DUBLIN OHIO

FIBER TO THE HOME STUDY

August 2021

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City of Dublin

OHIO, USA

DUBLIN OHIO: FIBER TO THE HOME STUDY

FTTH STUDY

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FTTH STUDY

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EXECUTIVE SUMMARY

This report looks at deployments, lessons, competitive technology, and projected evolution of residential broadband systems in the United States. It sets the foundation for best choices by Dublin Ohio for a Fiber to the Home (FTTH) strategy, design, and implementation as follows:

Large service providers dominate the operational FTTH landscape, followed by smaller overbuilders and operators. Competition from cable and satellite offers round out consumer choice, but for pure broadband access, FTTH is a powerful choice. Feasibility for FTTH, outlined in this report, shows good potential for successful rollout and competitive advantage for many years to come.

A **comparative analysis** of five access approaches for residential broadband: DSL (Digital Subscriber Line), HFC (Hybrid-Fiber Coax), PON (Passive Optical Network), Satellite, and Terrestrial show both legacy solutions and pathways to evolving these networks. The system maturity and cost of home access for DSL and HFC are attractive as opposed to fiber, but fiber has the advantage of reliability, operating costs, including maintenance, and evolvability.

The **dominant fiber technology** today, called "GPON" (gigabit passive optical networks), delivers higher bit rate performance and competitiveness with cable operators or MSOs, who seek to evolve their DOCSIS-based systems (4.0) for higher bit rate services.

As the **battle shifts** to a 10 Gb/s service, FTTH operators must make a choice between two systems, namely XGS-PON and NG-PON2. The recommendation for Dublin Ohio is for ***XGS-PON*** due to its ability to deliver a leading-edge 10 Gb/s symmetrical service with the same logical structure as GPON. It is also available in volume and being deployed by many operators today.

A **preliminary cost** of build encompasses the classic metric of "homes passed" and "homes connected." Metrics, timing, and general cost estimates are outlined in Sections 10 and 11 of this report. Business models are then provided in Section 13 for operational decision points. Current Dublin suppliers and vendor options are outlined, which show what Dublin residents can expect for the future.

The report also provides a foundation on the essential elements to consider as Dublin looks to be a US broadband leader. Recommendations on the next steps and a plan to move into the next phase of design are feasible as soon as possible with the team, partners, and suppliers provided.

Finally, we have provided two important appendices to the report. They speak to vision and funding.

- The first is from the Intelligent Community Forum, a thought leader in how cities can become more "intelligent" and how broadband investment enables growth and revenue.

- The second is an open letter from the Fiber Broadband Association, which outlines major funding available from the government for broadband initiatives.

1 FTTH SCOPE AND DEFINITION

1.1 SCOPE

Although Fiber to the Home (FTTH) is being deployed on a worldwide basis, this report will look at deployments, lessons, competitive technology, and projected evolution of systems in the United States.

The dominant type of technology in use today for FTTH deployments is based on gigabit passive optical networks (GPON), which will be the primary technology focus of this report.

GPON evolution plans for higher bit rate performance will also be analyzed in detail, given its importance to competitiveness with the cable operators' (MSOs) plans to evolve their DOCSIS-based systems, which currently have a dominant residential broadband share, to 10 Gigabits per second.

1.2 PON DEFINITION AND ARCHITECTURE

There are two fundamental types of architecture used by fiber systems, namely home run and fiber split systems. Home run systems, using a dedicated fiber to connect the network to each user, is sometimes deployed in commercial in-building solutions, but it is impractical for residential deployment, from both a cost and operational perspective.

For residential use, passive optical splitters are used to enable a number of users (typically 16 to 48) to share a fiber connection. These systems are referred to as Passive Optical Network (PON) systems. The architecture of such a system is shown in Figure 1.

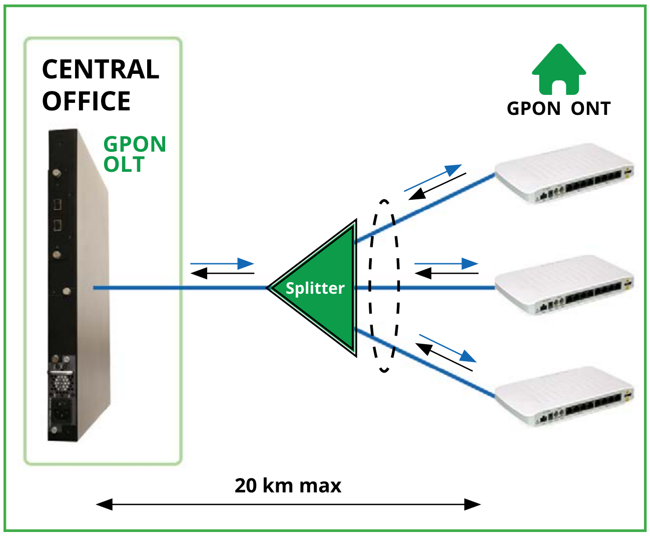


Figure 1. Components of GPON FTTH Network
Source: https://images.app.goo.gl/do9Cxz9hmHk3iyCa9

The basic premise is that each fiber within a bundle of fibers connecting the network to a community is shared by a number of residences. The sharing is accomplished by passive optical splitters that sit at operator-owned cabinets spaced throughout the neighborhood. A unique attribute of these systems is that they are passive, i.e. not requiring power and hence no battery backup. This significantly simplifies the outside plant portion of the network versus copper or coax-based systems.

The PON system uses single mode fiber and has separate wavelengths for downstream and upstream communication. For GPON systems, the downstream wavelength is 1490 nm, and the upstream wavelength is 1310 nm. Payload for GPON downstream is 2.4 Gbits per second and the upstream payload is 1.2 Gbits per second.

Downstream transmission which is "one to many" is relatively simple with all signals being encrypted and broadcast to every home, and each user able to decrypt the subset intended for that location. This is similar to how the HFC based systems of the cable operators work.

Upstream the "many to one" process is a bit more complex, so Time Division Multiplexing (TDM) gives each user a slot in which to transmit.

Architecturally, these PON systems are quite simple with no active electronics or power required in the outside plant portion of the network and simple digital signaling used in both directions.

1.3 TYPES OF PON SYSTEMS

As the technology driving long-haul high-speed transport for commercial use has matured, it has migrated down to enable low cost opto-electronic transmitters and receivers for use in residential networks.

Global standards have been developed by both the International Telecommunications Union (ITU) and IEEE since the introduction of PON technology. Figure 2 summarizes the types of PONs standardized for use today and being developed for future use.

The first version of standardized PON was based upon using Asynchronous Transfer Mode (ATM). As ATM fell out of favor a new version of the specification known as Broadband PON or BPON was standardized as ITU-T G.983, and about 10 million lines of this type of PON have been deployed worldwide. Verizon used this type of PON for their initial FiOS system, the first large-scale PON deployment in the US. As IP signaling grew in importance, Verizon migrated to a newer technology known as GPON, designated as ITU-T G.984. This is the dominant system in use within the US today. It is a proven, mature technology.

In parallel, the IEEE has standardized a PON optimized for ethernet transport, known as EPON, designated as 802.3ah. This technology is widely deployed in many countries in Europe and Asia but has very little deployment in the US. A potential future use of this technology in the US would be from the cable operators, or MSOs if (and it's a big if) they decide to move to FTTH rather than continuing to evolve their HFC-based DOCSIS systems (see Sec 3.2 below).

As demand for broadband speed continues to grow, both ITU and IEEE have standardized several new systems capable of 10 Gb/s speeds in both directions. The same process of technology migration from long-haul commercial fiber networks is driving the 10Gig transmitters and receivers necessary for these new PONs. Building on GPON, there are two types of 10G PONs that have been standardized, each targeting a separate market segment. The first, XGS PON, is the simpler of the two, being architecturally identical to GPON, with the same 20 km reach, using two new wavelengths (1577 nm downstream and 1270 upstream). This enables both GPON and XGS PON to run at the same time over the same infrastructure, allowing a seamless upgrade for operators already deploying GPON. The second, NG-PON 2, uses more complex architecture and more sophisticated technologies, such as tunable lasers, running multiple wavelengths in each direction to increase capacity. It is optimized for larger urban environments, with more commercial traffic in the mix.

Both of these systems are beginning to be deployed by some operators, with XGS PON used as an overlay or greenfield.

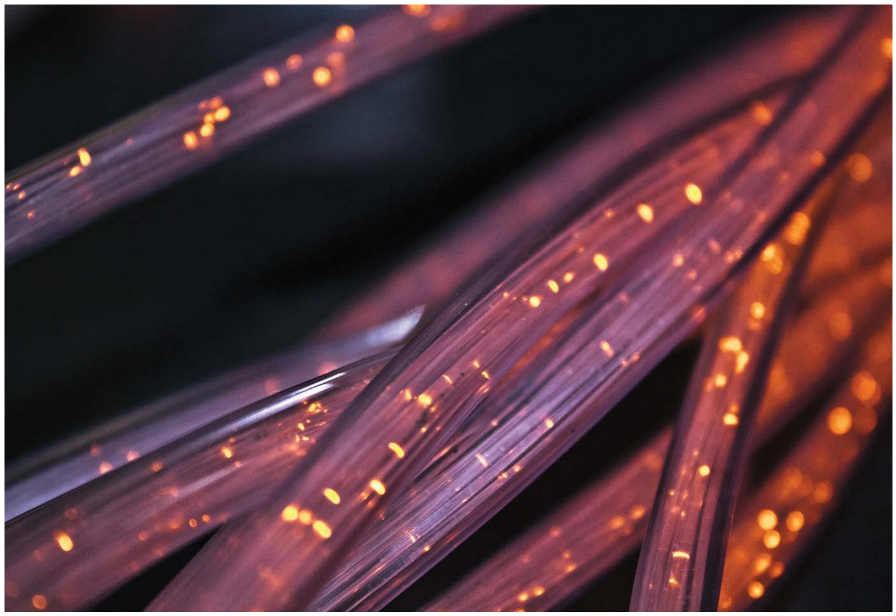
Work is also underway on yet higher-speed systems at 25 Gb/s or 50 Gb/s capacity, but this will require an entirely new generation of opto-electronic gear and is likely still some years out.

A key question for the deployment of the proposed FTTH system in Dublin, OH, is whether to deploy a GPON system (safe, but somewhat "me too") or to build a 10Gb/s XGS PON to get out ahead of the demand needs (riskier but of much higher image value). An analysis and recommendation regarding this question will be made in this report.

