WHAT FIBER BROADBAND CAN DO FOR YOUR COMMUNITY

13th Edition • Fall 2017

bandwidth • reliability • economic development • future-proofing
sustainability • affordability • symmetry • standards-based • security

A Fiber-To-The-Home Primer
from the Editors of

BroadbandCommunities

FiberBroadband ASSOCIATION

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Why Fiber?

WELCOME TO THE BROADBAND AGE

This is the age of fiber optics.

The information and communications revolution is being brought to you by glass – long, thin, pure strands 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 tiny fraction of it.

Because fiber optic cable has so much capacity, it has for decades formed 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 be cost-effective. Most would not work at all.

The final step – which is already in progress – is to extend fiber optic cables all the way to homes and businesses and replace the old networks entirely. Worldwide, network operators agree that only fiber to the home, (FTTH, also called fiber to the premises, or FTTP), can meet the exploding demand for bandwidth and deliver next-generation services. The only debates involve the speed of the transition.

In this publication, we explain how this evolution is likely to happen and how it affects communities, real estate owners, businesses that use broadband, businesses that supply broadband, and providers of content and services over broadband.

Along with the "how," we explain the "why" – why you need fiber and what fast, reliable, affordable broadband means to individuals, businesses and communities.

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

At the Noblis Center for Applied High Performance Computing, the fiber network operated by Danville, Virginia, enables always-on videoconferencing.

Fiber offers far more bandwidth, reliability, flexibility and security and a longer economic life than alternative broadband technologies.

In terms of cost, FTTH is more expensive to build in some cases and less expensive in others, depending mainly on what infrastructure is already in place and what kind of condition it's in. Fiber is always less expensive to maintain and operate.

Fiber is more sustainable. Fiber networks use less electric power than copper, can often be maintained remotely and are made of glass (that is, sand), not a mined and refined metal.

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 value fiber connections, too. For economic efficiency and for redundancy, critical business systems now operate at huge data centers – in the "cloud" – rather than on local computers. The speed, reliability and security of fiber connections are what make cloud services viable.

Soon, ubiquitous fiber will also be needed to connect 5G wireless cell sites, make possible near-universal self-driving cars and securely connect the internet of things – hundreds of networked devices in every home and throughout every community.

WHO HAS ACCESS TO FTTH?

In the United States, more than one in four households have fiber connections available, and about half of them (roughly 16 million) subscribe to FTTH services.

That's less than the average for the rest of the developed world. U.S. broadband providers have finally begun to catch up; 5 million homes are newly passed and marketed to consumers each year in North America. (A home with a fiber connection available is said to be "passed by fiber.") The target is moving, however. China has more than 100 million FTTH subscribers and more than 700 million homes passed by fiber, many in rural areas.

WHO IS BUILDING FTTH?

More than 1,100 entities (listed at www.fiberville.com on the **Broadband Communities** website) provide 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 cellular providers.

In addition, new companies have formed specifically to build fiber optic infrastructures. Other nontraditional providers include cooperative electric utilities, property developers, technology companies, municipalities and public-private partnerships.

Though small providers outnumber the large ones, the major telephone companies still account for about half of new FTTH connections and the majority of the existing connections in the United States. 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 close to 6 millon FTTH connections. In addition, it transferred about 1.7 million Fios customers to Frontier when it sold its residential assets in 17 states. AT&T, which has ramped up its FTTH build in the last several years, now has about 2 million customers. CenturyLink has some FTTH available in 11 U.S. metropolitan areas.

The large franchise cable companies have also experimented with fiber to the home, especially in new communities. Their pace quickened in 2015. As the demand for gigabit services grows, they have begun to build FTTH on a larger scale, usually by melding it into their existing networks, which have always been fiber from their local and regional hubs up to local nodes.

Existing telecom providers build FTTH as part of their normal upgrade cycles, to meet customers' bandwidth demands. However, nontraditional providers have more specific reasons to deploy fiber. For example, property developers can enhance the value of their real estate by putting fiber into new properties or upgrading existing properties.

Local governments, electric co-ops and other community-based organizations are attracted to FTTH because it positions their communities

for tomorrow's jobs and economic growth. There are now more than 220 municipally owned or public-private fiber networks, and hundreds of other communities are studying whether to build such networks. There are also about a dozen FTTH networks built by Native American tribal authorities. Some community networks serve only businesses; most serve households as well.

Finally, new types of entities are poised to enter the FTTH market. For example, investor-owned utilities, some of which are already deploying fiber for smart grids and leasing dark fiber to carriers, could easily extend their fiber to homes and businesses.

FTTH IS THE ONLY UNLIMITED BROADBAND TECHNOLOGY

In most areas, fiber already extends well beyond the backbone. That's why all types of broadband service have improved recently. Cable providers typically build fiber into neighborhoods and then use coaxial cable for the last 100 to 2,000 feet. Many phone companies build fiber to within a few thousand feet of homes and use copper wire with some variant of DSL (these days, often VDSL2) to deliver broadband. For in-building use and very short copper runs from existing fiber, a new DSL technology called G.fast is available.

In rural areas, fixed wireless broadband is common. A new wireless technology, 5G, is poised for large-scale deployment, starting around 2020, for both fixed and mobile use. The industry envisions 25 million "micro-cell" sites, typically attached to telephone poles and each serving as many as 10 or 12 households. Each micro-cell will be connected to fiber.

Another new option is to extend fiber with millimeter-wave, point-to-point wireless connections, which can help deliver broadband to especially difficult-to-serve neighborhoods. These links are designed in such a way that they can be replaced with fiber over time.

Despite many recent advances, 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 bandwidth will become less expensive rather than more expensive.

The latest FTTH technologies, such as NG-PON2, allow the same infrastructure to serve multiple providers or multiple separate networks (residential, enterprise and wireless) of a single provider. Each network can have its own wavelength (color) of light, and the different wavelengths share the same fiber strands. Software can be used to reconfigure the networks to meet special demands, such as game days at a big stadium. An NFL stadium, for instance, may have 4,000 cell sites to serve patrons who stream the game they are watching. But why pay for the connections when the stadium is empty?

THE PAYOFF

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

For example, ultra-high-definition video communications are challenging to implement well over any medium but fiber. 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, home education and medical monitoring services all benefit from fiber's high reliability.

In general, access to utilities makes private property more valuable, and now broadband over FTTH is the utility that owners and renters especially value. Fiber connections make homes easier to sell and to rent – in fact, according to recent surveys of residents by RVA LLC and analyses of actual real estate prices by the Fiber Broadband Association, 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. Fiber-passed homes also sell and rent faster, on average.

Renters and buyers both know that with fiber, 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. A 2010 study showed that entrepreneurs were a third more likely to start a home-based business if they had FTTH than if they had cable or DSL, and current data indicates that's still true. That's an extra $40 to $50 billion a year added to the U.S. economy.

FTTH communities have advantages in attracting everything from advanced manufacturing to contact centers to data centers. Today, fiber is often a non-negotiable requirement – Amazon's recent RFP for a new headquarters stated, "Ensuring optimal fiber connectivity is paramount at our HQ2 location." In addition, FTTH communities 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.

In these pages you'll see the advantages of ultra-broadband, especially broadband based on fiber to the home. ❖

Broadband and Bandwidth

An explanation of broadband terms

Q: What is bandwidth? And, by the way, what's a gigabit?

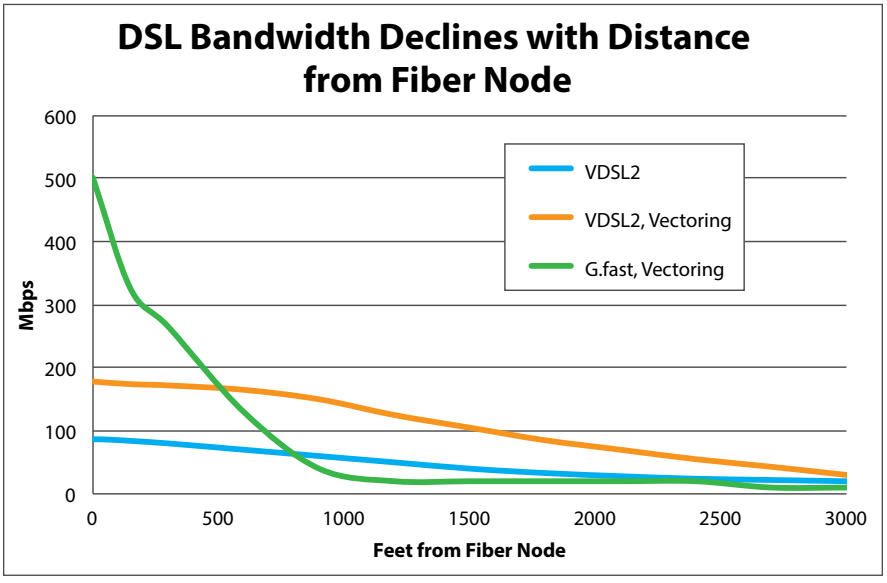
A: In a network, bandwidth (what engineers call bitrate) is the ability to carry information. The more bandwidth a network has, the more bits of information it can carry in a given amount of time. (Each "bit" is a 0 or a 1 – the smallest unit of information.) Networks that have high bandwidth tend to be more reliable because fewer bottlenecks disturb the flow of information and because the information flows through the network in less time, reducing the chance a disturbance will happen during the trip. These days, many fiber networks are designed to provide a gigabit (one billion bits) per second to users who need it. In fact, some 2 gigabit per second (2 Gbps) and 10 Gbps systems have been deployed. In a 1 Gbps network, a two-hour video can be downloaded in as little as 16 seconds, and the images will be perfect.

