineering firm to design the installation?

A: Fiber does need to be engineered in large apartment complexes – that's true for coax, too. But smaller installations do not need that kind of sophistication to work well. Greater standardization, clever new systems from equipment vendors, fiber that can be stapled and bent tightly around corners, distributors' growing design expertise and an expanding corps of qualified technicians have made less formal design regimes feasible.

Q: Will other labor on my construction site damage the fiber cable?

A: Optical fiber is very, very thin – thinner than a human hair. But vendors have developed many techniques to protect fibers from harm. Cable can be armored to ward off cuts. Contractors can route inexpensive microduct – hollow plastic tubes typically 1/8 inch in diameter – through walls before the walls are closed in with drywall or other materials. The microducts are easily repairable. After everything else is completed, thin fiber can be "blown" through the microduct for hundreds of feet. New fiber can be bent almost like copper. Some vendors offer fiber in thin adhesive tape that can be rolled onto walls.

Q: Do any building codes pertain to fiber?

A: Yes, all the usual fire and life-safety issues apply. For instance, just as copper with PVC sheathing would be considered a life-safety hazard because of the combustion products released when it burns, so would various plastics used in fiber that is meant for outside installation. Indoors, look for Low Smoke Zero Halogen (LSZH) cables. If you are using thin plastic microduct, it should

$5,000-$6,000
Value that FTTH adds to a typical house or condo.

$81
Monthly rental premium that FTTH adds to a $1,000 apartment.

20% Extra ROI (compared with cable) for adding FTTH to a rental property.

be labeled Halogen-Free Flame Retardant. You use a simple junction box to change from "outside" to "inside" wiring, just as you might with electrical cables.

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

Q: Where should we put users' network connections, assuming no specific building code or guidance document covers that subject?

A: 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, set-top boxes, digital picture frames, security sensors, fire and smoke monitors and, of course, computers. As the "Internet of things" develops, more appliances will be Internet-enabled. Many manufacturers already provide such connectivity.

To minimize wireless interference inside multifamily buildings, experts often advise using wired Ethernet connections for all stationary IP-connected devices. Portable consumer electronics devices, such as smartphones and tablets, usually communicate with the Internet via Wi-Fi – as do appliances (manufacturers have adopted a standard for building Wi-Fi into major appliances), so you also need a wireless gateway. Such gateways are offered by all network equipment vendors as standard-issue to be used on the home side of fiber network deployments.

Q: In single-family homes, I often see ONT boxes – the fiber terminals – hung on the outside walls. Can they also be placed indoors?

A: Yes. In harsh climates, where heat or heavy snow could affect the outside installation, you will probably want to put ONTs indoors. Outdoor ONT models are sometimes placed in garages or utility rooms; you can also buy small, portable indoor models that look more like cable or DSL modems and connect them with tough, flexible fiber that can be laid anywhere. Indoor ONTs, which are popular with apartment dwellers, are sometimes designed to be user-installed. Most are not much bigger than a cellphone.

Q: Why do ONTs sometimes require backup batteries?

A: Optical fiber cannot conduct electricity. Thus, to keep a network connection running during a power outage, you need a battery at the user premises or a fiber cable that includes a thin copper conductor connected to an off-site battery. This requirement is changing as cellular phones replace landlines – a change that has already taken place in most of Europe. In North America, where about three of five households still have landlines, many standard designs are available for in-wall, between-stud boxes that hold the battery, ONT and fiber connections.

Q: Does every dwelling unit or office need its own ONT located at the unit?

A: No. Separate ONTs for each unit in an MDU building can be located centrally, often in a basement or an equipment cabinet. There are also ONTs designed to serve multiple units, typically four or eight. This flexibility is made possible by small, low-power circuitry and by the fact that some ONTs can deliver 1 Gbps or more – often enough bandwidth to share among multiple customers.

Q: Is lightning a problem with fiber?

A: No. Because fiber does not conduct electricity, lightning strikes do not directly affect fiber at all.

Q: Is FTTH a sustainable technology?

A: FTTH generally consumes less power than other broadband technologies. Passive optical networks (GPON and EPON) are especially energy-efficient because they require little or no active electronics in the field.