	PON Name	Standards Body	Designation	Intro Year	D/S Speed	N/S Speed	Current Status
1.	BPON	ITU	G.983	1998	622Mb/s	155Mb/s	Replaced by GPON
2.	**GPON**	ITU	G.984	2003	2.5Gb/s	1.25Gb/s	Millions deployed
3.	EPON	IEEE	802.3ah	2004	1Gb/s	1Gb/s	Europe and Asia
4.	ION-EPON	IEEE	802.3av	2009	10Gb/s	10Gb/s	Europe and Asia
5.	XG-PON	ITU	G.987	2010	10Gb/s	10Gb/s	Replaced by XGS-PON
6.	NG-PON2	ITU	G.989	2014	4 x 10Gb/s	4 x 10Gb/s	Trials
7.	**XGS-PON**	ITU	G.9807	2015	10Gb/s	10Gb/s	Ramping up
8.	NG-EPON	IEEE	802.3ca	In progress	25 or 50Gb/s	25 or 50Gb/s	—
9.	G5p.x	ITU	g.hsp.x	In progress	25+Gb/s	25+Gb/s	—

Figure 2. Types of Passive Optical Networks (PONs)

2 COMPETING RESIDENTIAL BROADBAND TECHNOLOGIES



2.1 TWISTED PAIR COPPER

The first residential data offerings were introduced by the telephone companies to run over their existing telephone lines in the 1990s. Many variants of the basic technology, DSL, have been developed, and it is still a viable service. It typically operates at the lower end of the speed range but also at a typically lower cost. About 90% of US households have access to DSL services. Most of the larger players such as EarthLink, AT&T, CenturyLink, and Frontier offer services of up to 100 Mb/s.

The speed available to users with this technology varies with the distance from the home to the operator's exchange. This makes the service problematic for rural applications, which typically have longer loop lengths. Some operators are phasing out their DSL offerings as they ramp up their fiber network.

2.2 HYBRID FIBER COAX (DOCSIS)

The cable network operators, commonly referred to as Multiple System Operators (MSOs), originally built their networks with coaxial cable which had enough bandwidth to carry linear television channels. Every quarter of a mile or so, the signal needed to be amplified, which added noise so that the further down the chain subscribers were, the more the signal degraded. In addition, an amplifier failure at any point in the link shut off service to everyone down the chain from that point, so cable networks rightly had a reputation for poor quality and reliability. The MSOs solved this once optical technology became cost-effective, by running fiber part way to the customer and only using amplifiers for the last mile or so. This created the concept of hybrid fiber-coax (HFC), which has stuck as a name for this type of network.

As the service set expanded over time to include interactive video, voice, and broadband data, the HFC networks had to be modified to support these two-way services. The US MSOs created a jointly owned entity, CableLabs, to specify new services and network capability and also to provide vendor certification for the specs to ensure both low cost and interoperability. This process has been extremely successful and has since been expanded to include operators from all around the globe.

For residential data, the CableLabs specification was known as Data Over Cable Service Interface Specifications or DOCSIS. The first specs were released in 1997 and have grown in capability and sophistication ever since. The current specification is DOCSIS 3.1, which provides a shared 10Gb/s Gigabit downstream capacity and shared 1Gb/s capacity upstream. This allows the MSOs to offer 1 Gb/s service to their users. DOCIS 3.1 has been widely deployed, and as a result, the MSOs currently enjoy about a 70% market share in the US for residential data.

Recognizing the threat of fiber to the home systems, CableLabs are currently working to increase system capacity to support 10 Gb per second service in the future.

2.3 WIRELESS (SATELLITE, TERRESTRIAL)

There are two categories of wireless residential broadband offerings to be considered, namely those based on satellite technology and terrestrial wireless options.

Looking first at satellite technology, residential data using satellite plays at best a niche role in the industry. Current offerings are limited in speed by the GEO satellite technology, despite ongoing improvements, and the user terminal, which must be mounted outside, is quite expensive. The advantage of satellite is its availability in places where wired connections cannot be provided. This includes not only the obvious rural locations, but pockets of sites within urban environments where access is difficult.

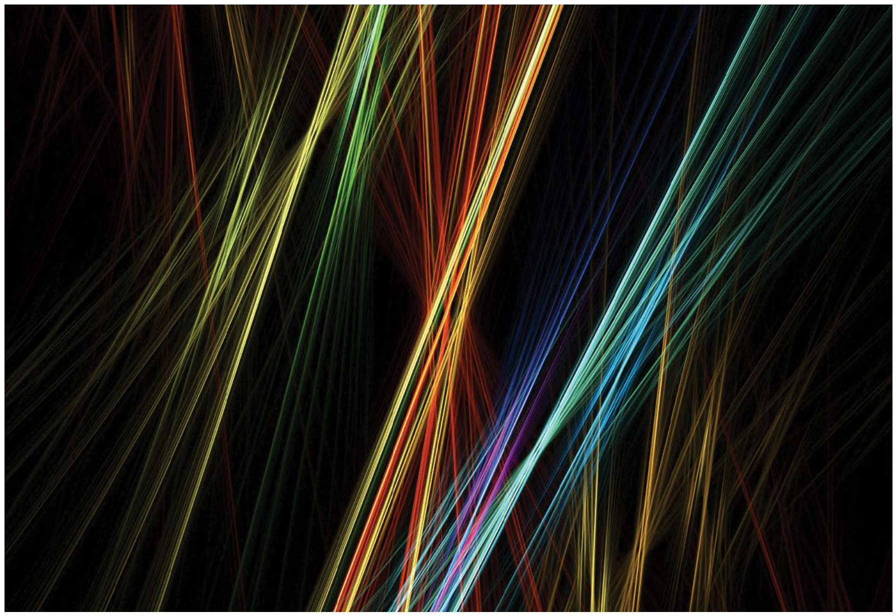
A new type of satellite deployment using a large number of satellites, at much lower orbits (LEO-based systems), is promising significant improvement in speed, but the technology will remain limited in its ability to compete with existing broadband offerings.

There are two types of terrestrial wireless solutions available to provide residential broadband. The first, known as Fixed Wireless Access (FWA), has been available in some limited areas for quite some time. The speed available is a function of the frequency used to make the connection. A number of systems have been deployed to date, but the main drawback, like satellite, is terminal cost and complexity, as well as the relatively short distance between operator antenna sites and users, depending on power budget and frequency.

The availability of licensed millimeter wave spectrum has enabled 5G operators, owning the spectrum, to deploy higher bit rate systems and operators such as T-Mobile and Verizon see a significant opportunity to provide a residential broadband service going forward with this technology.

Another terrestrial wireless option for residential customers is to use their 5G mobile broadband capability as a hotspot for their other devices and forgo any other residential broadband offering completely. Even with the significant increase in speed becoming available as 5G networks get built out, there is not nearly enough bandwidth available to support this type of offering on a broad basis. Operators will, therefore, likely limit their hotspot capability in terms of data caps and pricing plans to curtail the broad use of this option.

3 COMPARATIVE ANALYSIS



COMPARATIVE ANALYSIS

To make a meaningful comparison between the strengths and weaknesses of the five competing access technologies, namely DSL, HFC, FTTH, satellite, and wireless, the first and most essential parameter to consider is the required speed of the service.

The use of data within the home has been growing at more than 20% per year for many years. Per Cisco's Annual Broadband Report, the average landline broadband speed in North America in 2020 was 92.7 Mbits per second. This is expected to be 106.8 Mbits per second this year and grow to 144.8 Mbits per second by 2023. With this speed as a baseline average, today's satellite service can effectively be eliminated as a viable contender except for the niche applications as noted above. Similarly, today's wireless options, whether fixed wireless access or 5G mobile broadband, are going to be limited in market penetration and availability, although this may change in the future (see Section 7). This leaves DSL, hybrid fiber-coax, and FTTH to be analyzed for strengths and weaknesses.

A key factor when evaluating FTTH versus DSL or HFC networks is that the latter two have already been built out to most homes. This means the copper and coax drops have been universally deployed in the US and the investment in building these networks has already been recouped. Copper networks were, for the most part, subsidized by the original monopolistic models of the telephone companies, and the coax networks, although privately funded, have taken many years to reach a point of financial viability. In fact, the term EBITDA, commonly but mistakenly used as an indicator of profitability, was first coined by John Malone during the long and expensive buildout of TCI, the largest cable system in the US.

This typically puts FTTH at a competitive disadvantage because the drop to the consumer's home needs to be installed for every customer, adding significant cost to the build-out.

Digging a bit deeper, as the original copper and coax-based networks have been upgraded by the operators to provide ever-increasing speeds for consumer broadband, fiber has been deployed by both architectures to reach deeper into residential neighborhoods. This is shown in Figure 3.

So what we end up with, common to all three choices, are fiber-based architectures to the neighborhood, with differing drop connections to the home.

The main competitive criteria, in addition to the dropping cost, are reliability, operating costs, including maintenance, and evolvability for future bandwidth growth. A key advantage of FTTH versus the other two technologies is that the device used to distribute the fiber to each home is a passive splitter.

For FTTH, this means there is no power, no active electronics to be maintained, and no interference from electrical events such as lightning. It is also untappable for improved security. Both coax and twisted-pair architectures use hardened electronics in the neighborhood, which must be powered, maintained, and are subject to interference or intrusion.