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

A: The amount of bandwidth we need grows every year. Worldwide internet traffic roughly doubles every two years and has increased even faster lately because of smartphone use. Much of the 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. Traffic has continued to increase since then.

Video requires not only extra bandwidth but also extra reliability. The smallest delay in data transmission can result in distorted views. People now watch video on several screens at once; in addition, video formats are becoming more bandwidth-intensive. So-called 3D immersive HDTV – already used in some academic and industrial settings for telepresence – requires between 50 Mbps and 300 Mbps. 4K video, sometimes called Ultra HD, requires 16 to 32 Mbps even with the best compression technology, depending on how fast the screen action is and how much of the screen is taken up by fast-moving objects.

Virtual-reality (VR) video is now readily available for movies, games and even news reports. VR adds visual information to each frame, making possible multiple alternative views, and thus can vastly increase file sizes and bandwidth requirements. Consumers can easily create VR clips with "360-degree" cameras that cost $300 or less and view them on phone screens attached to simple headpieces – one style, from Google, is made of cardboard. But VR also requires very tight synchronization between the sound and the images. If they are slightly off, users can be nauseated.



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 to 200 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 extra electronics are a new point of possible failure, of course.

278 EXABYTES
Monthly global internet traffic, 2021 (3x current)

51%
2016 growth in peak-hour data traffic

Q: Is video the only driver of bandwidth demand?

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 create larger and larger images; 30 megabyte images are not uncommon, and some digital cameras produce 100 megabytes per image. Amateur HD video cameras create about 10 gigabytes per hour of video – the equivalent of 300 of those 30 MB still images. The fastest specialized cameras for filming explosions and movie special effects can create up to 300 terabits (300,000 megabits) per second.

Self-driving vehicles will exchange data with nearby cars and the internet through roadside micro-cell access points (rather than directly with each other) at about a gigabit per second per car – dwarfing today's video volume.

Voice-activated searches on Siri, Google Search and Cortana take more bandwidth than text searches, and they require near-perfect transmission to be decoded by supercomputers at data centers (no, Siri doesn't live on your phone). As voice search becomes the norm, upstream bandwidth is being saturated quickly.

In health care, the medical images produced by equipment such as CT scanners are easily a hundred times larger than camera images. A 2D mammogram image is about 20 megabytes; the newer 3D mammograms average 500 MB but can reach 3 GB.

Business and science have 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 particle physics to control of electrical grids. Big data doesn't work without big bandwidth. A single DNA sequencer produces enough data to monopolize a 5 Gbps connection.

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

A: Downstream bandwidth gets the most attention because most users need more downstream bandwidth than upstream – especially for video entertainment. But emerging consumer uses, such as voice-activated search and dictation, home video uploads, cloud storage, distance learning, video communication and telemedicine, may require as much upstream bandwidth as downstream. Small businesses, often home-based, often need upstream bandwidth as well – consider a wedding photographer sending proofs by email to clients. Businesses now often copy all their working data files upstream to a remote computer center for safekeeping.

Fiber is far better able to support upstream bandwidth than any other medium.

Q: Can't copper carry high bandwidth?

A: Copper can support high bandwidth for only a few hundred yards – the length of two or three football fields. The longer a signal travels on copper, the lower the bandwidth is. That's true for even the newest copper-based technologies. Vectored DSL allows 50 Mbps downstream for as far as 1,800 feet under ideal conditions, though it won't work on very old copper wiring, it limits upstream bandwidth and it requires expensive electronics. G.fast starts out with high bandwidth over very short distances, but older DSL technologies catch up within 1,000 feet. Under ideal conditions with vectoring (crosstalk cancellation between individual copper strands) and bonding (simultaneous use of more than one pair of copper wires), G.fast can provide 500 Mbps bandwidth in each direction up to 300 feet (and sometimes a bit more) from a fiber node – at least in the lab.

33%
Cellphone share of worldwide internet traffic, 2021

63%
All wireless devices share of worldwide internet traffic, 2021

G.fast has an important role: In multiple-dwelling-unit (MDU) buildings that have existing good copper wiring, G.fast can meet today's bandwidth needs, but it requires bringing fiber very close to customer premises and is still limited in comparison with true fiber to the home.

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) over fiber without degrading enough to keep it from being received. The international minimum standard is 20 kilometers (12 miles).

Q: What about wireless? I'm hearing about trials of gigabit LTE, and the emerging 5G systems will provide 3 Gbps or more.

A: That's the potential bandwidth shared by all users connected to an access point. 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. 5G wireless will perform better because it accesses more radio spectrum and because each tiny cell site will typically service only 10 households.

However, even 5G is not a substitute for fiber. All wireless broadband technologies depend on fiber to move information to and from cell sites. Even so, each antenna can support only a finite number of cellular signals. Cellular data traffic grew 4,000-fold from 2005 to 2015 and will grow another eightfold to 10-fold by 2020.

Cellular providers severely limit wireless data use, encouraging or forcing customers to use Wi-Fi connections instead of cellular networks for data. (Some

The Light Fantastic

All modern communications systems are based on fiber optic cable – hair-thin (or thinner) strands of glass that carry information by transmitting pulses of light, which are usually created by lasers. 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, whether that copper is in the form of wire or coaxial cable.

- **Fiber is great for rural areas.** Signals travel long distances inside fiber cable without degradation or need for refreshing – 40 miles or more in many real-world networks and 65 miles or more in some.
- **Fiber is easy to deploy.** Thin fibers can be packaged in a cable or 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 to walls with adhesive tape and painted over.
- **Fiber is permanent.** Once installed, fiber is upgraded by changing the electronics that create and receive the light pulses, not by replacing the cable itself.
- **Fiber is rugged and weatherproof.** Unlike copper, it does not corrode, is not easily affected by water and generates no heat. Lightning doesn't damage it. Nothing hurts it except a physical cut.
- **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. Even optical networks that require electronics in the field use far less power than copper networks do. Glass is easily made from sand, an abundant resource.
- **All-fiber networks are 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 a 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 an item 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!

INCHING TOWARD FTTH

Why doesn't everyone have FTTH? The reasons are historical – copper networks were built first. When last-mile copper is in good condition, network operators try to avoid replacing it. There are many, many ways they can improve its bandwidth and reliability until replacing all the old copper with new fiber is practical. However, these technologies are not as reliable as FTTH and generally do not offer as much bandwidth. So consumers should understand that what they are getting is not as good.

DSL. One strategy already mentioned is bringing fiber close to users – sometimes called FTTN, for fiber to the neighborhood or fiber to the node – and using some version of

wireless providers are experimenting with unlimited data plans, but they generally end up canceling heavy users.) Wi-Fi connections, in turn, work best when they can quickly offload data to a fiber network. A typical cellular data plan allows 3 to 5 gigabytes per month. Use your phone to view video, and you quickly run over the limit. Over a gigabit fiber line, 5 gigabytes would take just 40 to 50 seconds to download! So a typical phone's monthly data limit is 1 minute of peak usage on an FTTH connection.

Point-to-point wireless links, typically using millimeter-wave antennas to extend fiber networks, can provide high data rates. (There's a slight penalty in reliability, however.) This kind of wireless is *not* cellular. Each user gets much of the total bandwidth potential of the transmission link as long as the wireless link can be connected easily to fiber. Increasing the user density in a point-to-point wireless system makes the links shorter and thus more reliable. This is exactly the opposite of cellular, in which higher densities mean that more people must share each cell site. Once bandwidth needs require an upgrade to fiber, the wireless link can often remain in place as a backup.

Q: What makes fiber "future proof"?

A: The equipment used to send light signals over optical fiber keeps getting better. So equipping an existing fiber network with new software and 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 inexpensive compared with

DSL. In all versions of DSL, the light pulses from the fiber are converted into an electrical signal and sent via copper to the user. The bandwidth the user gets depends on the type of DSL used, the number of customers sharing the same copper line, and the distance between the user and the conversion point. Best results are obtained when that distance is 3,000 feet (.9 km) or less; beyond a mile, DSL service is extremely slow.

Fiber extended to the basement of an MDU building is called FTTB, for fiber to the basement (or building). If fiber comes to the curb or backyard of nearby homes, it may be called fiber to the curb or cabinet, or FTTC for short. It may also be called fiber to the distribution point, depending on the conversion technology used.

When fiber is within 300 to 500 feet (100 to less than 200 meters) of homes, the newest DSL technology, G.fast, can provide fiber-like speeds. The electronics can be expensive and tough to maintain, but G.fast saves the cost of replacing the last few feet of copper with fiber.

Cable. Most cable TV companies use hybrid fiber-coax (HFC) networks. In a typical HFC system, fiber runs to a neighborhood node (often called a DOCSIS node, for Data Over Cable Service Interface Specification). Coaxial cable from the node serves between 100 and 500 users. In recent years, cable companies have been splitting fiber nodes and pushing fiber deeper into networks to increase bandwidth.

Ethernet. MDU service providers often bring fiber as far as each floor of a high-rise building and then deliver fiber to individual units over an Ethernet LAN, using Cat 5E or Cat 6 copper cable. Ethernet LANs can also be used in single-family neightborhoods, but they rarely are. Ethernet LANs can extend about 300 feet and provide gigabit service.

Wireless. There are two ways wireless can combine with fiber. One, sometimes called hybrid fiber-wireless (HFW), attaches millimeter-wave wireless to a fiber node to exchange signals with user premises up to two miles away. HFW has been available for several years and is used to serve areas – often a few buildings – in a network that uses mainly fiber. In San Francisco, for instance, it is used to serve large apartment buildings and commercial spaces. In Boston, it is often used to serve clusters of small frame buildings with three to six dwelling units in each.