FTTH enables more sustainable lifestyles, too. A 2008 study by PricewaterhouseCoopers showed that the greenhouse gas emissions associated with deploying an FTTH network are outweighed within five years by the savings from increased telecommuting. Other fiber-enabled applications, such as telehealth, telepresence, distance learning and cloud computing – and, of course, smart-grid applications and home energy management – reduce travel, minimize heating and cooling loads or help shift energy consumption to renewable sources. ❖

Property Developers Win With Fiber

For a collection of articles on properties that have deployed fiber to the building or fiber to the unit, , see www.bbpmag.com/property/Property_Land.php. There you will find details of the precise technologies used at three dozen properties in all property sectors and in all regions of the U.S. Here are two recent examples.

ATLANTA CONDO TAKES DO-IT-YOURSELF APPROACH

The Brookwood, a 219-unit high-rise condominium in Atlanta's ultra-chic Buckhead neighborhood, now has an attractive, low-cost amenity for condo owners as well as cost savings for the management office. When homeowners took over management of the community from the developer, one of their top priorities was to improve broadband services and provide the fastest Internet speeds in Atlanta to all residents. They succeeded: Today, every resident of The Brookwood can get 50 Mbps symmetrical Internet access for only $22 a month.

Atlanta's Brookwood condo installed its own fiber backbone.

> Fiber-based broadband adds cachet – and value – to multiple-dwelling-unit properties. Communities with fast Internet speeds are appealing to buyers.

After reviewing proposals from several traditional providers, the association decided to take matters into its own hands. At the recommendation of Clara Sorrells of FirstService Residential, the property's management company, it hired Broadband Planning, an Atlanta-based consulting firm that represents both owners and condominium associations in negotiating broadband services.

Richard Price, owner of Broadband Planning, explains, "Technology is rapidly changing, and property managers and community boards of directors need to know all the options available for their communities before getting locked into long contracts with cable providers. Communities with fast Internet speeds and the ability to have choice for cable providers are going to be more appealing to potential buyers."

The Brookwood Residential Condominium Association created a committee, led by a resident and telecommunications professional, Karen Angellatta-Wheeler, to work with Broadband Planning and search out high-quality companies that could help the condo association accomplish its goal.

After a yearlong search, the association made a bold move: It decided to build an Ethernet data network in the building, using the telephone wires that already served each unit along with commercial-grade Ethernet electronics and a 10 Gbps network backbone.

The system is powered by a whopping 500 Mbps data circuit, which can be upgraded to 1 Gbps or more with only a week's notice to keep the building on the cutting edge. The Brookwood's bandwidth pipe is even larger than that of nearby Georgia Tech, and it serves a much smaller constituency. Because it was a modification of the existing infrastructure, the new system was implemented without major cost.

This solution gave all residents 50 Mbps upstream and downstream – a service that was not previously available to residential users in this area – at a cost of only $22 per month. There's access to a dedicated customer service line that dispatches technicians 24 hours a day.

The Ritecom Group, a well-established local commercial broadband and fiber optic contractor, provided the design, network equipment and commercial-grade customer service for an all-inclusive monthly fee. The Ritecom equipment and services and the separately contracted commercial-grade circuit are the association's only two expenses.

The association uses the excess bandwidth for management office telephones and other low-voltage monitoring, cutting its management office monthly expense from more than $1,500 to $250.

Callaway House was the first student housing in Austin to offer gigabit Internet access.

GIGABIT TO STUDENTS IN AUSTIN

Callaway House, a new student housing community, offers 1 Gbps Internet service. Austin, home to the University of Texas and a thriving high-tech industry, is a lucky city. Google Fiber is building a gigabit network there. AT&T launched its GigaPower service there. But several hundred exceptionally lucky University of Texas freshmen didn't have to wait for the completion of these large-scale projects: Their off-campus residence hall opened in August 2013 with unrestricted 1 Gbps connectivity to both the Internet and the university network.