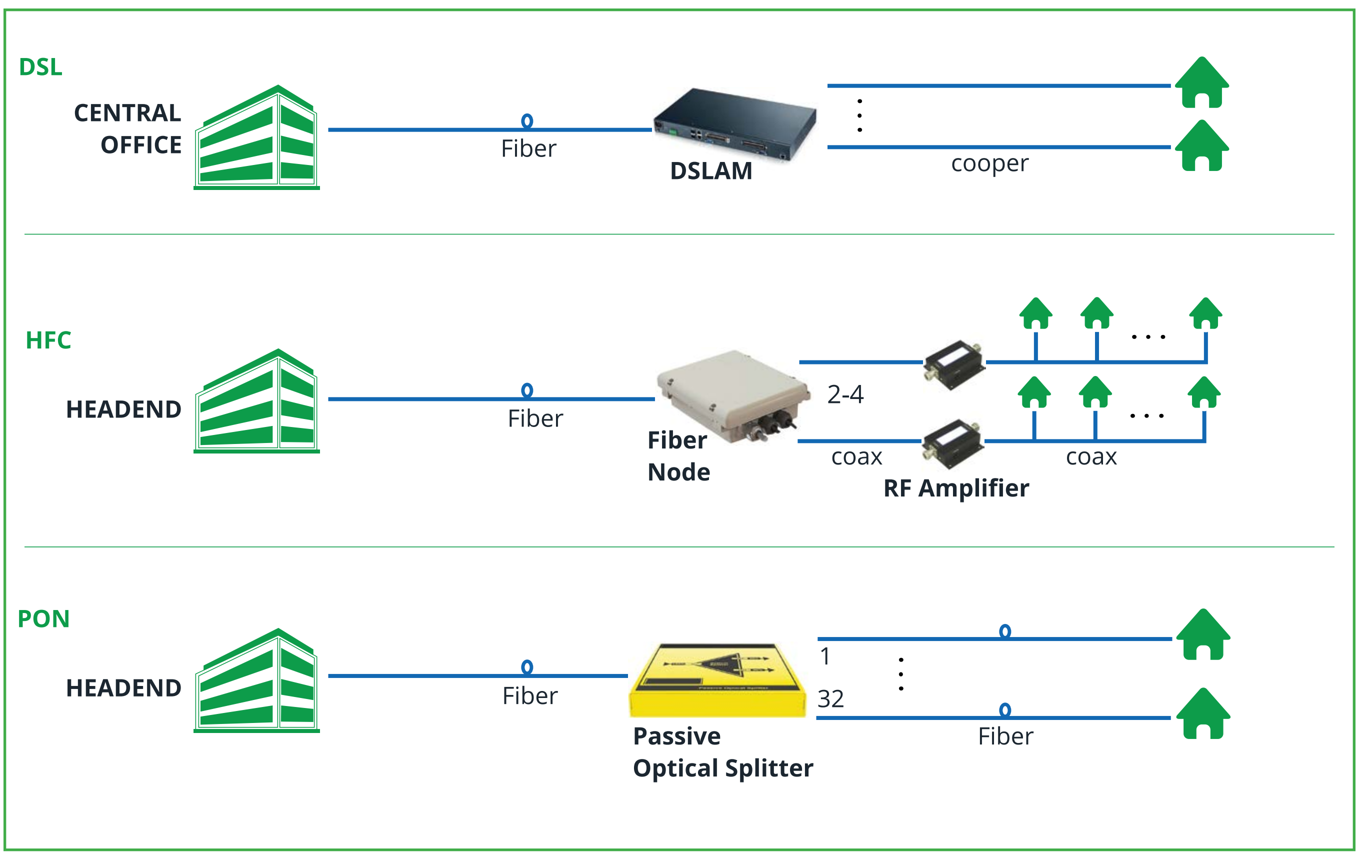


Figure 3. **Residential Architectures**

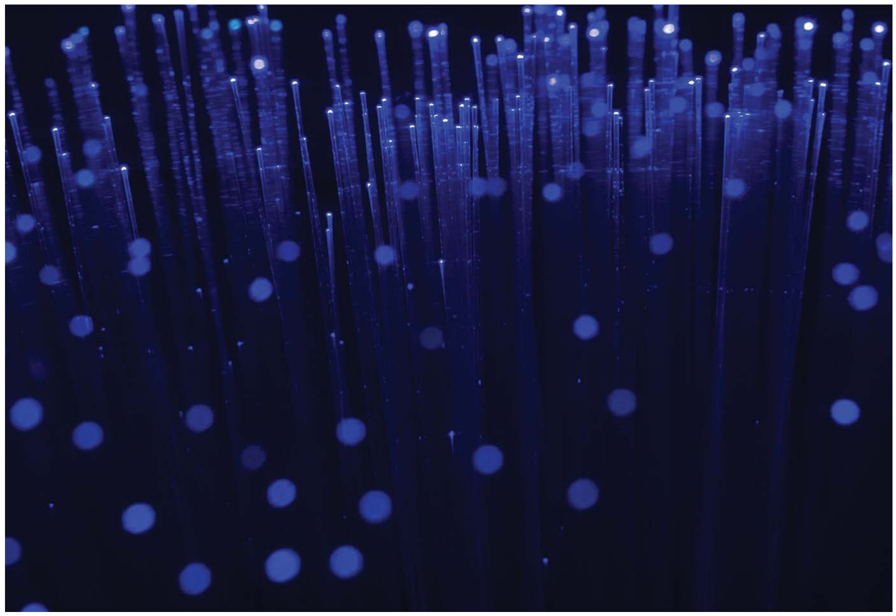
In terms of evolvability, the FTTH architecture can be upgraded to a higher bit rate via changes in the transmitter at the operator's central office location and the optoelectronics in the device at the side of the residence. Coax and twisted pair, in contrast, require significant engineering rework, pushing fiber deeper, and changing out electronics in the neighborhoods.

Finally, twisted pair is reaching the limits of its performance capabilities, while coax and fiber have significantly more bandwidth "runway." These differences are summarized in Figure 4.

Architecture	*Connection to Home*	*Active Electronics*	*B/W Potential*	*Total Member Users Sharing*
DSL	Copper	Yes	100Mb/s	1
HFC	Coax	Yes	10Gb/s	80-150
FTTH	Fiber	No	50Gb/s	32

Figure 4. Residential Comparison

4 FTTH DEPLOYMENTS IN THE UNITED STATES



4.1 OVERVIEW

As of September 2020, according to RVA LLC market research, FTTH has passed 53.8 million homes in the United States, and 22.5 million homes have been connected, for an impressive average take rate of 42%. Telcos have built almost 80% of these homes passed, with two large service providers having over 50% of the total build. The full breakout of types of providers is shown in Figure 5.

The two other main segments of the broadband market are served by DSL (telcos) and HFC (MSOs), as shown in Figure 6. The MSOs have the largest share of market overall. A relatively small number of homes are served by fixed wireless or satellite.

Historically, twisted-pair copper-based systems (DSL) and fiber hybrid coax (HFC) based systems were deployed by telcos and cable companies

Categories	FTTH Provider (%)
Tier 1 Telcos	67.0%
Tier 2/3 Telcos	12.2%
Over-Builders	8.2%
MSOs	7.9%
Municipalities	3.4%
Rural Electrics	1.0%

Figure 5. FTTH Provider Categories

Service Type	Connections (millions)
FTTH	22.5
DSL	18.0
HFC	71.0
Satellite FWA	6.0
None	10.5
Total	**128M**

Figure 6. Residential Broadband Connections - US

respectively to deliver residential broadband service. As consumer demand for speed increased over time, the bandwidth advantage of HFC (big pipe) over copper (little pipe) won out, and the cable companies took the dominant share of residential broadband from the telcos.

To counter this, as well as to enter the lucrative video distribution business, the two major US telcos both decided to use an even bigger pipe, namely fiber, to compete with the MSOs in video and take back lost share in broadband data. Although FTTH had been introduced in the U.S. on a small scale since the late 1990s, these two telcos drove the first large-scale FTTH deployments.

One service provider, with copper drops that were predominantly aerial and hence more cheaply replaced by fiber, decided to build a true FTTH system starting in September 2005. They built a system using BPON for voice and data, with a separate down-stream wavelength for broadcast video.

Starting in June 2006, another major service provider, with copper connections to the home primarily underground, chose to build a hybrid system taking fiber deep into neighborhoods but using existing copper to carry switched video and data the last 200 feet or so. This means it was not a true FTTH system but rather a hybrid system, which could, however, be converted to true FTTH in the future by replacing the last copper connection with fiber.

The broadcast video requirements of these two systems were solved very differently, and both telcos had to build proprietary systems. Despite being proprietary, the investments by these two major operators drove the awareness and demand for FTTH systems.

As streaming video technology matured, video could be delivered within the existing data delivery system, rather than handled separately, and a new form of FTTH, GPON emerged as the dominant system deployment choice. This technology has successfully been deployed by many other operators, including smaller telcos, over-builders, municipal governments, and co-ops. The one major exception to the use of GPON is the MSO segment, whose members use EPON for their limited FTTH builds, for technical reasons to be covered below.

4.2 SERVICE PROVIDER ONE

There are three drivers behind Service Provider One's decision in 2005 to deploy fiber-to-the-home.

First, their copper plant was aging, requiring a high maintenance budget, and was limited in the data speeds that could be supported using advanced DSL. Second, as noted above, the MSOs were making great improvements to the technical capabilities of its HFC based data offering, DOCSIS. Third, the MSOs were enjoying a significant revenue stream from video services over HFC, at the time the jewel in the crown, and making inroads against voice offerings with VoIP service on HFC.

Service Provider One decided to go on the offense, with a superior broadband offering and a competitive video offering, using a purpose-built fiber-to-the-home system, which they launched in 2005 in Keller, Texas.

As the pioneer for a large-scale FTTH deployment, they faced two principal challenges. First, they had to come up with the learning curve on the deployment and connections to the home of the fiber itself. Second, they had to develop a custom solution for delivery of a professional quality video offering over fiber.

The first challenge, field deployment of the fiber itself, took quite some time and effort to solve. The fact that most of the existing copper plant was aerial (both distribution and drop to the home) was essential to hitting their business case goals since underground plant was 2 to 3 times more expensive to deploy.

A principle technical and cost issue was the splitting and termination of the fiber itself. At the time, the best technical solution was called fusion splicing, which required a skilled technician and good weather (no rain or excessive wind). The initial install times were greater than four hours on average per home, meaning two homes per shift could not be done by their unionized technicians without paying overtime. In addition, in many cases, the environment, particularly multi-dwelling units, was not deemed safe for a single technician to enter, so they worked in pairs, with a third technician needed to stay with the truck to avoid vandalism.

The install time interval could be considerably speeded up with the use of pre-connectorized fiber, but the optical loss introduced by the connector made this a nonstarter for carriage of video and for unterminated split links. The development of the hardened angled physical contact (APC) connector solved this problem. In conjunction with ONT devices at the residence interface with fiber trays enabling excess fiber to be coiled without exceeding the bend ratio limits, this enabled the technicians to carry a small number of pre-connectorized fiber cable lengths in their truck, significantly improving install time, the single biggest cost factor in the early deployments. Companies like Corning were critical to the advances needed to get the costs down. Bell Aliant from eastern Canada, with a strong recommendation from Scientific-Atlanta to deploy FTTH, was another early pioneer, ultimately passing over two million homes, and worked closely with on best practices to drive install costs down.

The second consideration was deployment of cable TV style video on their PON. A separate wavelength at 1550 nm was used to carry QAM modulated video downstream, similar to HFC networks. A key cost leverage point was the use of existing copper outside plant enclosures to house the fiber-to-the-home splitters. To do this, however, and carry the video signals, an optical power budget far exceeding current HFC practice was required. A single-sourced product, a super high power optical amplifier known as a YEDFA (Ytterbium-Erbium Distribution Fiber Amplifier), was provided by Scientific Atlanta.

After some years of operation, Service Provide One refocused their triple-play services back to the northeast corner of the US, as they put more resources on their wireless offerings.