An emerging wireless technology that will partner with fiber is 5G cellular. The vision is that 5G micro-cells, perhaps 25 million in the United States alone, will supplement pure fiber connections that already exist and create new connections – especially in rural areas – where each micro-cell will serve five to 10 residences. 5G can use multiple radio bands from 600 MHz (similar to broadcast television) to 35GHz (in the millimeter-wave region of the radio spectrum). This should make 5G service reliable in bad weather and allow it to offer enough bandwidth and low latency (reaction time) to accommodate household needs and the needs of driverless vehicles. But all the micro-cells have to be connected to fiber strands to work well.

FTTH TECHNOLOGY DOES NOT STAND STILL

The first fiber deployed in volume to homes about 20 years ago used technologies called EPON and BPON and typically supplied 600 megabits per second to be shared by as many as 64 customers. Today, the norm in the United States is 2.4 Gbps shared by 8 or 16 customers.

The emerging technology, NG-PON2, offers up to 80 Gbps divided among multiple customers. It allows multiple carriers to seamlessly share the same network and allows the network to automatically reconfigure to meet customer demands. It can connect to 5G wireless small cells and G.fast fiber distribution points as well as to homes and businesses. Yet it runs on fiber that might be 20 years old or more, sometimes supplemented by copper that is even older. The Light Fantastic!

the original cost of laying the original fiber. At the customer end, a system can be designed so that customers 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 has been used for almost 40 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, Florida) was more than 30 years ago.

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

A: Don't be fooled! It is true that most cable, DSL and 4G wireless networks use some fiber. 5G fixed and mobile wireless networks will use an enormous amount of fiber because each small cell will need to be fiber-connected. However, this approach requires expensive, difficult-to-maintain electronics at the point where fiber meets copper or at the wireless antenna. 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-

Telehealth

Fiber has long been the technology of choice for in-hospital networks and for the consultations between local clinics and off-site specialists that improve the standard of health care outside major metropolitan areas.

In addition, telehealth is making its way into homes and offices. Reliable, high-speed internet connections, combined with secure video conferencing systems and networked health monitoring devices, allow patients to receive health care services from home or from the workplace. Today, Wi-Fi hotspots and expanding fast cellular service supplement fiber to bring emergency medicine to many more.

Until recently, regulatory and insurance restrictions limited the opportunities for home-based telehealth. But use is now expanding, in part because reliable fiber broadband is more available and in part because of new products aimed at the young and the well-off.

As of summer 2017, 35 states and the District of Columbia require private insurers to cover telehealth, although not always to the extent they cover in-person services. Medicare covers some costs in areas (especially rural) that don't have easy access to caregivers, and Medicaid coverage is available in 48 states plus the District of Columbia. At press time, the Medicare Telehealth Parity Act of 2017 and several other telehealth bills with bipartisan support were pending in Congress.

The Federal Communications Commission has $400 million in annual Healthcare Connect funding to subsidize broadband service for rural healthcare facilities. It also pays up to 65 percent of project facilities costs. The Rural Utilities Service has about $30 million available each year for telemedicine and educational facilities grants, but they cannot be used to cover local matches for Healthcare Connect. They are targeted to areas that already have broadband service, and they cover equipment and training.

TELEHEALTH IN ACTION

Following are some examples of how telehealth is being used:

- The Cleveland Clinic, a leading U.S. health care provider, operates a nationwide virtual urgent-care clinic called Express Care Online. A patient can call in from any smartphone, tablet or computer and have a secure video call with a clinician, with or without an appointment. In most patients' states, the clinician can provide a prescription if appropriate.
- Children's Mercy Hospital in Kansas City conducts 200 telemedicine evaluations a month – about 10 percent of its total. Doctors in 23 specialties can see patients via telemedicine, and Mercy's radiology and cardiology departments help diagnose and monitor children at smaller hospitals that could not justify the cost of hiring a specialist.
- Thomas Jefferson University and Health System in Philadelphia

based business, you'll need more. If multiple people in your household use the internet at the same time, 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: With cable, DSL and wireless, there's often a gap between advertised and actual bandwidth. Is that true for fiber?

A: No. Cable, DSL and wireless networks are often heavily oversubscribed – that is, providers promise users more than the total amount of available bandwidth because they know not all users are 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 subject to speed degradation when wiring condition is poor. 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.

Q: My cable company says it can deliver fiber all the way to my home. Is this possible?

A: Yes, using any of several methods, including a new technology called DOCSIS 3.1, which can work well with fiber. However, DOCSIS (whether 3.1 or earlier versions) limits upstream data bandwidth – and in some cases, downstream bandwidth, too – even if there is fiber all the way to the home. This is because their systems have generally been designed to carry video one way, down to a subscriber's home.

At the same time, some cable companies are beginning to install true fiber to the home, replacing DOCSIS with technology such as GPON, EPON or active Ethernet, that allows symmetrical gigabit services. It's confusing – and that's why consumers need to find out exactly what a cable company is offering. ❖

has invested more than $20 million in telehealth. Its virtual emergency room, JeffConnect, connects patients with doctors 24 hours a day to deliver care and consultation by video conferencing through phone, tablet or computer.

- The Centerstone Research Institute, a nationwide behavioral health provider headquartered in Nashville, runs a telehealth program, Coaction Health, for health care "superutilizers." Coaction Health provides broadband connections and intensive broadband-based monitoring for clients whose multiple physical and mental health problems make them very expensive to treat. Clinicians conduct daily assessments of each client, and sensors in clients' homes alert clinicians to the need for additional interventions (for example, if a client has not gotten out of bed). By reducing unnecessary hospital visits and by getting clients to the hospital in a timely fashion when they are in need of care, the program greatly reduces the costs of their care.
- University of Arkansas for Medical Sciences (UAMS) and the Arkansas Trauma Communications Center can examine an injured patient by video and direct treatment and follow-up for the injury at the nearest hospital. This saves medical evacuation flights that can cost upward of $30,000 each. UAMS also runs a telestroke program called AR SAVES, which offers life-saving consultations for stroke victims in 53 hospitals. As a result of the program, 33 percent of stroke victims in those hospitals now receive clot-busting drugs, compared with 1 percent earlier.
- NewCourtland, a senior services provider in Philadelphia, has operated its LIFE telehealth program, modeled on the Medicare/Medicaid Program of All-Inclusive Care for the Elderly (PACE) initiative, since 2007. PACE serves individuals age 55 or older who are certified to need nursing home care, are able to live safely in the community with supportive services 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-plus per day (usually more) in nursing home costs. By employing remote monitoring over broadband, NewCourtland's pilot project 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.
- 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. Fiber providers, whose networks rarely suffer outages, have a huge advantage in supporting programs like these.

The future of telehealth looks even better as active young adults get used to monitoring their waking and sleeping hours with sensors on smart watches tethered to home Wi-Fi. Large computing firms, most notably IBM with its Watson supercomputer technology, are rolling out services to monitor and interpret such data automatically for physicians who care for those with chronic medical problems. Apple and other marketers of "fitness" watches aim to do the same. ❖

Why We'll Always Need More Bandwidth

In a century of telephone communications, the bandwidth on voice channels changed very little. But for the past 25 years. internet bandwidth needs have grown exponentially. Cisco Systems estimates that global internet traffic in 2020 will be equivalent to 95 times the volume of the entire global internet in 2005.

As late as 1988, the national internet backbone was a single T1 trunk line – that is, 1.5 Mbps. In 1992, global internet networks carried approximately 100 gigabytes of traffic per day. Ten years later, in 2002, global Internet traffic amounted to 100 gigabytes per second. In 2015, global Internet traffic reached more than 20,000 gigabytes per second! By 2020, the gigabyte equivalent of all movies ever made will cross the global internet every 2 minutes. Monthly worldwide IP traffic will reach 25 gigabytes per capita by 2020, up from 10 gigabytes per capita in 2015.

Naysayers say the boom is about over because humans can only absorb so much video, and video is responsible for at least 60 percent of all internet traffic (either on the web, by direct streaming, or through file sharing). In fact, the boom has just gotten started.

Bandwidth needed for self-driving vehicles to communicate among themselves will be greater than the bandwidth needed for video – a gigabit per second for each of the 20 million vehicles on U.S. roads at any one time. That number doubles during rush hours, so the peak could be three times higher than today's residential demand peak – and residential demand will continue to grow too, thanks to the internet of things, more viewing devices and so forth.

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 decade, internet video evolved from a novelty to the standard way of accessing news, information and entertainment. New internet-connected devices emerged – always-on smartphones and tablets that keep us connected with the world full-time, smart TVs (and TV-connected devices such as Fire TV Sticks and Chromecasts), home security devices and thermostats that broadcast alerts and video images to our phones, smart watches and fitness trackers that save our workout information in the cloud. Phones and computers magically respond to voice commands, aided by internet connections to supercomputers.

About 1 billion people now have access to the cloud. Consumers and businesses store data, run programs and access computing power in the cloud. Most new computers, tablets and smartphones come with free cloud storage – the default storage location setting for Microsoft Office is now in the cloud. Most users no longer know or care exactly where their files are located or their programs are running. All they need is fast, reliable internet access.

Families stay in touch via social media and video calls – Facebook,

The bandwidth demand from connected cars will exceed the demand for internet video.

The Networked Future

Innovation will continue, bandwidth needs will keep growing – and 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 new applications emerging today:

- Virtual reality and ultra-high-definition video with four times the pixels of conventional HD. (With the new home video cameras that can shoot in 4K format, the demand among video enthusiasts is becoming as great for upstream bandwidth as for downstream.)
- Videos and games created in virtual-reality formats, including 3D virtual reality
- Self-driving vehicles
- Smart utiity grids and other internet-of-things applications
- Seamless audio control and voice recognition capability for all digital devices – the devices get their smarts from remote computing centers.
- 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 in which students not only watch their professors but also participate in real-time, video-based discussions.