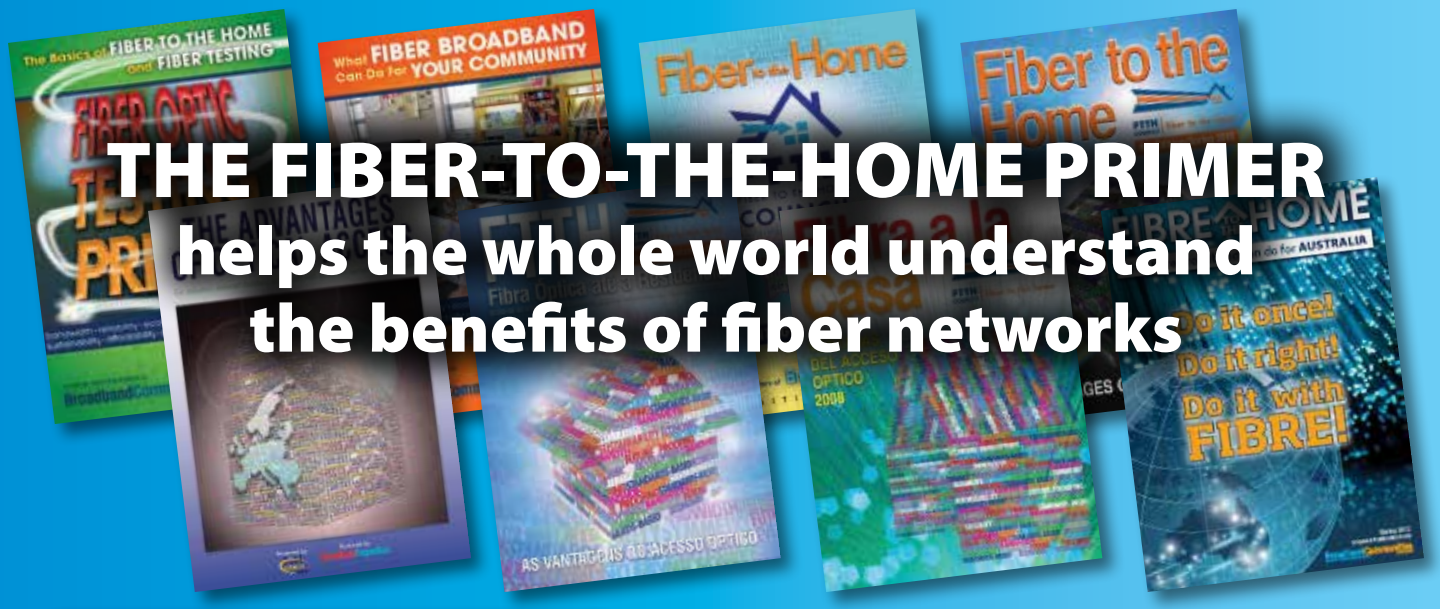
American Campus Communities (ACC), the property owner, is well aware of broadband's importance to student housing. When ACC conducts surveys in the 191 student-housing properties it owns or manages, residents always rank Internet access high on the list of amenities. After all, students tend to own multiple connected devices and to be heavy users of bandwidth for both schoolwork and entertainment. In addition to taking online courses, they carry iPads to class, buy e-textbooks, participate in Skype study groups and post their homework to online services such as Blackboard. "Broadband is not a reason for them to pick a property, but it's a reason for them to leave if it's poor," explains Jorge de Cardenas, ACC's senior vice president and chief technology officer.

When ACC planned The Callaway House, it saw a good opportunity to take a "significant step up" in bandwidth delivery, according to de Cardenas. First, the market was right – the University of Texas has a strong focus on technology innovation – and second, entry costs were relatively low because Austin's fiber infrastructure is abundant. (This is one reason Google chose Austin for a citywide gigabit network, de Cardenas points out.)

ACC turned to CampusConnect, an Austin ISP that had both student-housing expertise and available fiber, to design and build the network. "We wanted to try it out to see what kind of impact it would have," de Cardenas says.

ACC is already looking for additional markets where gigabit networks might be feasible. At the same time, it is tracking the experience of Callaway House residents to find out how students use the bandwidth available to them and whether an outstanding technology amenity will become a driving factor in the selection of an apartment.

ACC wasn't sure what students would do with their gigabit access, other than taking online classes (yes, more than one of 10 courses taken by students on U.S. campuses are online, despite the proximity of classrooms) and relaxing with Netflix movies on the weekend. But that was not a problem. De Cardenas says, "We're removing the barriers to students' doing things we don't even know about yet. We're creating an environment that's conducive to academics, to innovation, to all kinds of new things." ❖



THE FIBER-TO-THE-HOME PRIMER helps the whole world understand the benefits of fiber networks

"The Primer is an excellent way to not only educate people about the basics of FTTH but also inform them of its many benefits."

—Mark Erickson
City Administrator and Economic Development Director - Winthrop, Minn.

BUILD COMMUNITY SUPPORT

Printed FTTH primers are helping thousands in communities get on the same page about the benefits of fiber networks.

Community leaders and fiber champions are launching mailing campaigns to send FTTH primers to every household and business.

Besides the primer, mailing packets include brochures, questionnaires and schedules of public meetings about fiber networks.

FTTH marketing campaigns use volunteers, both adults and children, to reach every household and business in a project area.

Get more information or place your request for a bulk shipment of printed primers for your community at:

www.FTTHPrimer.com
877-588-1649