As of 3Q20, Service Provide One had over 6.5 million FiOS residential connections, with 6 million taking Broadband data, about 4 million taking video, and over 3 million taking voice services, available in ten states in the northeastern US.

4.3 SERVICE PROVIDER TWO/GPON

In the mid-2000s, Service Provider Two was facing the same issues regarding competition from the MSOs. Unlike Service Provider One, with copper plant that was old and primarily aerial, Service Provider Two had newer copper, which was in many cases underground, making a massive rollout of fiber to the home cost-prohibitive. Instead, Service Provider Two chose to run fiber deep into the neighborhoods and continue to use copper for the last short segment to the home. DSL speeds over copper degrade as distance increases. By shrinking this distance considerably, the DSL speeds could be increased accordingly. An aggressive target was set of 25 Mb/s per home, which was significantly more than the MSOs were delivering at the time, typically 5 Mb/s.

With this approach, the threat of broadband subscribers being lost to the MSOs was mitigated, and the network upgrade cost was significantly lower than a full fiber to the home deployment. The big issue, however, with this design became one of providing professional quality video which needed to share the 25 Mb/s home budget. To address this, Service Provider

Two had no choice but to move to a switched video solution, quite radical at the time, and rely on a newly invented superior video compression scheme known as MPEG-4 to provide video service, including high-definition video.

Service was launched in June 2006 in San Antonio, Texas. Improvements in the DSL electronics over time increased the bandwidth to 70 Mb/s per home.

The service ultimately passed over 30 million homes in 22 states. By the end of 2014, the service had 12.2 million data subscribers, 5.9 million video subscribers, and 4.8 million voice subscribers.

4.4 OTHER TELCOS

In 2009, Bell Aliant, partially owned by Bell Canada, launched a true fiber to the home system in eastern Canada (see Section 4.2). Following the success of this system and Bell Canada's subsequent acquisition of total control of Bell Aliant, Bell Canada has recently started deploying fiber to the home in lieu of fiber to the node.

As of second quarter 2019, Bell Canada had 4.9 million homes passed with fiber to the home, 4.8 million homes passed with fiber to the node, and 100,000 homes passed with fixed wireless access. In addition, Bell Aliant has over 2 million homes passed with fiber to the home and 250,000 homes passed with fiber to the node.

This makes Bell Canada one of the biggest operators, along with AT&T and Verizon, of fiber to the home in North America.

Smaller telcos, some of whom purchased Verizon FiOS systems in cities like Fort Wayne IN, Portland OR, and Buffalo NY are collectively passing about 5.5 million homes. They are growing their footprints aggressively and have collectively announced public plans to pass another 10 million homes with FTTH over the next decade.

4.5 OVER-BUILDERS

Over-builders are defined here as private firms that see an opportunity to compete with existing telephone and cable companies to build a new network. A number of these companies launched in the mid-2000s, primarily using Hybrid Fiber Coax as their network of choice. Companies like Knology, Wide Open West, and RCN built new networks and competed primarily by doing a better job with customer service, local content, and to some extent, price. As data rates increased, fiber to the home became the preferred network for this model, with a total of 4.6 million homes passed by 3Q-20, representing almost 9% of the total fiber to the home build-out in the US.

The most aggressive and interesting of these players is Google Fiber. Their intent was to stimulate usage of high bandwidth applications by pushing the envelope on available broadband speeds, particularly in the upstream.

Kansas City was the first deployment, having been selected among 1100 applicants to be the first location. The focus was put on cities with tech-savvy young urban professionals as target customers. By 2015 service was expanded to 10 cities. The estimated cost of completely wiring these cities was over $1 billion each. Google paused the program in 2016 and dropped their internal video offering in favor of a bundled streaming option. In San Antonio, Texas, Google Fiber announced its intent to build 4000 linear miles of fiber, but as of May 2019 had built about 600 miles.

A number of measures were taken to curb costs, including "nano trenching" at a very shallow distance and high-power optics to drive more users per split and/or further reach from the headend. They also pioneered the process of "fiberhoods" whereby a threshold percentage of users committed to signing up for service prior to the construction being started. They have had a number of construction-related issues and have shut down service in some cities such as Louisville, Kentucky, abandoning the nano trenching process in favor of a deeper micro trenching process in other cities.

Overall, the service is still up and running in 11 cities with 2 Gb/s downstream and 1 Gb/s upstream service at $100 a month, including free installation and the Wi-Fi6 router.

Google Fiber have an estimated 500,000 subscribers and have passed an estimated 1.5 million homes.

4.6 MSOs

The Multiple System Operators (MSOs) are the cable companies that use Hybrid Fiber Coax as their network of choice. Their standardized data offering on this network, DOCSIS, has been phenomenally successful, undergoing continual evolution and enhancement for many years, and allowing themselves to build and maintain a dominant share of the residential Broadband data market. As this network has evolved, the fiber part of HFC has been pushing deeper and deeper into the neighborhoods. Although there has been some consideration for taking the final step and pushing fiber all the way to the home, it appears the MSOs are planning further enhancements to DOCSIS to allow a 10 Gb/s service to be offered in the future, without having to change the drop to the home from coax to fiber.

There are two notable exceptions to this bet on HFC as a continued network of choice.

The first case for Fiber to the Home is driven by major property developers, who offer to partner on video services for their tenants but require an all-fiber infrastructure as a marketing tool for their properties. All of the big MSOs have developed programs to respond to these opportunities, building on their expertise in all-fiber-based deployments for business customers.

The second case involves one of the newer large MSOs, Altice, which is the fourth largest operator in the United States with 4.9 million subscribers. Altice has its roots in the Netherlands and entered the US market in 2010, acquiring two existing MSOs, Suddenlink, and Cablevision.

The Cablevision property covers the northeastern US, directly competing with Verizon FiOS. In 2016, Altice launched a program to convert its network to a fiber to the home system capable of providing 10 Gb/s service, focusing on the areas of direct competition with FiOS. As of the first quarter of 2021, 1 million homes had been passed with fiber to the home in the Northeast. 44% of new customers are taking a 1 gigabit per second symmetrical product.

The stated plans for fiber to the home expansion include 500,000 homes passed this year and 1 million homes per year thereafter until they have converted their entire base.

Of note here is that Altice is offering a full triple play service including "cable TV-style" video, utilizing technology from the parent company in Europe. This gives them access to a higher revenue stream per subscriber than most other fiber to the home players.

Overall, the MSO operators have about four million homes passed or 8% of the total fiber to the home deployment.

4.7 MUNICIPALITIES

In the early 2000s, many municipal governments undertook Fiber to the Home projects to enhance the quality of life for their citizens. In an often-cited analysis done by Professor Christopher Yoo at Penn Law School's Center for Technology, Innovation and Competition, 88 municipal fiber projects were examined, most of which were small rural communities. Costs per home passed, not including customer drop fiber, ranged from $765 to $5,549, with a median cost of $2,215. Twenty of these systems reported their financials separately, and the study did an NPV analysis of each of these builds over the period 2010 to 2014. What was found was not encouraging. Eleven were cash-flow negative, seven would require more than 60 years to break even, and only two had reasonable financials. One of these systems was Bristol, TN. Scientific Atlanta provided Bristol with a video headend, high-powered YEDFA optical amplifiers, and a custom-designed video ONT to enable them to capture a higher revenue per subscriber than most other fiber-to-the-home systems.

Several factors were at play in the poor financial performance noted in Professor Yoo's study. First, the fiber builds themselves were undergoing a steep learning curve on cost reduction. Second, video services, viewed as an essential offering at the time, required a complex implementation, with smaller suppliers, higher network costs, and higher content costs. Third, the business operations cost of customer service, maintenance, marketing, etc., was new for many municipal governments.

Over time, however, for the surviving operators, costs were lowered and the nature of the business changed, with higher bit rate, especially upstream, favoring fiber to the home, and video service becoming less important in the overall mix.

By 2018, Kagan Associates identified 218 active municipal providers, with 174 of them overbuilding existing operators and 44 buildings in new unserved areas. Ten percent of these projects were a public-private partnership, and only about one-third offered some type of video service in the mix. Only five percent included a smart grid offering.

Looking at some examples of municipal deployments, two long-term municipal service providers have been particularly successful, Cedar Springs, Iowa, and Wyandotte, Michigan. Both of these systems began as HFC-based overbuilders, which allowed them to use mature technology, especially for the video service.

Looking first at Cedar Springs, in northwest Iowa, there are 42,000 residents living in 16,000 homes. Cedar Springs municipal government began in the late 1990s with pre-DOCSIS Hybrid Fiber Coax and then upgraded to DOCSIS. In 2006 they began experimenting with the BPON, then being deployed by Verizon. In 2010, they launched a three-year program to replace their HFC network with GPON, spending about $20 million, Their GPON supplier, Motorola, exited the business and put their products on an end-of-life cycle, so a switch had to be made to Calix as their principal supplier, with significant disruption. in 2012 they provided a Fixed Wireless Access service to some subscribers and went through one product upgrade cycle but are now in the process of shutting it down in favor of fiber to the home.

In 2020 they began a three-year project to upgrade to XGS-PON, capable of offering a 10 Gb/s service. Partway through the upgrade, they changed vendors from Calix to Ciena, who had a superior XGS-PON offering. This upgrade involves changing out the OLT equipment and upgrading the routers at the headend, and changing out the ONT at customers' homes, but the fiber network deployment is untouched. PON systems run in parallel during the transition. So far, they have swapped out 6000 ONTs and have 8000 left to go.

Cedar Springs has an amazing 90% market share for broadband data. They offer video service as well, which requires a lot of ongoing effort to maintain. They were selected by PC Magazine as Fastest ISP in the Nation in 2020 and the best Gaming ISP in the Nation in 2021.

A ten Gb/s service is being offered for $107 per month with no install fees and no contract. They currently have “a few dozen“ subscriptions for the service per Robert Houlihan, their CTO.

Another system, Wyandotte Municipal Services, has offered residents of this city of 25,000 basic cable services since 1983, upgrading to triple play HFC in the 1990s. They have just launched a Fiber to the Home based network rebuild, which will take two years, covering 13,000 homes passed and 700 commercial buildings with an XGS-PON network, capable of delivering a 10Gb/s service. They currently have about 46% share of the residential Broadband market and are paying for the Fiber to the Home build-out with a 15-year revenue bond. Their success with FTTH is as yet unproven, but they have been a viable broadband supplier for many years.

In nearby Medina County, OH, a public-private partnership-based FTTH buildout is underway to provide service to 50,000 households over the next three to five years. The project is expected to cost $50M and is being financed by Lit Broadband and Peak Communications, the two private partners. The first phase, costing $8M, is now under construction in Seville, with service expected to begin this summer. A mix of aerial and underground construction will be used. The “fiberhood” concert, pioneered by Google Fiber, is being used to determine which neighborhoods will be built first. The network is planned to be (digital) Open Access based. Video Services will be exclusively streaming offerings.