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, virtual doctor visits save trips to the doctor's office or emergency room if people don't need to be seen in person. A **Broadband Communities** editor recently participated in a video conference between a relative, her in-home physical therapist and cardiologists at two different hospitals. The therapist used a mobile app to live stream the physical therapy session.

Taking classes from home or dormitory has become routine for many. MOOCs, 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 26 million users enrolled in 2,500-plus courses from 29 countries and 160 institutions – and Coursera accounts for considerably less than half of such online activity.

Millions of devices have begun communicating on the internet without user intervention. Both home appliances and industrial equipment, for example, can send maintenance alerts when they are not working properly.

Telecommuting and home-based businesses are on the rise. A quarter of 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.

1 second

A million minutes of video will stream on the internet each second in 2021

196 FIBER STRANDS

each thinner than a human hair, in a bundle not much thicker than a pencil, can carry all the world's internet traffic.

Gigabit (And More) To the Home

According to a recent study by Viavi, 57.5 million U.S. consumers have access to gigabit internet service today – not including millions more with access to Verizon's Fios Gigabit Connection, which is just slightly slower than a gigabit. A gigabit (1 Gbps, or 1,000 Mbps) is about 100 times higher than the average downstream internet speed in the United States and many times higher than the average upstream speed.

In recent years, hardly a week has gone by without the announcement of another gigabit deployment. However, not all gigabits are created equal. Many of the gigabit connections offered are non-symmetrical – their upstream speeds are often quite low. Asymmetrical speeds are offered mainly over cable networks.

In other cases, gigabit tiers are offered at prices that would discourage anyone but home-based IT consultants from subscribing. Only fiber to the home (or fiber to the building or floor with excellent inside wiring) consistently supports symmetrical gigabit speeds to multiple users.

GIGABIT FIBER OFFERINGS

Google Fiber made "gigabit" a household word – the term is now more widely recognized than "fiber to the home" – but was hardly the first to offer these speeds. Among residential providers, EPB Fiber Optics (the municipally owned network in Chattanooga, Tennessee) was the first to offer 1 Gbps access throughout a large service area.

Other network operators, both public and private, quickly followed suit. By the end of 2016, large companies such as AT&T, CenturyLink and Cox had begun offering gigabit FTTH service in selected locations, and Comcast offers 2 Gbps FTTH service in some locations. Independent telcos, municipalities, electric co-ops and competitive providers also joined the gigabit club.

The first residential 10 Gbps deployment was announced in late 2014 by US Internet, an ISP in Minnesota. Several others soon followed, including Rocket Fiber, a new ISP that is revitalizing Detroit. Residential 10 Gbps service is still well beyond the affordable range, but some customers have already adopted it for home-based business use.

Providers find that offering gigabit service enhances their reputations as technology leaders without adding significantly to their backhaul costs.

WHAT WILL YOU DO WITH A GIG (OR 10 GIG)?

The number of gigabit subscribers is still small but is steadily growing. A survey by Telecom Thinktank and RVA LLC found (not surprisingly) that gigabit subscribers are heavy internet users. They are online an average of 8 hours per day, compared with the overall average of 2.5 hours, and they have many networked devices. Many are content creators, and others are work-at-home professionals who need low latency and rapid file transfers.

Broadband Communities' interviews with gigabit users suggest that gigabit speeds are especially useful for telecommuters who need to work without interruption while other household members watch videos or engage in other recreational uses.

GIGABIT APPLICATIONS

Soon, gigabit speeds will enable entirely new applications. US Ignite, a nonprofit coalition of industry, academic and government partners, is promoting the development of new applications in health care, education, workforce development, energy, advanced manufacturing and public safety, and many of these – such as applications for managing smart cities and smart electric grids – have reached the stage of commercialization. Because US Ignite applications rely on fast internet speeds and low latency (instant response times), they are being tested in gigabit cities throughout the United States.

Cities across the United States are holding "hackathons" – events in which software developers collaborate intensively over a weekend or several days – to encourage the development of high-bandwidth applications. In just a few years, gigabit applications may revolutionize the delivery of government services, health services, education and more. ❖

2X

Growth in peak-hour internet traffic vs. growth in total traffic

Aha! CUSTOMIZED Courses at Your Site

On Fiber-to-the-Home Financing and Operations

Education is our mission at Broadband Communities, and now we are offering a new way to carry it out – a service focused on fiber-to-the-home. Our editors and experts will visit your community or organization to help you learn about …

INNOVATIVE PATHWAYS toward paying for the network you need.

NEW OPPORTUNITIES for public-private partnerships.

NEW WAYS to phase and bootstrap a project with current cash flow … sweat equity … and savings on a municipality's existing communications costs.

VENDOR FINANCING that is often available in the form of delayed payments … just-in-time inventories … and equipment leasing.

Courses can include use of any or all of our unique tools:

- MSO, ILEC or Muni Financial Calculator
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- Rural Calculator
- Monthly Revenue Calculator
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Our sessions will give you such important information as:

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Let us come to your site for daylong or two-day intensive lessons.

We'll start with whatever tools you need, and teach you how to use them. We'll also talk about what has worked, what hasn't, and where projects similar to yours have succeeded or gone bad. Our classes include custom exercises drawn from your situation, to give you hands-on experience in both the spreadsheet math and the thought processes involved. You'll get beyond some old misleading rules of thumb and gain a solid understanding of how FTTH is different.

HOW IT WORKS.

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WHO CAN BENEFIT?

Everyone interested in or already building a broadband network.

THE NEED.

Our custom courses are a convenient, low-cost way to bring people up to speed on the latest technologies, what they cost, and what they can provide.

Take the first step toward your community's fiber future … BBC experts can customize a program that will meet your needs. And it's surprisingly affordable – as little as $2000 plus expenses.

Barbara DeGarmo, CEO
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Vital For Education

Can communities afford not to assure high-capacity broadband for their students? U.S. communities and private schools spend $700 billion a year educating 55 million K–12 students. Yet these students rank 35th in math, 23rd in reading, 27th in science and 16th in technological readiness compared with students in other developed nations.

High-speed broadband is one key to closing the gap – and to getting a better return on taxpayer investment. Today's best-connected schools demonstrate how broadband enhances students' educational opportunities. Though nearly all schools now have internet access, and 97 percent are connected to fiber, not all schools have access to sufficient bandwidth. According to EducationSuperHighway, a nonprofit dedicated to helping schools close the digital divide, more than 6.5 million U.S. students still do not have the basic level of connectivity necessary for online testing and learning, and millions more have only the bare minimum.

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.

Students in these districts access media-rich digital learning materials, in which texts are supplemented by audio, video, interactive exercises, educational games and, increasingly, augmented and virtual reality. Such immersive lessons engage students and accommodate many different learning styles.

One big issue that is taking longer to solve: ensuring that all students have access to broadband after they leave the school building. Fortunately, marketing surveys show that families with K–12 children are more likely than any other demographic to buy broadband services. Still, not all homes have broadband available, and not all parents can afford broadband connections. Census data shows there are still 5 million households with school-age children who are not effectively connected to the internet.

Here are a few of the many districts that have solved this problem.

NORTH GEORGIA NETWORK

North Georgia Network (NGN), a cooperative regional fiber provider, supplies dedicated gigabit internet connectivity to area schools. High schoolers connect to labs, teachers and courses that are available in other districts but not in theirs. Preschoolers at the Little School in Clarkesville, Georgia, recently watched a puppet show staged 80 miles away – too far for a field trip – as it was streamed into their classroom. When it was over, they participated in a live Q&A with the puppeteer.

OWSLEY COUNTY, KENTUCKY

For the Owsley County School District in depressed eastern Kentucky, the mission is "to create an innovative learning environment that breaks down all barriers to student learning and prepares all students for college, career and the 21st-century world."

It's a big goal for one of the poorest counties in the nation: Median family income is about $20,000 in the small rural school district, Four of every 10 adults lack high school diplomas, and nearly 90 percent of the 740 students qualify for free or reduced-price meals.

But Owsley is rich in broadband. Almost all students have gigabit fiber internet access, both at school and at home, thanks to People's Rural Telephone Cooperative (PRTC), the district's local telephone company. PRTC has donated service in some cases, and the district tries to help students with surplus equipment if they don't have home computers. Students take courses online that are not available locally, and sophomores, juniors and seniors are offered dual-credit courses at several local colleges.

In May 2014, Owsley High graduated its first student receiving both a high school diploma and an associate of arts degree. One of Owsley's most innovative ideas is virtual snow days. Each winter, students missed nearly a month of school when snow and ice made traveling to school too dangerous. Now, kids log in to Blackboard Learn, the district's learning management system, and tackle the day's work from home. Blackboard allows teachers to upload lessons and supplemental materials for students to access anywhere electronically. "Instead of just learning from the book, it gives you a lot of additional material," said one Owsley High student, who says she accesses the site frequently to supplement her Spanish classwork.

Thanks to programs such as MasteryConnect, which monitors student performance and spots remediation needs, teachers can deliver individualized lessons. Both teachers and administrators monitor the coursework to ensure that the virtual day parallels the learning that would have taken place on a regular instruction day. Owsley's teachers don't get snow days off, either. "I send [students] Facebook messages, email them, text and call," reports one math teacher. Notices and requirements for each snow day also go out on Twitter and Infinite Campus Messenger. Students can message back.

Equipment provided with a county health department grant connects the school nurse with a local health care provider, who can virtually examine a patient and then call in a prescription or refer the child to a specialist. Staff

members have access to the service as well.

The district keeps finding new ways to take advantage of the community's robust fiber infrastructure. Two of its school buses are now equipped with Wi-Fi.

COACHELLA VALLEY UNIFIED SCHOOL DISTRICT

California's sprawling Coachella Valley Unified School district also uses the bus Wi-Fi trick, but on a grander scale. The district covers more land area than Rhode Island and – although only 30 minutes from wealthy Palm Springs – is the second-poorest in the nation. Many students live in trailer parks. Some live in abandoned rail cars. To bring its 20,000 students the advantages of broadband, Superintendent Darryl Adams relies on 100 school buses and a program called Wi-Fi on Wheels.

The money comes from the community, which voted in 2012 for Measure X, a $45 million school bond to fund the Mobile Learning Initiative over 10 years. Every student got an iPad, and every bus is equipped with Wi-Fi so students can work during daily commutes of up to two hours.

After school, some buses park near underserved students' homes all across the district. Solar panels on the bus roofs charge batteries that keep powerful Wi-Fi routers running all night to provide broadband. Israel Oliveros, who provides the technical support for the district, explains, "We run power through [an existing] conduit … through the front of the bus" to the router. Antennas provide broadband over a 150-foot radius.

FORSYTH COUNTY, GEORGIA

Since 2012, the Forsyth County school district just outside Atlanta has used a business Ethernet connection from Comcast to support streaming video, interactive whiteboards, mobile devices and digital content for 40,000 K–12 students in 35 schools. The system provides learning plans based on individual student needs, preferences and performance. It 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 lets students use their personal 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 costs and creating new learning environments. 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.

The Social Media for Older Adults class at New York City's Queensbridge public housing runs two days a week for 10 weeks, covering such topics as Facebook, Twitter, LinkedIn, Instagram and Kickstarter. It is taught by Older Adults Technology Services (OATS), a nonprofit that receives funding from city agencies, private foundations, corporations and individual donors. (Tom Kamber, executive director of OATS, is shown at right.)

As might be expected, almost all students said they wanted to keep in touch with their families on social media. But many were emphatic in their desire to make their community better by setting up local organizations to help the homeless, teenagers, addicts and others.

Good ideas came thick and fast. One was for a better online community newsletter. Several involved leveraging local church congregations to gather clothing and appliances for homeless residents moving into apartments of their own or amplifying the ability of city agencies and telehealth to help the neighborhood's infirm.

The heavily used classroom complex, in the basement of the Jacob A. Riis Neighborhood Settlement, was filling with children as the public-school day ended and the seniors finished their class. Almost every child carried a tablet, laptop or smartphone.

Smart Cities, Smart Farms

Fiber networks benefit all types of communities. In particular, the emerging "internet of things" offers applications that transform both cities and rural areas. Internet of things applications collect vast quantities of real-time data from sensors or other devices, transmit it to centralized computers for analysis and sometimes take action based on the results. Sensors are often connected wirelessly, especially if they are attached to movable objects – but real-time collection and upload of large data sets depends on dense, reliable fiber networks.

In cities, fiber connections are revolutionizing the delivery of services. One common application is IP cameras for protection of lives and property. Security cameras are used both by local governments and property owners. For example, the Newark (New Jersey) Housing Authority greatly increased the safety of its public housing when it installed a high-performance, fiber-based physical security solution. The high quality of the camera images, which enabled the housing authority to aid in prosecuting crimes, was made possible by having enough bandwidth to transport and store the camera footage. Using a fiber network, the Housing Authority also linked its emergency operations center to the Police Department and the Office of Emergency Management, allowing all three entities to share camera footage and databases.

In the Belgian city of Antwerp – one of the first cities in Europe to invest in fiber infrastructure – the Antwerp City of Things includes tens of thousands of sensors and connected devices built on the city's underlying broadband infrastructure. In one project, cars from the Belgian postal office were equipped with sensors to measure the city's air quality in real time. In another experiment, sensors were installed to measure traffic on two routes.

Other smart-city projects that many cities are pursuing include street lights that adapt to movement by pedestrians, cyclists and cars; trash cans that alert sanitation workers when they need to be emptied, and parking lots that tell drivers which spaces are open. All these applications depend on having fiber available throughout a city.

Newark's fiber-enabled emergency operations center keeps the city functioning in an emergency.

RURAL APPLICATIONS

The internet of things is equally important in remote areas. Energy companies monitor wind turbines, check the status of oil wells and tanks and monitor power generation equipment. Farmers use fiber-enabled solutions to prevent expensive equipment and livestock from leaving their properties. By placing sensors on grain bins, they can receive alerts if any grain is missing. Sensors in barns or chicken coops monitor temperature and humidity and close curtains or turn on fans and water pumps if animals are likely to be in distress.

Most important, broadband allows farmers to practice "precision agriculture." Sensors in the field or on tractors measure soil conditions, enabling farmers to apply exactly the right amounts of fertilizer, water and other inputs to each square foot of farmland. This reduces costs and avoids harmful pollution and runoff. ❖

Broadband, Property Values And Economic Growth

Recent studies continue to show that access to high-quality broadband boosts property values and contributes to economic vitality.

2014

Fiber to the Home Council Americas (now Fiber Broadband Association) released a study finding higher per capita GDP in U.S. metropolitan areas in which gigabit internet is widely available. Infrastructure investment, job creation, entrepreneurship, productivity gains and companies relocating to or expanding in gigabit cities are all elements of this growth.

Broadband Communities' examination of all 3,144 U.S. counties showed a clear relationship between access to robust broadband and population gain or loss.

2015

FTTH Council Americas found that access to fiber increases a home's value by up to 3.1 percent. Using the National Broadband Map and a nationwide sample of real estate prices from 2011 to 2013, the study's authors investigated the relationship between fiber-delivered internet services and housing prices.

The boost to the value of a typical home – $5,437 – is roughly equivalent to that added by a fireplace, half a bathroom or a quarter of a swimming pool. For homes that had access to gigabit-per-second broadband, transaction prices were more than 7 percent higher than comparable homes that had access only to 25 Mbps or lower speeds.

Broadband Communities showed that the 20 states that restrict municipal broadband have lost rural population at a faster rate than other states, even though overall population growth in those states is higher. The study concludes that lack of broadband access is responsible for at least a quarter and probably half of all rural job loss.

2016

Michael Render of RVA LLC surveyed MDU residents in the United States and Canada to find out what they would pay for access to ultra-high-speed, reliable broadband. Respondents were asked what discount they would require on a $300,000 condominium purchase or on $1,000 per month rental apartment to live where they would not have access to fiber. Render determined buyers would need an average discount of $8,628, and renters would require an $80 discount per month.

Render also found that fiber access increases residents' satisfaction with their homes and appears to reduce churn, helping building owners and operators maintain high levels of occupancy and provide a quality living environment. There is evidence that residents in MDUs with better broadband also spread the word, reducing customer acquisition costs for these MDU properties. Using base financial data from the National Apartment Association, Render estimated that fiber can add 11 percent to net income for MDU owners and operators per average apartment unit.

Broadband Communities showed that the relationship between job loss and lack of broadband access holds for all types of counties except counties where the primary economic activity is mineral extraction. Those counties lose and gain jobs based primarily on international demand and prices for the commodity extracted. (In the future, however, broadband access may help some mining counties transition to a new economic base.)

2017

RVA showed that, although residents rank good broadband as the top amenity they desire in a new dwelling, building owners and property managers (who tend to be older) rank it lower. ❖

Because there are so many home-based workers, installing a fiber connection can add the same value to a home as a quarter of a swimming pool.

FTTH for Communities

By the end of 2017, the number of public and public-private fiber networks in the U.S. reached about 220 – and many of these serve multiple communities. Many communities are expanding the networks they started building in earlier years and are upgrading them to offer gigabit-speed service. However, the bulk of FTTH communities are served by private carriers, so municipal efforts often focus on attracting private investment rather than on building municipally owned networks.

Questions Municipal Officials Ask About FTTH

Q: How will a fiber network help our local economy?

A: 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 more attractive – especially for young people – which can stem the population loss that many small communities experience. If inadequate health care resources hamper growth, fiber connections permit local health care providers to call upon specialists in regional centers. And if an unprepared workforce is a hindrance to 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.

Q: How can I get fiber to my residents without building my own network?

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, help with marketing or an accelerated permitting process. Consider using tax increment financing or helping providers apply for grants.

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 propose fiber swaps to a potential provider. Take a fiber inventory to find out whether abandoned or unused fiber in your town might 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 online 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. A variety of arrangements between the public and private parties are possible, depending on legal requirements and on each party's assets and capabilities.

Complete the Google Fiber city checklist (goo.gl/RYX3hu) to provide information about existing infrastructure, help ensure access to existing infrastructure and help make construction speedy and predictable. Then use that information to issue a request for information, a request for proposals or another formal document that outlines your community's goals for expanding broadband access and invites service providers to propose how they might meet those goals.

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 dig up streets and sidewalks.

If a cable network is being upgraded to fiber, in some cases the old coaxial core can be ejected from the cable and replaced by fiber without any digging.

When there is no good, cost-effective alternative to trenching, microtrenching techniques allow fiber to be laid with less disruption to traffic. In microtrenching, a

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

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 public or private network builders "rent" bandwidth to a potentially unlimited number of service and content providers, offer an alternative for municipalities that are restricted from selling retail services or simply do not want to be in that business.

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 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.

Municipal Options: Pros and Cons

What's the right path for a municipality that wants better broadband for its residents and businesses? Here are the basic choices:

1. The private option

Large national carriers cannot regularly monitor the needs and business opportunities in every community they serve. So tell your existing carrier about its shortcomings and your needs. Be ready to offer incentives. Appeals to incumbent carriers may carry more weight if you are in one of the 30 states that do not limit municipal networks, and you can threaten to create a competitive network.