Another small but interesting deployment is in Ammon, Idaho. They began building their first neighborhood of five hundred homes in March 2019. Residents in each neighborhood are able to join a Local Improvement District (LID), with the costs to build the network shared by those who opt-in. They can pay their share up front or over a twenty-year period. The network is Open Access, with four companies currently offering internet access.

4.8 RURAL ELECTRIC CO-OPS

Electric co-ops represent nonprofit community-owned entities that provide power for 42 million mostly rural Americans. As of 2018, per Kagan Associates, 163 co-ops are providing one gigabit per second Fiber to the Home service, out of the 900+ co-ops in the country. Their model is heavily dependent on government subsidies, for the most part. A density of at least eight customers per mile is considered the benchmark for economic viability. Advantages of these co-ops are outside plant experience, including trenching and aerial construction, as well as billing and customer service capability.

As an example, a recent partnership was announced between Blue Ridge Electric Co-op and West Carolina Telco to provide high-speed Internet to the 1800 mi.^{2} coverage area they jointly serve in the Carolinas. After a two-year feasibility study, a pilot program has recently been launched with customers expected to be online this summer. With over 6000 miles of power lines, it could be a number of years before coverage is complete, and government subsidies will play a key role.

Electric co-ops are not on the leading edge of innovation but are providing an increasingly essential service to their large consumer base.

5 LESSONS LEARNED AND CURRENT OUTLOOK

LESSONS LEARNED AND CURRENT OUTLOOK

Two large service providers were the principal players who started the residential Fiber to the Home market, grew it to volume, and continue to invest in it today. They did so originally as a defensive measure, to stop the threat to their DSL data service from cable operators, and as an offensive measure, to enter the video services market being shared between cable and satellite players. Both providers achieved up to 30% triple-play market share in their built-out markets but building only to a subset of their respective copper bases. They achieved only about 5% share each on a national basis.

These two telcos worked hard to drive down the construction and fiber deployment costs and develop methods and procedures which have benefitted the entire industry. The net is that Fiber to the Home deployment costs have been coming down continually over time.

On the data side, the MSOs continued to improve their offerings, but as customer demand for higher speed increased, particularly in the upstream, the superior bandwidth of Fiber to the Home increased its penetration, even as DSL services sharply declined.

On the video side, both large service providers had to develop custom solutions to match the MSO offerings, and video continues to be problematic for deployment over Fiber to the Home. As consumers increasingly “cut the cord“ in favor of streaming offerings linear broadcast video has become much less important in the overall mix of services provided. This has served to mitigate the disadvantage of delivering video services via Fiber to the Home versus Hybrid Fiber Coax. Most new FTTH builds are only providing carriage for streaming video, meaning lower revenue per subscriber, but significantly less complexity in building and maintaining the network and servicing the customer base.

Lastly, the skills and resources needed to become a service provider proved difficult for many of the smaller players, who struggled to acquire and maintain their customer base as they grow their skill sets internally.

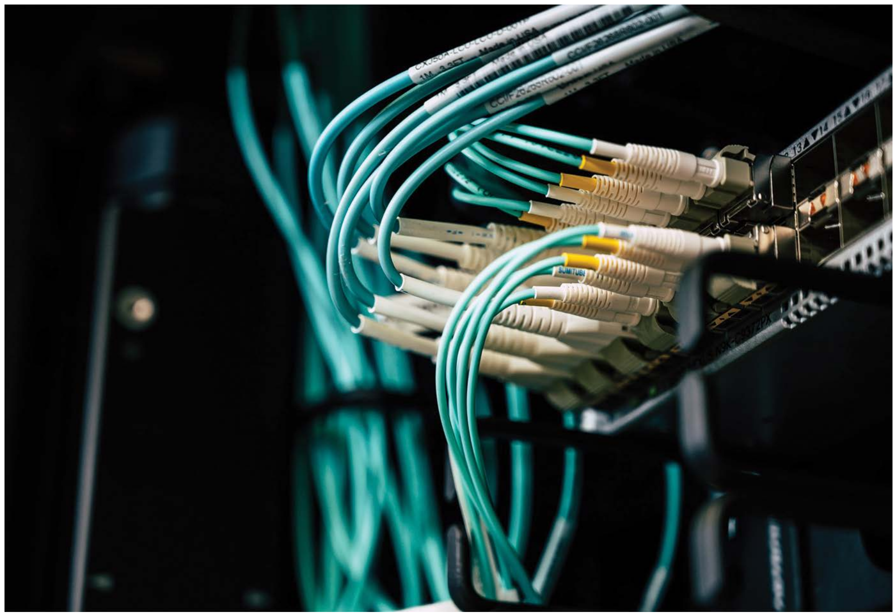
Looking ahead, both large service providers have embarked on a significant fiber build-out, combining the need for fiber to support their 5G wireless rollouts as well as supporting the expansion of Fiber to the Home buildouts. Verizon are limiting their FiOS activity to filling out their existing footprint while using 5G-based Fixed Wireless Access to provide residential broadband outside their FiOS space. AT&T are still pursuing a broader expansion of Fiber to the Home footprint, adding 1.1 million Fiber to the Home customers in 2019. During their investors meeting this May, AT&T CEO John Stankey indicated their intent to double their FTTH footprint to 30 million homes by 2025. They have also indicated, post-withdrawal from their less successful media efforts, to increase their fiber spending further. Other telcos have followed suit, with many announcing major Fiber to the Home expansion plans. Windstream, for example, has announced a five-year $2 billion fiber build project. Consolidated Communications recently announced plans to pass 1.4 million homes with a new build out of FTTH.

The shift to higher speed PON is well underway, with the same cycle of Fiber to the Home providing superior speed to cable (this time at 10 Gb/s versus the previous 1Gb/s cycle.) In 4Q20, per Dell’Oro, worldwide spending on XGS-PON OLT jumped by 400%.

The MSOs have a plan to compete with the higher speed PON capability and offer their customers a 10 Gb/s service (limited to 6 Gb/s upstream). They have, however, a much more complex path which will take some period of time and significant network upgrades to accomplish. (See Section 8).

The window for deploying a superior product with 10 Gig XGS-PON is clearly open now.

6 CURRENT RESIDENTIAL BROADBAND SUPPLIERS IN DUBLIN



CURRENT RESIDENTIAL BROADBAND SUPPLIERS IN DUBLIN

Dublin Ohio has a pretty typical residential broadband pattern, with a dominant cable provider, Spectrum, and a dominant DSL provider, AT&T. In addition, a cable over-builder WOW covers 2/3 of the residential footprint and an additional DSL provider, Frontier, covers a small footprint.

AT&T has also deployed Fiber to the Home to cover about 12% of the residential footprint, and the fixed wireless player Bresco Broadband covers 80% of the homes.

The two major national satellite operators, Viasat and HughesNet, offer lower speed service across the city.

Finally, EarthLink, operating as a CLEC, using AT&T facilities, offers similar coverage to AT&T and will not be further discussed here.

Figure 7 summarizes the residential broadband providers in Dublin, Ohio.

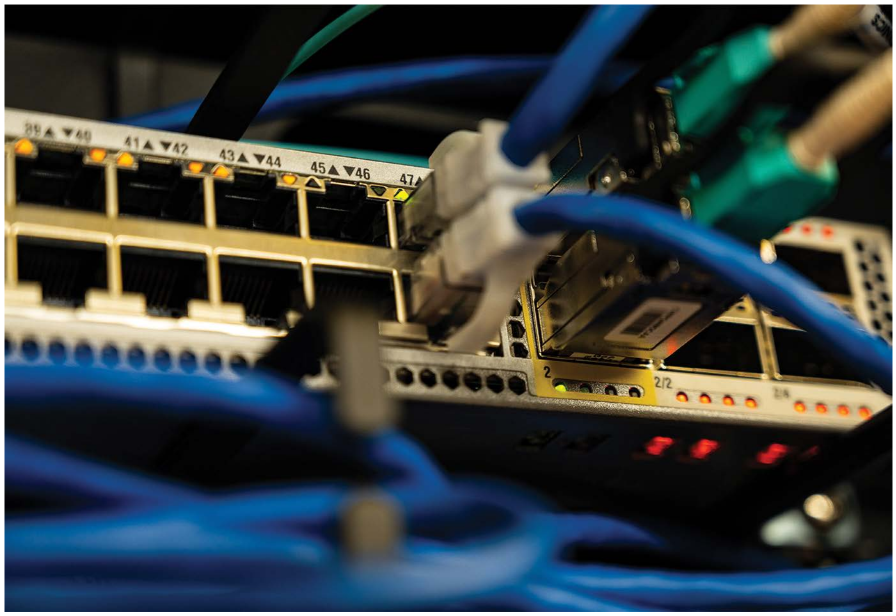
Dublin is the 29th most connected city in Ohio, per Broadband Now, with average download speed of 106.4 Mb/s. The average price paid by consumers is $53.93.

Both of the cable operators have upgraded to DOCSIS 3.1, so one-gigabit downstream service is available to anyone who wants it, and with two providers price will likely stay competitive. AT&T also offers a one-gigabit downstream service on their Fiber to the Home product and also has a far superior uplink capability of 1 gigabit per second for those who need it. They have only, however, currently deployed to a small part of the coverage area. AT&T have typically focused their build-out on covering apartment complexes in an effort to maximize their homes passed number while minimizing costs, driven by their FCC commitment to passing 12.5 million homes nationally. Now that this commitment has been met, and with 5G needs driving more fiber requirements, AT&T may well expand their Fiber to the Home reach in Dublin over the next two years or so. They have not yet made any public commitment to upgrade their network in Dublin to a 10G XGS-PON.

ISP	Type	↓Speed (Mb/s)	↑Speed (Mb/s)	Coverage
Spectrum	Cable	1000	35	100%
AT&T	DSL	100	20	92%
WOW	Cable	1000	50	69%
Frontier	DSL	50	50	12%
AT&T Fiber	FTTH	940	940	12%
ViaSat	Satellite	50	3	100%
Higherd Net	Satellite	25	3	100%
Bresco Broadband	Fixed Wireless	50	50	80%

Figure 7. Residential Broadband Providers in Dublin, Ohio

7 POTENTIAL NEW RESIDENTIAL BROADBAND SUPPLIERS IN DUBLIN



POTENTIAL NEW RESIDENTIAL BROADBAND SUPPLIERS IN DUBLIN

To complete the analysis of competitive suppliers of residential broadband in Dublin, there are two emerging technologies that are receiving a lot of press attention and may be deployed in Dublin over the next two or three years. These are 5G-based Fixed Wireless Access and LEO-based satellite internet service.