Pro: Giving up a small amount of revenue to modernize a communications infrastructure can be a great deal. This approach sometimes succeeds, as it did in Fort Wayne, Indiana.

Con: National carriers will take a long time to respond and may threaten a lawsuit if you try to compete. You have no control.

2. The public option

Investigate building a municipal network alone or in partnership with nearby communities. Expect to spend $3,000 to $7,000 per customer to build the network and $75,000 or more for a consultant to create a business plan that attracts capital and other funding. Unless you have in-house expertise, expect to contract out the network monitoring, maintenance and emergency repair work. Educate yourself by using the community toolkits and "deep dives" put together by the Fiber Broadband Association, **Broadband Communities** and others (see "Digging Deeper"). Lining up anchor tenants such as developers, hospitals and public facilities (schools, public safety, libraries and so forth) is a must.

Pro: Independence. An existing municipal utility, usually a public power company, knows the customers, has a management team in place, typically owns the utility poles and may have other assets that can be borrowed against. That lowers financing costs – not only because the assets can be pledged but because lenders see less management risk.

Con: Very few municipalities, even if they have municipal electric utilities, have the expertise, political will and resources to create a public broadband network. Of the 15,000 communities in the United States big enough to have their own school systems, and 40,000 inhabited places overall, only about 250 are served by public fiber broadband systems.

3. The public-private partnership option

Public-private partnerships are the most popular approach at this time. Often, the private company is a small incumbent telephone carrier (ILEC) already serving the area. Some potential partners are CLECs – competitive local exchange carriers. Many CLECs are set up by developers of housing or commercial office space. Many are actually owned by ILECs that go hunting for business outside their regular customer footprints. Still other potential partners are neither ILECs nor CLECs. Different regulations apply to each type of company.

In a partnership, each partner brings something to the table in exchange for partial ownership of the resulting entity. A small community phone company, for instance, might offer its existing customer base, management team, central office and more. The community might offer access to financing through lower-interest bonds or government grants, or access to municipal or school land.

Pro: Partnering cuts the risk substantially. It also tends to lower the cost of capital – less is needed, and interest rates are lower. Two entities – a community and a small carrier – can do something each alone could not.

Con: Public and private entities tend to have different goals. Most important for municipalities to remember is that private companies can be bought, sold and merged. Thus, a very careful "prenuptial agreement" must be worked out to cover what might happen if such events loom.

4. The electric co-op option

If your community is served by an electric co-op, encourage it to build a broadband network. There are more than 900 electric cooperatives in the United States. About 50 have built (or are building) fiber broadband systems that serve residential or commercial customers, and many others are making plans to do so.

Electric co-ops have to establish smart grids to manage their delivery of electricity. Smart grids and expanded telecommunications services can be combined on the same network, making the business case stronger for both. Smart grids can handle metering and complex time-of-day pricing and demand management tasks. They also make an electric system more resilient. That is, the grid will fail less often and recover faster because

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

so much of it is automated. That's the "smart" part. But modern electric grids often accommodate distribution of highly variable solar and wind power, making them less stable without "smart" automation.

Pro: Electric co-ops know their customers, own assets that can be mortgaged, usually have maintenance and repair staffs in place, and own their utility poles or have access to poles they don't own.

Con: Some states ban electric co-ops from offering telecommunications services. Electric co-ops (and their lenders) tend to be more risk-averse than telecom companies because their technology changes more slowly and because they don't operate in competitive markets.

5. Other options

Communities have become creative in devising new ways to get broadband built. Huntsville, Alabama, leased its fiber to a national carrier, Google Fiber, to run a fiber-to-the-home system there. Given the size and complexity of the network, this was considered preferable to simply hiring Google or a local carrier to manage the system.

Some cities have encouraged local companies (broadband users, rather than broadband providers) to establish their own connections and sell services to other businesses nearby. Real estate developers, particularly developers of near-campus dormitories, are displaying interest in expanding their customer bases into surrounding neighborhoods. ❖

Is FTTH Too Expensive?

You may hear people make statements such as, "Of course fiber to the home is the best technology, but it's too expensive." Usually, FTTH is *not* more expensive than other technologies. But it's a complicated subject.

Three kinds of costs should be taken into consideration: the cost of constructing a system, the total lifetime cost of the system, and the opportunity cost.

Construction costs for FTTH per customer vary depending on the terrain, the availability of utility poles, the population density per road mile and other factors. But if no other network is in place, building costs are comparable for every type of wired network – fiber, copper, coax. That shouldn't be surprising because labor – which doesn't vary much for different types of networks – accounts for most of the cost of building a network.

So in a new housing subdivision or a new multifamily community, FTTH is not expensive. It costs roughly the same as putting in a copper or coaxial network.

The equation is different in an existing neighborhood or MDU, which usually has a telephone and/or cable network in place. If the existing copper infrastructure is in top condition, rebuilding it with fiber is more expensive than keeping it. But if the copper infrastructure is in poor condition, replacing it with fiber may be the less expensive option.

The equation changes yet again when fiber can serve multiple purposes. An electric or water utility that builds fiber to manage its grid can extend that fiber to serve homes with broadband for a relatively low cost. (If the fiber for the smart grid extends all the way to meters, there is almost no extra cost to use the fiber for broadband.) Similarly, a multifamily property owner that builds a fiber network to manage a "smart building" can use that fiber for broadband at a low cost.

The newest FTTH technology, NG-PON2, offers tremendous synergies. Because of its extremely high bandwidth, use of multiple wavelengths and potential for software-defined networking, it facilitates using the same fiber for multiple purposes, including residential broadband, business broadband, cellular connections and the internet of things. Verizon is experimenting in Boston with building a network that will support both 5G cellular service (which requires fiber very close to homes) and Fios residential broadband services. This reduces the construction cost per customer for fiber to the home.

Total lifetime costs include not just construction but also maintenance, operations and depreciation. In capital projects of all kinds, deployers attempt to consider total lifetime costs. Taking post-construction costs into account gives fiber infrastructure a great advantage over copper and wireless because it has a longer lifetime and much lower maintenance and operations costs. It requires less power and fewer repairs, and it depreciates more slowly.

Opportunity costs are benefits foregone by *not* doing something. Here again, fiber is a clear winner. By building a fiber network, a community can reduce its telecom spending (both public and private), take advantage of new smart-city applications and support economic growth. Thus, *not* building a fiber network incurs the opportunity cost of those foregone benefits. ❖

Community Success Stories

Communities without robust broadband pay a price – they lose their jobs and residents. The **Broadband Communities** continuing study of population trends shows that a quarter of all rural job loss since 2010, and maybe as much as half, is due to lack of broadband access. In states where communities can't even threaten to build their own networks, counties with poor broadband lose population four times as fast as in states that do allow muni broadband.

But investing in great broadband doesn't inevitably lead to economic success – it's only the first step. 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 fiber 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. The bad news: Most planners have never studied bandwidth issues, and few know how important broadband is to fulfilling a master plan.

Following are a few of the many FTTH success stories **Broadband Communities** has reported on.

RENVILLE AND SIBLEY COUNTIES, MINNESOTA

These two underserved rural counties, and the small towns within them, collaborated to develop a publicly owned fiber network. Despite overwhelming local enthusiasm for the project, the town and county governments did not reach agreement on a financing plan. Ultimately, instead of building a municipal network, residents formed a cooperative – the first cooperative anywhere in the United States formed specifically to build a broadband network – and RS Fiber was born. Bonds issued by the towns and townships are helping finance the network, which has also tapped into bank financing, state grants and other sources of funds.

RS Fiber hired Hiawatha Broadband Communications, a local competitive provider, to build and operate the network and provide services. Ultimately, all premises, including farms, will be served by fiber, but because the fiber build is starting in the towns, the outlying areas are temporarily served by wireless broadband. Farmers already use the wireless service to monitor their crops and livestock.

While the project was underway, a medical school announced plans to open in the town of Gaylord. Easy access to Minneapolis and St. Paul and the rural location were selling points, but broadband was a necessity. The medical school, which is expected to have an enrollment of 600, will add hundreds of professional and support service jobs in Gaylord and surrounding communities.

The town of Winthrop has started to promote itself on social media, boosting tourism and recruiting new residents. People are beginning to move to the areas where fiber is available; homes for sale are being snapped up before they are even formally listed.

Winthrop News, the local newspaper, has a new lease on life. Not only does it now have trouble-free connectivity to the printer, but it is reaching out to new, younger readers through a Facebook page. Soon it will be able to add a digital edition and live video.

SANDY, OREGON

Sandy, a town of 10,000 in the forests 25 miles east of Portland, built its own gigabit fiber network. In 2001, when the local telephone company couldn't provide a DSL connection to city hall, city officials began to worry about broadband availability for local businesses and residents. Sandy formed its own utility to provide DSL over the phone company's infrastructure

20X
Growth in virtual reality traffic by 2021

2 MILLION
Robotic surgeries could be performed each year in the U.S. with reliable broadband.

before investing in a wireless system that would ultimately stretch across and beyond city limits.

After concluding in 2008 that the wireless network was unreliable and could not provide the high-capacity connections that were already becoming necessary, city leaders decided to provide broadband to businesses via municipal fiber. By 2012, most of the larger companies in the downtown area had connected to the network, which sold 100 Mbps service.

In 2010, city officials held a "Why Wait for Google?" contest that invited residents to demonstrate demand for fiber to their homes. The city intended to build an FTTH pilot project in the neighborhood that had the highest response rate. But the contest demonstrated strong demand everywhere. After comparing the cost of the pilot project with the level of demand, the city decided to build fiber everywhere. SandyNet calculated that the network would need a 35 percent take rate to pay off the bond. Even before finishing the network, SandyNet achieved a take rate of 60 percent.

The network enabled the city to replace its aging phone systems with VoIP and gave police the ability to use high-speed connections to deliver grand jury testimony. Having reliable, affordable, high-speed internet gives people greater opportunities to work from home. That improved the real estate market.

Sandy used an urban renewal district (often called a tax increment financing, or TIF, district) to add a business fiber loop to the almost completed network. Businesses taking advantage of the expansion do not have to pay a connection fee.

TULLAHOMA, TENNESSEE

Tullahoma, with a population of about 19,000 (9,200 households and more than 1,000 businesses), has one of the older, established municipal fiber systems. But the city isn't resting on its laurels; in 2012, it became the smallest U.S. gigabit city (since that time, even smaller cities have gone gigabit), and it continues to earn high marks for service quality, reliability and customer support. It became cash-flow positive in 2013 and expanded to nearby communities.

LightTUBe Installer Robert Overman assists in a residential installation.

Residential internet offerings range from 30 Mbps/5 Mbps to 1 Gbps symmetrical, with 140 channels of video available. To differentiate its service even further, TUB created two local TV channels, which broadcast local news, high school sports, school plays and community events.

In addition to selling triple-play services to residents and businesses, TUB is its own best customer: It uses the fiber network for several smart-grid applications including time-of-day pricing. Its automated metering infrastructure (AMI) system reads electric and water meters and uses the fiber backbone to backhaul information from the wireless collectors.

Other smart-grid applications include automatic reconfiguration of circuits to minimize the effects of outages and supervisory control and data acquisition (SCADA) to monitor and control the water and wastewater infrastructure.

Like many municipal broadband networks, LightTUBe contributes to the city's economic vitality. Tullahoma is trying to attract technology, health and retail businesses. The fiber network helped attract a new call center and enabled existing businesses to expand. It also attracted new residents who need to be able to work from home.

As of 2016, about 100 residential customers subscribed to the gigabit service tier at $90 a month. Even if the market for gigabit service is small, the fact that TUB can offer the service is a matter of civic pride, and TUB has generated excitement about it through ads, billboards and community sponsorships. ❖

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 MDU owners are retrofitting older properties as well. As early as 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.

For a new multifamily community, a fiber network is almost certainly the most cost-effective option. It also takes up less space than copper or coax – equipment rooms are smaller, and fewer of them are needed. Risers are smaller, too. Finally, fiber uses less electric power than copper.

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

A: Fiber does need to be engineered in large apartment complexes – but that's true for coax, too, as well as for managed Wi-Fi.

Smaller buildings do not need sophisticated engineering. 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 and common.

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 PVC 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 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. Unlike electrical cables, some fiber can be stripped of its outer sheath with a simple hand tool and used inside or out without a splice.

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 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, thermostats, security sensors, fire and smoke monitors and, of course, computers. As the "internet of things" develops, even more appliances will be internet-enabled. Many manufacturers already provide such connectivity.

The newest generation of FTTH gateways can handle close to 4 Gbps wireless throughput, and some FTTH deployers now use Wi-Fi connections for all devices except whole-home DVRs. Creating a wireless home network requires careful placement and tuning of equipment, but it is generally much simpler and less expensive than rewiring homes, which was standard practice until very recently.

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 or at least in garages. Outdoor ONT models are sometimes placed in unheated 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 unless they are combined with a wireless gateway.

Q: Why do ONTs sometimes require backup batteries?

A: Optical fiber cannot conduct electricity. Thus, keeping a network connection running during a power outage requires a battery at the user premises or a fiber cable that includes a thin copper conductor connected to an off-site battery. Many standard designs are available for in-wall, between-stud boxes that hold the battery, ONT and fiber connections. As cellphone use has grown – in 2017, fewer than 7 percent of U.S. households do not have cellphones

Other Options for MDUs

A brownfield building with existing good copper can be modified to deliver excellent service for today's needs.

Fiber can be brought to the basement or to a pedestal on the development's grounds. From there, variants of DSL such as VDSL2 can bring good broadband service 500 feet away, or more. Variants of G.fast can bring fiber-like speeds 300 to 500 feet away, in systems that are beginning to be deployed now.

Cable coax can carry increased bandwidth by conversion to DOCSIS 3.1 – a task handled at the local DOCSIS node, which is often split so that each node serves 50 to 100 customers rather than the old limit of 500 customers. The DOCSIS node is served by fiber and can be converted to an all-optical or G.fast network as well.

Gigabit connections can be provided via Ethernet from fiber terminals in the basement or in a utility closet on each floor. The distance limit for most Ethernet cable is about 300 feet.

Providing wireless service for cell phones and for communitywide Wi-Fi that users can take outside their units and onto elevators or into garages may need specialized engineering. However, the task is often easier in older buildings, whose materials are not as impervious to signals using cellphone wavelengths. One shortcut offered by most telephone companies: Users' individual Wi-Fi systems can be configured to handle cellphone communications, and cellphones can roam on different Wi-Fi hotspots.

Owners that retrofit older buildings with non-FTTH solutions should keep in mind that they will need to continue upgrading their infrastructure to meet growing bandwidth demand. In many cases, short-term savings may be dwarfed by the higher costs of operating, maintaining and upgrading non-fiber infrastructure. Fiber to the unit is the only future-proof solution.

– the need for batteries to keep voice communication working has become less urgent. In areas that have poor cell service, however, you should consider using backup batteries for ONTs.

Q: In a multiunit building, 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 many ONTs can deliver 1 Gbps or more – often enough bandwidth to share among multiple customers. In fact, 10 Gbps ONTs are becoming common.

Q: Is lightning a problem with fiber?

A: No. Because fiber does not conduct electricity, lightning strikes do not directly affect fiber at all. Fiber does not have to be grounded.

Q: Is FTTH a sustainable technology?

A: Glass is made from sand – an inexhaustible resource that uses far less energy and creates far less pollution to manufacture than does extraction of copper from its ore. FTTH generally consumes less power than other broadband technologies. Passive optical networks (variants of 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. ❖

64X
Growth in global internet traffic, 2005 to 2019

2 MINUTES
By 2020, all movies ever made could be streamed in 2 minutes.

Property Developers Win With Fiber

For a collection of detailed articles on these and other 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 technologies used at more than 40 properties in all property sectors and in all regions of the U.S. Here are three recent examples.

$25 GIGABIT WOWS RESIDENTS

Park Square at Seven Oaks in Bakersfield, California, is an upscale apartment community whose developer built its own fiber-to-the-unit network. Now every resident receives gigabit internet service for an unbeatable $25 monthly price – an attractive amenity for high-tech professionals.

Bakersfield, halfway between Los Angeles and Fresno, is home to high-tech hipsters and oil executives. Telecommuting is popular there, in part because it reduces employers' needs for high-priced office space. For telecommuters, the basic prerequisites are a strong cellphone signal and a broadband connection – preferably a gigabit. Andrew Fuller, president of Fuller Apartment Homes, knew he needed first-class broadband to appeal to his target audience.

Fuller had done many bulk service deals with cable companies, obtaining bandwidth at one-third the street price and using cheap and plentiful internet access as a marketing tool. By the time Park Square was being designed, bulk wasn't such a good deal. It would have cost 80 percent of market price.

Instead, Fuller decided to bring fiber to the 224-unit, mid-rise property, build a traditional copper Ethernet LAN and provide internet services directly – an approach he had used once before. But the 14-acre Park Square site needed cable lengths that far exceeded the limits of Ethernet over copper.

The solution: a full FTTH network. Installing the GPON fiber LAN cost considerably less than Fuller would have paid a service provider, and the costs of operation, maintenance and future expansion are also lower. Consultants helped raise the contractors' comfort with the technology.

Network operations and technical support are outsourced to a local service provider. Fuller Apartment Homes has a commercial contract with a national carrier for bandwidth to the property. The carrier's fiber terminates in the Park Square clubhouse. Fiber is run directly to each of the 16 buildings, and a fiber patch panel on the side of each building distributes the fiber to an ONT in each unit.

Said Andrew Fuller: "The field subcontractors … knew mostly electrical and standard copper communications cabling, but installing an optical fiber network was something many had never been involved with before. Surprisingly, with the help of a local network cabling expert, they discovered that it was really pretty straightforward."

The total cost was about $100,000, or a bit more than $400 per unit. Fuller Apartment Homes saved up to $150,000 by building the network itself. But the true ROI, says Fuller, came from halving network power consumption and reducing the space needed for telecom closets and from the longer usable life of fiber.

FIBER TO THE UNIT IN DEER RIDGE APARTMENTS

Jamestown (aka "The Buffalo City") is a thriving city in North Dakota with a diverse economic base – the kind of place people want to move to. IRET Properties, a midwestern real estate investment trust, had already built rental properties there, but rental vacancy rates were still below 2 percent. As Steven Paul, IRET's regional manager, says, "This showed the need for quality housing in that market," so IRET decided to build another multifamily property.

Deer Ridge Apartments, which opened in fall 2015 with 163 units in three buildings, is now the largest apartment community in Jamestown. It's targeted to a broad range of middle- to upper-income residents – anyone from University of Jamestown students to empty nesters – and offers such amenities as a heated underground

"In the future, apartment properties might be branded or labeled in terms of their internet access as much as their curb appeal. If owners don't plan for that, they'll miss an opportunity."

garage, a game room and a fitness center. "The entire project is the amenities," Paul says. "That's what has differentiated us."

Once the plans for Deer Ridge Apartments got underway, the opportunity for a new type of amenity presented itself. Jamestown is a CLEC community for Dakota Central Telecom (DCT), a telephone cooperative based in Carrington, North Dakota, about 40 miles from Jamestown. Over the last few years, DCT has upgraded all its facilities, both in its home territory and its CLEC territory, and it is now 100 percent fiber-based.