Looking first at Fixed Wireless Access, this type of technology has been around for a number of years and is generally focused on serving areas where wired service has not been deployed. In fact, as noted above, Bresco Broadband is offering a 50 Mb/s service in most of Dublin today.

With a big three wireless operators all rolling out their 5G offerings, there is potential to provide a new level of Fixed Wireless Access services as part of this 5G rollout. The 5G standards include a much broader range of frequency spectrum for use by 5G. Millimeter-wave (mmWave) operates at a much higher frequency than existing cellular systems. The millimeter spectrum can carry a vastly increased payload but with a much shorter range. This option becomes a prime candidate for a 1 Gb/s service, not previously possible for Fixed Wireless Access. In addition, new mid-range frequencies including CBRS, and C-band offer another path to high-capacity Fixed Wireless Access services.

Both Verizon and T-Mobile have announced their interest in pursuing this opportunity to deploy 5G-based Fixed Wireless Access to compete with the cable operators for residential broadband customers. Verizon have targeted a long-term market of 30 million users, and T-Mobile has announced a plan to cover 10 million users by 2024. AT&T are not pursuing a residential 5G-based Fixed Wireless Access program.

The second new potential competitive technology is LEO-based satellite services. Existing satellite services are quite limited in speed and have high latency but are universally available as evidenced by the current Viasat and HughesNet offerings in Dublin.

A radically new system of satellite coverage, using a very large constellation of satellites in much lower orbit, known as Low Earth Orbit (LEO) is under construction by a number of large players, including the existing satellite operators.

The most notable of these systems is Starlink, being built by SpaceX. Starlink has launched over 1500 satellites and are in beta test with thousands of users in the US, receiving up to 150 Mb/s service. A pizza box size terminal is required to connect. While interesting for rural and underserved markets, and no doubt subject to improved performance over time, this service will not play in the 1 Gb/s+ marketplace.

8 RESIDENTIAL BROADBAND NETWORK EVOLUTION

8.1 INTRODUCTION

The MSOs have enjoyed the majority share of the residential broadband market in the United States for a number of years now. The telcos, by shifting from DSL to Fiber to the Home, were able to deliver a superior product and take back share from the MSOs. The telco DSL offering was relegated for the most part to the lower speed, cost-sensitive segment and/or access where there is no upgraded DOCSIS or Fiber to the Home service available.

In response to this telco push, the MSOs have invested heavily in upgrading their data offering to DOCSIS 3.1, capable of deploying a 1 Gb/s service and rolling this capability out to most of their base. They are still limited in upstream traffic to about 200 Mb/s, giving GPON based Fiber to the Home with symmetrical service, a leg up for applications requiring significant upstream bandwidth.

Now, however, the battle is shifting to the next generation of network gear to enable 10 Gb/s service to be offered. For the MSOs, this means DOCSIS 4.0, while for the Fiber to the Home operators, there is a choice of two systems, namely XGS-PON and NG-PON2.

8.2 DOCSIS 10G PROGRAMS

The MSOs use a formal specification and certification process managed by a jointly owned entity, CableLabs. This allows vendor interoperability and lowers overall costs. The next evolution of the currently deployed DOCSIS 3.1 standard is DOCSIS 4.0, which has been under development for several years now. This specification will enable a 10Gb/s downstream service to be offered to individual subscribers, but upstream will be limited to 6 Gb/s.

Another major program has taken a higher priority in the standardization, certification, and deployment cycle. This program is Distributed Access Architecture (DAA). As a first step, virtualization of the network side of the Broadband system is being implemented, a technique being utilized by virtually all types of network operators worldwide. Virtualization lowers networks costs while increasing deployment flexibility and system upgrade velocity. In conjunction with this, Distributed Access Architecture pushes the DOCSIS signaling out to the fiber node. This enables lower user latency and increases the bandwidth available to users by allowing more efficient modulation techniques. 5G wireless networks are taking a similar path, with container-based virtualization of the core and Multi-acess Edge Computing (MEC) processing pushed to the edge.

The DAA program, under field trial at large MSOs such as Cox Communications and Comcast, has turned out to be quite difficult from an operations and maintenance perspective, and a lot of work remains to be done before volume rollout can occur.

For DOCSIS 4.0 itself, which will proceed behind DAA, there are two competing methods of implementation that are under consideration. The first method changes the system from the currently deployed simplex mode to full duplex. The second method increases the size of the coax pipe from 1.2 to 1.8 gigahertz. Each of these methods requires new silicon for volume deployment and extensive upgrades, including the environmentally hardened electronics in the field. (In contrast, Fiber to the Home has NO electronics in the field).

The vendor community is balking at finalizing development plans until the specifications are agreed upon. The net is that the MSOs are serious about a 10G upgrade and are working hard to finalize their plans, but it will be quite some time before a systemwide upgrade can be achieved. This leaves a window for 10G Fiber to the Home systems to stake out the high ground and take back the share of the most valuable segment of the user base – the high-end "power users.”

There is an interim step the MSOs can take, pushing up the frequency range of their optical transmitters and receivers to increase capacity and offer their customers service beyond the 1Gb/s limit of today’s deployed DOCSIS 3.1. Both Comcast and Charter executives mentioned this possibility on their most recent earnings call. How quickly this interim step could be certified by CableLabs and at what pace and cost it could be rolled out remains to be seen, but it would clearly be a quicker process than DOCSIS 4.0

Whether this step is taken will depend on the perceived threat and timing of 10Gig PON systems from the FTTH competitors.

8.3 FTTH 10G PROGRAMS

As noted in Section 1, there are two different types of 10G PONs are being tested or deployed today.

The first of these systems, XGS-PON, is functionally identical to GPON, with a single wavelength downstream and single wavelength upstream, with TDM used to allow multiple users in the upstream. Two new wavelengths, 1577 nm downstream and 1270 nm upstream, allow XGS-PON to share the same fiber as GPON, so existing GPON systems can have high-speed users incrementally added. A WDM module, also known as a coexistence element, is required at the headend to support this. The reach of XGS-PON is identical to that of GPON, namely 20 km.

Google Fiber has been trying to standardize a “super PON” with a 50 km reach, but so far has not been successful.

The second type of higher-speed PON is NG-PON2, also known as TWDM PON. This is a more complex system, with 40 Gb/s of total throughput capability, of which 10 Gb/s symmetrical is available for each subscriber. It has the same basic PON structure, with only a passive splitter between the OLT in the headend and the ONT at the residence. Four wavelengths in each direction are multiplexed onto the single fiber, so the OLT and ONT devices are correspondingly more complex, with tunable lasers and active filters. Unique wavelengths have been standardized to ensure coexistence with GPON and/or XGS-PON. This architecture is more amenable to a significant mix of business traffic rather than predominantly residential traffic.

AT&T began deploying XGS-PON in March 2020, initially rolling it out to 40 markets. So far, AT&T has indicated they do not plan to deploy NG-PON2 technology.

Verizon has introduced a “One Fiber” program for a consolidated fiber build, serving their 5G, business, and residential markets. They have selected NG-PON2 to support this broad initiative. After trials in 2018, issues arose with the tunable optics, which have taken some time to resolve. Verizon have a field trial currently underway in Tampa, Florida, to test a new supplier of tunable lasers, in which they have invested.

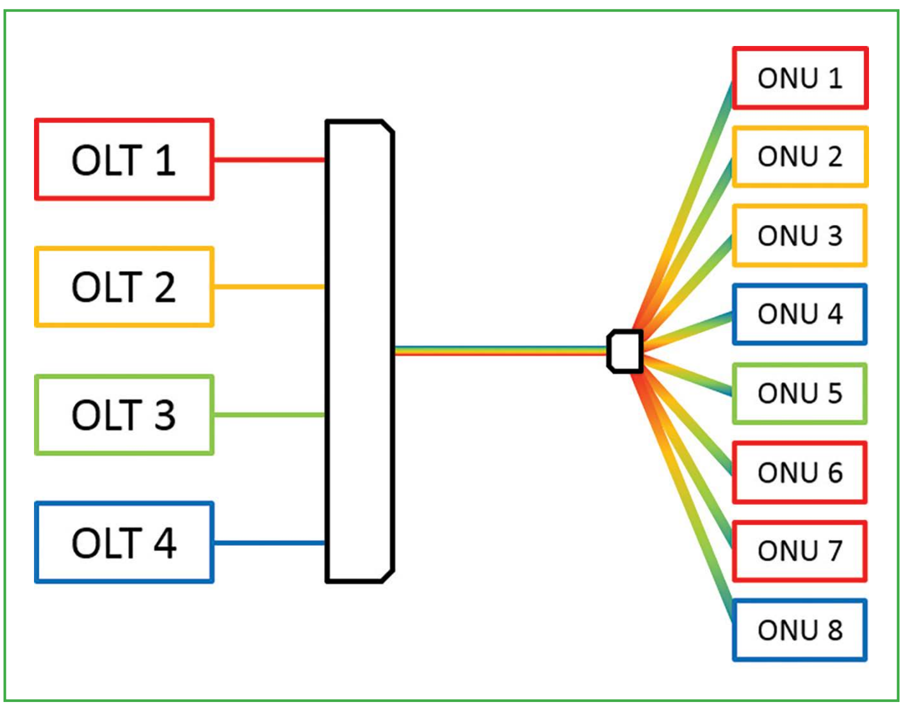
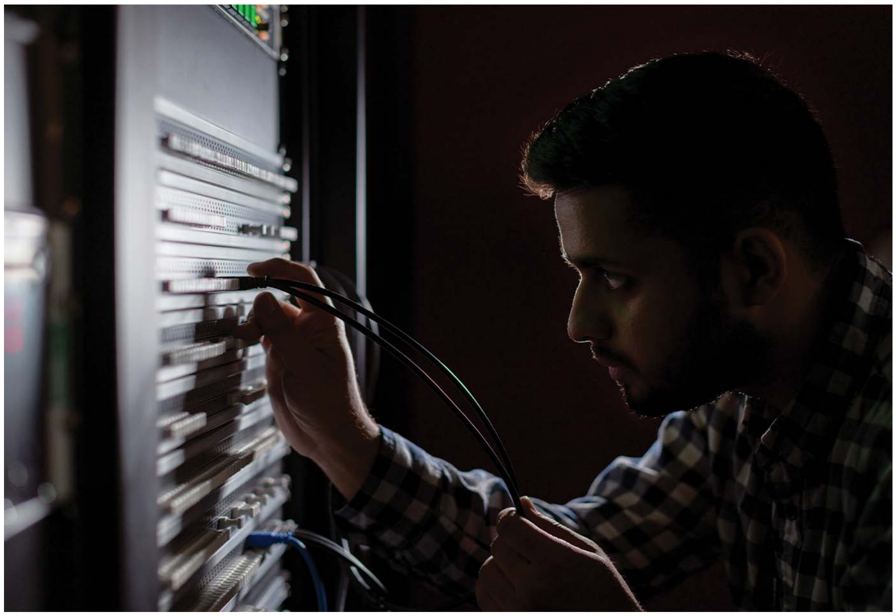


Figure 8. NG-PON2 distribution network. Light from four OLTs (left), each of a different wavelength, are combined into a single fiber using a wavelength-sensitive mux. The combined fiber transports the data to and from the end-users and is equally split among the ONUs. Each ONU communicates with just one OLT at a time through the use of tunable lasers (upstream) and active filters (downstream).