Because DCT's service area is mostly rural, MDU buildings are relatively rare. DCT does serve another Jamestown MDU with fiber, but that building has copper cabling from the comm room to the individual apartments. As Deer Ridge was new construction, DCT saw it as a great opportunity to try out some new fiber-to-the-home technology that it hadn't had a chance to use before, such as indoor riser-rated microduct and 3mm pushable/pullable fiber, as well as managed Wi-Fi. IRET saw a great new amenity for its residents – an amenity that no other service provider in Jamestown was offering.

And the residents? After some initial puzzlement about where to plug in their computers, "they're excited about it," Paul says.

SAN TRAVESIA: POSITIONING FOR LONG-TERM COMPETITIVENESS

Things are percolating in the McDowell corridor, a formerly rundown, 8-square-mile portion of southern Scottsdale, Arizona. Ever since the mall that anchored the area closed, the city has promoted revitalization there; today, private capital is pouring in, and new jobs are opening up. The McDowell corridor has great potential because it's close to everything – the Phoenix beltways, the Sky Harbor Airport, Arizona State University, the quaint Old Town (Scottsdale's downtown area) with its financial and health care institutions, and the cities of Phoenix and Tempe.


San Travesia

"It's a phenomenal location," says John Carlson, vice president of the residential division of Mark-Taylor, one of Arizona's largest apartment developers. So phenomenal, in fact, that Mark-Taylor chose it as the site of a Next Generation community – the designation it gives its newer assets, whose living units, Carlson says, are "more like modern, custom homes" than like apartments.

Assembling the 29-acre site was a complex undertaking – Mark-Taylor had to redevelop several parcels, including the dilapidated mall – and took several years. It was worth the effort, Carlson says: "We felt this was the ideal product for an urban environment like south Scottsdale. An opportunity with this much space is quite rare. We leveraged the expansiveness by building the Valley's largest rental units. … We believe residents appreciate that apartments don't have to be compact just because they're in urban locations."

San Travesia (named after the Spanish word for "crossroads," not for an actual saint) opened in January 2015, complete with "everything a discerning apartment resident expects, and more." The average resident age is 32, and the average household income is above $100,000. Residents include both empty nesters moving out of their houses and young professionals who aren't ready to buy their first houses.

One thing Mark-Taylor expected discerning residents to want was good internet access. Fortunately, the property was being planned at about the same time as Cox Communications' 1 Gbps service, branded as Gigablast. When Cox approached the developer about installing the new technology at San Travesia – based on fiber to the unit and wireless 802.11ac gateways – Carlson jumped at the chance. "Our strategy is long-term hold," he explains. "We're not looking to exit. We wanted to be armed with the right technology to take care of our residents on a going-forward basis."

The choice appears to have been a good one. When the property first opened, leasing agents had to explain to prospective residents what a gigabit was; today, residents tell their friends about the gigabit service, and the friends call the leasing office to ask when they can move in. The property is 9 percent ahead of its rent projection – which, given that Mark-Taylor prides itself on accurate projections, is "very significant," Carlson says.

The company's next three developments will all be Gigablast communities. "There's no going backward at this point," Carlson says. "The take-home is that, as you move into the future, apartment properties might be branded or labeled in terms of their internet access as much as their curb appeal. If owners don't plan for that, they'll miss an opportunity." ❖

Digging Deeper

Interested in fiber to the home? Start with a visit to www.bbcmag.com. **Broadband Communities** publishes a print and online magazine seven times per year, publishes breaking news online every day and holds two conferences per year. Its mission is building a fiber-connected world.

Broadband Communities' database at www.fiberville.com shows all FTTH deployments in the United States – about 1,100 at the end of 2017 with more added every week.

Broadband Communities' investor feasibility models and monthly cash flow models for FTTH are available free at www.FTTHAnalyzer.com. The models are designed to be easily adapted to your specific situation – whether you are in an urban or a rural district, whether you are a community leader, a service provider or a property owner.

Hundreds of network providers use these models, but they are a special boon to municipalities and small telephone, cable and electric companies starting to investigate the feasibility of fiber in their localities. The models allow you to perform preliminary studies for little or no cost and then decide whether to take the next step of hiring a consultant. Most users of these models get rough cost data from nearby communities or companies that have already deployed fiber. Find them on the fiberville.com database. Planning a network in two or more very different sections or time periods? The Multi-Neighborhood Financial Analyzer can handle it easily.

The **Fiber Broadband Association** (www.fiberbroadband.org), formerly the Fiber to the Home Council, is a nonprofit association whose mission is to accelerate deployment of all-fiber access networks by demonstrating how fiber-enabled applications and solutions create value for network operators and their customers, promote economic development and enhance quality of life. It holds quarterly meetings and monthly webinars and offers other information for fiber deployers. See especially its Community Toolkit (toolkit.fiberbroadband.org) for resources for municipalities, providers, activists and more. The toolkit guides you through the process of getting started, organizing your community, creating a business case and building a network.

Fiber serves the whole world's communication needs, even at King Tut's tomb in Luxor, Egypt.

LEGAL AND FEDERAL

The law firm of **Baller Stokes & Lide** (www.baller.com) offers links to many groups working on broadband issues and to discussions of laws and regulations covering FTTH. Its open resource library is at www.baller.com/category/community-broadband.

The Commerce Department's **National Telecommunications and Information Administration** (NTIA, www.ntia.doc.gov/category/broadband) helped fund more than $3 billion worth of middle-mile fiber networks (the networks that link national interstate communications trunks with local broadband providers). It also helped coordinate multiple federal agencies as they rewrote regulations to encourage broadband network construction.

The **Federal Communications Commission** regulates broadband providers and oversees the Universal Service Fund, which supports broadband in high-cost areas through such initiatives as the Connect America

1 IN 4
U.S. households have access to FTTH.

Fund. View proposed regulations and submit comments on them at www.fcc.gov.

The Department of Agriculture's **Rural Utilities Service** (www.rd.usda.gov/about-rd/agencies/rural-utilities-service) helps fund infrastructure, including telecommunications infrastructure, in rural communities and on Native American reservations. The application process is now online. To apply for Telecom Infrastructure and Telecom Farm Bill grant and loan funding, visit www.rd.usda.gov/programs-services/rd-apply.

ORGANIZATIONS AND ACTIVISTS

The **National Association of Telecommunications Officers and Advisors** (NATOA, www.natoa.org) supports the communications interests of local governments. It helps clarify local, state and federal communications laws, administrative rulings, judicial decisions and technology issues. It analyzes and addresses emerging issues in areas such as local government communications and internet policy; broadband planning best practices; cable franchising; wireless zoning; new technology initiatives and advancements; and operation of public, education and government (PEG) access channels. Members include consultants for and employees of state or local governments and agencies. Industry representatives, students, government or access center employees can join as nonvoting associates.

The **Rural Telecommunications Congress** (www.ruraltelecon.org) is a national nonprofit organization for government, university, industry and private citizens committed to addressing crucial broadband issues in rural areas.

The **Blandin Foundation** (www.blandinfoundation.org) aims to help rural Minnesota communities thrive, but its information on FTTH, including case studies, is relevant to any would-be deployer. The foundation has partnered with nearly 70 Minnesota communities and 110 organizations.

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. In 2015, it expanded its brief to help communities evaluate the broadband networks that make these services possible.

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, blog and podcasts (www.ilsr.org/initiatives/broadband, www.muninetworks.org) have helped many communities.

The **Coalition for Local Internet Choice** (CLIC, www.localnetchoice.org) represents private and public interests that support the authority of local communities to make their own broadband choices – including construction of their own networks.

90%
of seniors who own condos demand fast internet.

10X
Growth in global video game traffic by 2021.

Next Century Cities (www.nextcenturycities.org) had 181 member cities in 39 states at the end of 2017. Its members are committed to helping other cities realize the full power of high-speed, affordable, accessible broadband. It is politically neutral and does not advocate exclusively for municipal-run networks. Member communities have pursued a variety of paths to better broadband, including private and public-private networks. The organization also offers a community activists' toolkit on its site.

The **Schools, Health & Libraries Broadband Coalition**, popularly known as "Shelby" or SHLB (www.shlb.org) promotes broadband for anchor institutions and their communities.

KC Digital Drive (www.kcdigitaldrive.org) is the organization formed to ensure that Kansas City–area communities would take full advantage of the gigabit network deployed there by Google Fiber. It shares its findings with other communities around the United States.

NTCA – The Rural Broadband Association (www.ntca.org) represents small and rural telecommunications carriers, of which a substantial portion have deployed some fiber to the home. It sponsors a Smart Rural Community program and a Certified Gig-Capable Provider program.

The Multifamily Broadband Council (www.mfbroadband.org) advocates for independent broadband operators and service providers that serve multifamily housing communities, fostering knowledge and networking among its members. ❖

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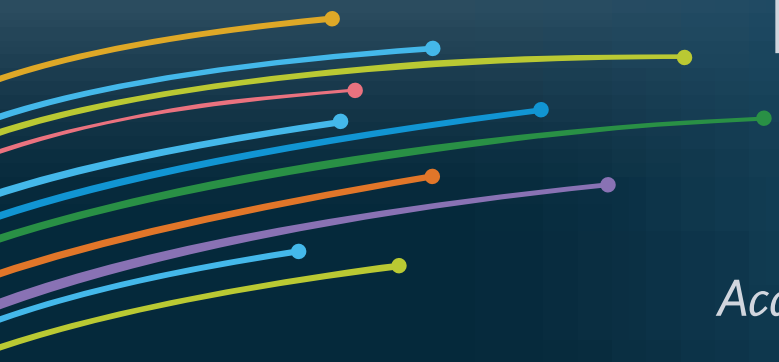

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