9 RECOMMENDED ARCHITECTURE AND ASSUMPTIONS



RECOMMENDED ARCHITECTURE AND ASSUMPTIONS

Given the demographics and geography of Dublin, the stated objectives of doing the study, and the competitive residential broadband environment in the city, it is recommended that a 10G XGS-PON be deployed for Fiber to the Home services. This architecture is shown in Figure 9. The details of the architecture and assumptions driving each element are as follows:

SINGLE DATA CENTER SITE

Regardless of the type of PON selected, whether GPON, XGS-PON, or NG-PON2, the reach capability between the service providers Data Center and the residences can range up to 20 km, or a little less than 13 miles. Given the geography of Dublin, with 25 mi.² in a roughly a 4 x 6-mile rectangle, regardless of site selection for the Data Center, it is not anticipated that any fiber route (roughly corresponding to the roadway system) between the Data Center and any residence will come close to exceeding that limit. This simple architecture would, however, be vulnerable to a fiber cut taking down service for all subscribers. For this reason, it is recommended that an unmanned remote hub be sited in the network to provide main fiber ring redundancy. This would operate logically equivalent to the architecture shown in Figure 9, but with the remote set of OLTs and IP Switching functionality connecting the subscribers to the network.

LEASED DATA CENTER SPACE

It is recommended, if possible, that the data center equipment be placed in a leased data center space. If not, a completely new site would have to be built from scratch with a considerable cost for a secure, back-up powered, redundant entry facility used in this type of application. This construction, if necessary, would add considerable cost and project timeline expansion.

DATA CENTER EQUIPMENT

The PON architecture is quite simple. Equipment required at the Data Center would consist of OLT racks, switches and routers, a fiber management system, and Operational Support Systems (OSS) and Business Support Systems (BSS) equipment. This is shown schematically in Figure 10. For a system serving Dublin, less than five racks of equipment plus a fiber cross-connect rack would likely be required. The number of fibers entering the building (between 1500 and 2000) may require modification at the building entry point and/or riser system. A workstation space would also be required.

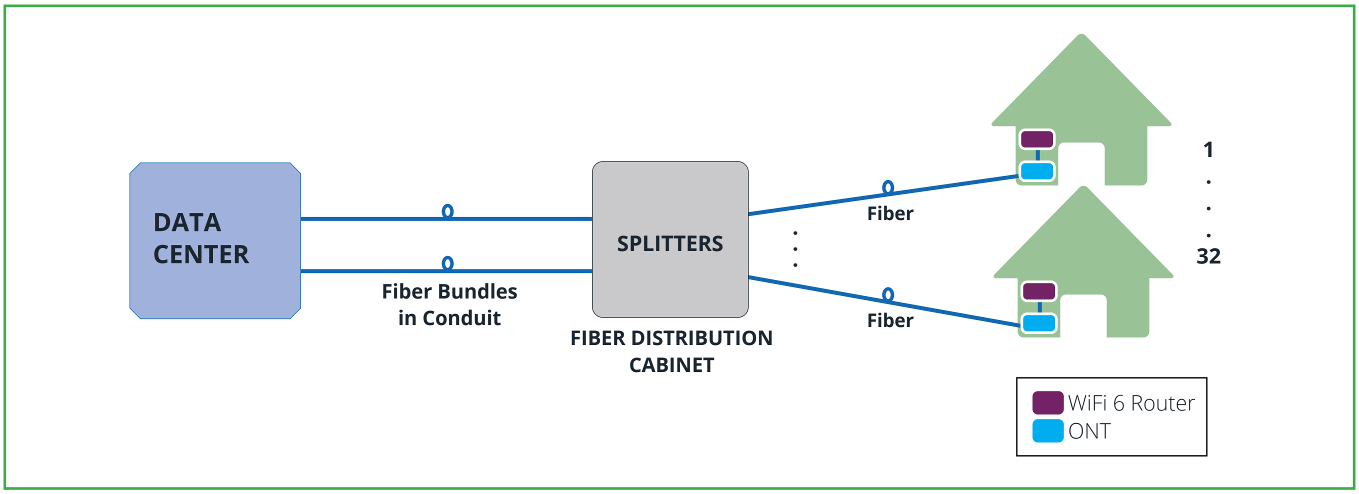


Figure 9. **XGS-PON Architecture**

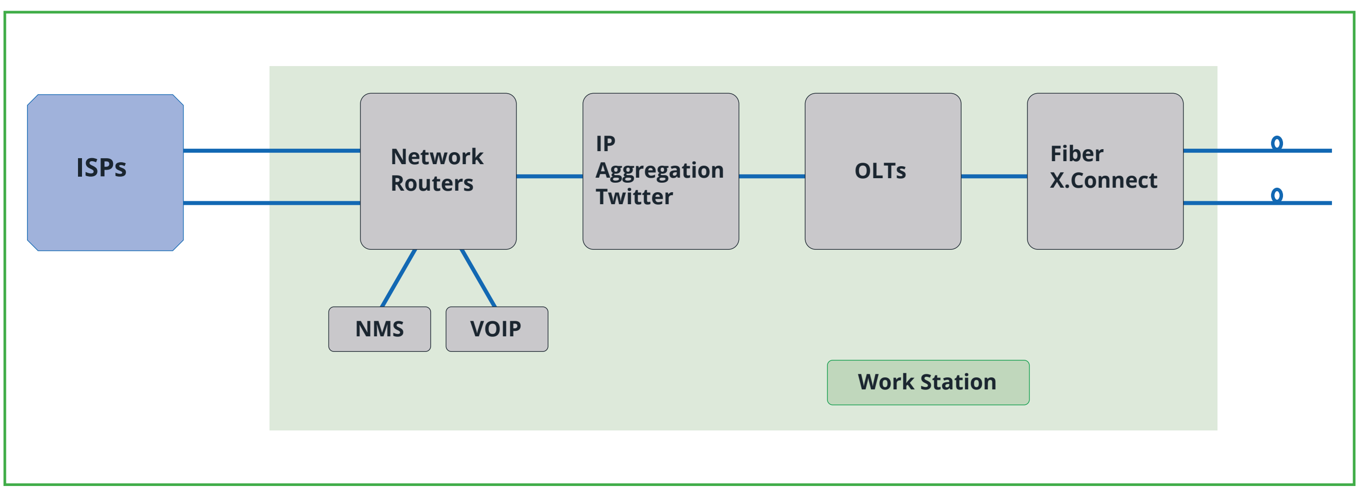


Figure 10. **Simplified Data Center Equipment Modules**

REMOTE HUB SITE

As noted above, it is recommended to provide a remote hub site to ensure fiber route diversity and protect from a system-wide failure due to a fiber cut. This unmanned facility would be powered and cooled and sited on a concrete pad. This hub would house an IP switch, OLTs, and a fiber cross-connect panel.

SERVICES

Although residential broadband data will be the primary service, triple-play offerings are commonly provided, adding voice and video to the mix. Given that the Fiber to the Home build is a greenfield effort, customers will be migrating over from competitive providers, and they will be expecting triple-play services.

Voice capability is quite easily added to the service offering by adding a VoIP gateway at the Data Center. The Wi-Fi6 router in residence comes equipped with VoIP connections. A number of companies are available with which to partner in operating this service if it is not desired to do so internally (see Section 13).

For video services, the situation is more complex. Traditional cable-based video services, also known as "linear video," require a significant investment in designing and building a video headend to provide this capability, and it is not recommended to do this.

As noted in section 5, the public is rapidly migrating to a streamed video model. It is recommended that this capability be offered for video services by bundling one or more streaming services such a Sling TV, YouTube TV, or Hulu as part of the service offering. No hardware in the Data Center will be required for this capability. If an IPTV system is desired, there are partners who can provide both the additional Data Center equipment, Digital Set-tops for the home and operate the system (see Section 13). This functionality has not been costed for this study.

OPEN ACCESS – FUTURE

It is not recommended, at least initially, to offer an Open Access model, which would require additional software in the Data Center. This is not primarily a technical issue, at least for digital Open Access, but rather a business issue which will be discussed in detail in Section 13.

PON SELECTION

There are three PON choices available. Many operators are successful today with GPON, which can offer up to 1Gb/s symmetrical service. GPON is the most mature and lowest cost of the choices. AT&T has deployed GPON in Dublin, but only to about 12% of the homes passed, in all likelihood near large apartment complexes, which account for 16% of the residences in the city. Spectrum and WOW have both upgraded their networks to DOCSIS 3.1 and are offering 1Gb/s service, albeit with a slower speed upstream.

The net is that 1 Gb/s service is available commonly in the city, and GPON would be an advanced but somewhat "me too" offering, and for this reason, it is not recommended.

This leaves XGS-PON and NG-PON2, both capable of offering a 10 Gb/s service. NG-PON2 is more complex, has more technology risk, is more costly, and is best suited for a mix of residential and business offerings. Since this deployment is targeted primarily at residential use and is a greenfield launch, it is therefore strongly recommended that an NG-PON2 architecture not be deployed. The recommended architecture then is XGS-PON which delivers a leading-edge 10 Gb/s symmetrical service, uses the same logical structure as GPON, and is available in volume and being deployed by many operators today.

FIBER ROUTE PLAN

Once the Data Center location has been selected, a detailed fiber route plan will need to be developed, laying out the path taken to each neighborhood, fiber count, splice points, and solutions for obstruction such as Interstate 270, Highway 33, and the Scioto River crossings, as well as smaller obstacles to construction.

For purposes of this study, it is not assumed that any advantage will be accrued from using Dublink conduit or fibers, but this may well be of significant value during the detailed fiber route planning. With no aerial routing available in the city, which is typically the lowest cost construction, a buried conduit is required to house the fiber bundles.

During this study, the optimal placement point for the Remote Hub would be determined.

OUTSIDE PLANT (OSP) CONSTRUCTION

Although some builds have been done recently with a process called micro-trenching, this is not a preferred method for long-term viability and is not recommended. The horizontal boring method, which takes longer but minimizes disruption to the landscape, and buries the conduit deeper, is recommended as the conduit construction method. The cost of this process is significantly impacted by the presence of buried rock, which is known to be present in the Dublin environment, so assumptions will be used to take this into account in the Project Cost section.

FIBER DISTRIBUTION CABINET AND SPLITTERS

The industry standard split ratio for PONs is 1 x 32, meaning up to 32 homes share the 10 Gb/s bandwidth available on the system in each direction. With no aerial construction available, Fiber Distribution Cabinets (FDC) will need to be placed somewhere in each neighborhood to house the splitters serving those homes. This layout will be finalized during the fiber layout design process but will typically service 200 to 300 homes and allow space for extra splitters to enable future selective capacity increase by reducing the split ratio to 1 x 16.

Along neighborhood right of ways, a concrete pad and FDC will need to be placed. Unlike Hybrid Fiber Coax or DSL builds, no power will be needed at these sites. The distribution fiber feeding each neighborhood will be over-provisioned to accommodate for this type of growth or other users such as cellular backhaul, which may represent a significant future opportunity as all three wireless carriers upgrade to 5G service.

DROP FIBER

From the splitters in the FDC, individual fibers will be run to each single-family home and connected to an Optical Network Unit (ONU). It is recommended that fibers be pre-connectorized and available in a small number of lengths to optimize the installation process. For small multi-family units, duplexes, townhomes, etc., the process is essentially the same. For large apartment complexes, the splitters are contained in cabinets on the outside of the apartments, (see Figure 11), with appropriate fiber counts to serve them. Fibers are then distributed within the complex to ONUs within each apartment.

ONU/ROUTER

It is recommended to install the ONU, (See Figure 12), which brings the fiber connection to each residence, inside the home. Some consumers may object to this so outside ONUs must be available. These must be environmentally hardened, and powered, adding cost to the solution. It is recommended to provide a wireless Wi-Fi router as part of this offering, rather than have the consumer provide their own. It is further recommended that a Wi-Fi6 router be provided, since this unit is able to support the higher speeds in the home for a 10 Gb/s service. Note that not all vendor's ONU equipment supports this capability today.

Figure 11. **Splitters in Outdoor Cabinets**

Figure 12. **Optical Network Unit Installation**

10 ESTIMATED PROJECT COSTS

ESTIMATED PROJECT COSTS

To estimate project costs for this study, a number of assumptions will need to be made. By far, the highest cost is the construction of the fiber conduit and splicing and testing of the fiber network itself. Other costs will include a number of categories of equipment costs, including the data center equipment, fiber distribution cabinets and splitters, drop fiber including installation, and ONTs and Wi-Fi6 routers in the residences. Major project-level costs will also include the development of a map-based high-level fiber route plan and an overall project plan, including RFPs for design, construction, equipment sourcing, QA, and systems integration.

One of the advantages of Fiber to the Home is that a significant portion of the cost can be deferred until the customer is connected for service. Costs will therefore be categorized firstly as cost per home passed, and secondly as cost per home connected.

10.1 HOMES PASSED COSTS

FIBER ROUTING PLAN

Once the Data Center site has been established, a high-level map-based fiber routing plan can be developed. During this process, any synergies with the potential use of the Dublink system would be identified. The optimal placement of the remote hub would also be finalized. A professional firm would need to be selected to conduct a study, and quotes would be needed to finalize a price, but a plan of this type would typically be in the $200,000 to $300,000 range and take approximately 4 to 6 months.

OVERALL PROJECT PLAN

Once the Data Center site is finalized and a map-based fiber route plan is established, an overall project plan needs to be developed. This plan will include preparing RFPs and assisting in selecting vendors for overall system design, OSP construction, equipment sourcing, fiber slicing/QA, and systems integration. This project plan would typically take 6 to 12 months and would cost in the $200,000 to $300,000 range.

DATA CENTER

As noted above, it will be assumed that a leased space for data center equipment will be feasible. If not, the cost of constructing a new facility would need to be added, in addition to the time required for this task.

To estimate the equipment cost for an XGS-PON, the primary costs are the OLTs, which connect to each splitter in the field. Two racks of equipment would be more than adequate, with XGS-PON OLTs and supporting gear costing roughly $1.2 million to $1.4 million.

Two more racks of equipment for the core aggregation switches and core routers would need to be added. The cost of these switches and routers would be roughly $600,000 to $700,000. The cost of a VoIP module needed for voice services would be roughly $200,000.

An NMS system for the switches and routers and a similar management interface for the OLTs would also be needed. The cost would be in the order of $200,000, depending on the vendor and level of management support required. This would bring the total network equipment cost in the Data Center to $2.2 million to $2.5 million, which is an algorithmic estimate based on a number of passings.

For all this equipment, a typical software license and/or service-level agreement would add approximately 15% of the equipment value per year to the ongoing operating costs.

OSP CONSTRUCTION COSTS

The fiber routing plan will dictate the Outside Plant construction activity, the biggest part of the overall cost. Prior to having the fiber routing plan, a rough cost range can be estimated as follows:

A reasonable first proxy for the fiber route miles needed is the number of road miles, which in this case for Dublin is 278 miles. Refining this estimate further, it is observed from the map of Dublin city that there are roughly 10 major residential subdivisions.

Assuming each subdivision could be reached from the data center location and the remote hub by a 4-mile run of conduit, and that each neighborhood would have roughly 15 miles of roads, this would bring the OSP construction need as 80 miles to reach the neighborhoods and 150 miles to connect the neighborhoods, yielding a total fiber conduit need of 230 miles. It should be cautioned that these are very rough estimates, and the fiber route plan will be required to finalize the mileage count.

Typically, a construction company will be hired to build the OSP, including all permitting and restoration, and blowing the fiber through the conduit. They would not usually do any splicing.

For comparative purposes aerial construction is approximately eight dollars per linear foot, assuming no major telephone pole replacement issues, and represents the lowest construction cost.

Horizontal boring, the method recommended here, has a baseline price of roughly $15 per linear foot, assuming no issues with buried rock, special permitting costs, or other non-standardized situations. This would set a baseline best case price for 230 miles of fiber conduit construction, not allowing for drop fiber, of $18.2 million. Known major crossings are Interstate 270, Highway 33, and this Scioto River. As a very rough cost estimate, $200,000 for each of these could account for efforts needed to cross. This will bring the best-case baseline cost to $18.8 million.

Given the presence in Dublin of buried rock, a diamond bit drill would be required in this circumstance, driving up costs. As a rule of thumb, this cost may be $20 per linear foot, giving a high estimate cost of $24.9 million.

This represents quite a wide range. The map-based fiber routing plan and Dublink synergy analysis will potentially reduce the route miles, but until quotes can be obtained from qualified construction companies, the use of the higher estimate is probably prudent.

REMOTE HUB

As part of the fiber routing plan, an optimal location will be determined for the placement of the remote hub. This will be an environmentally hardened hut, containing OLUs, an IP Switch, and fiber cross-connect. The cost of this facility and the electronics would range from $1.6 to $2.0M.

FIBER NETWORK SPLICING AND QUALITY ASSURANCE COSTS

As the network is being constructed, considerable splicing costs are required, and quality assurance must be conducted to certify and document compliance to both the design and standards. For a build of 16,280 homes passed, this cost can be roughly estimated at $2 million.

FIBER DISTRIBUTION CABINETS

Once the fiber has been brought to the neighborhood, Fiber Distribution Cabinets need to be sited and built to house the 1x32 splitters. As a first estimate, cabinets containing ten 1 x 32 splitters, plus room for growth, serving 300 homes passed, will be assumed. This gives a total of 55 Fiber Distribution Cabinets required.

The splitters themselves can be estimated to cost $720 each. Permitting, pouring concrete slab, placing the cabinet, and splicing cost for each FDC may be estimated at $12,000. Each FTC, including splitters, would therefore be $19,200, yielding a total cost estimate of $1.1 million.

Costs Per Homes Passed Summary

The summary of cost estimates for the build are shown in Figure 13. This yields a cost range of between $1,609 and $2,040 per home passed, which is within the norm of similarly sized projects.

10.2 HOMES CONNECTED COSTS

DROP FIBER AND INSTALLATION

A typical number for a drop fiber connection, including ONT, assuming pre-connectorized cable, is $800 to $900.

CUSTOMER PREMISES COSTS

This will include a WiFi6 router with VoIP port, installation, and test. Costs of this will range from $200 to $500.

Cost per Home Connected Summary

A total of $1000 to $1400 per home would not be incurred until a customer is connected. This “success-based” capital represents from 33% to 47% of the total capital spent per customer, depending on range of cost estimates used.

Homes Passed Costs

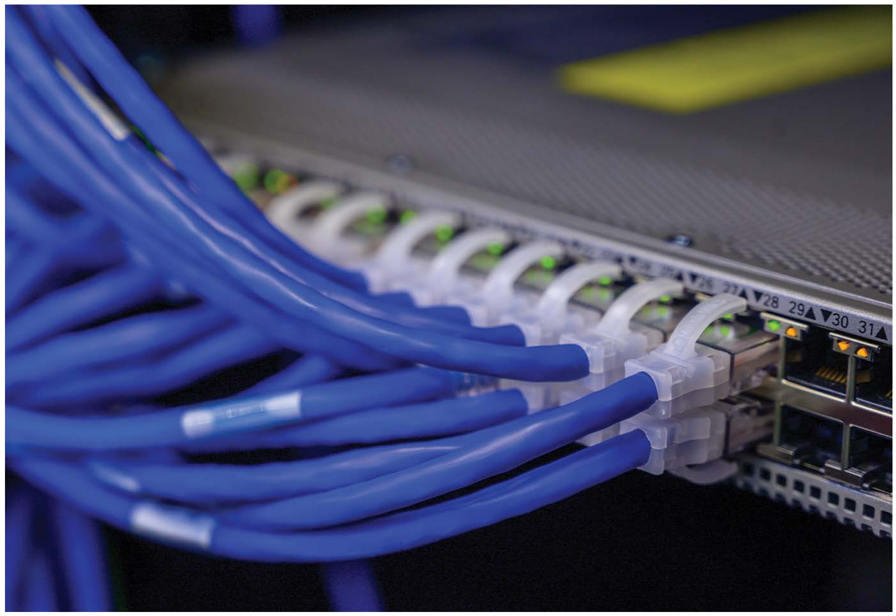
	Low	**High**
Fiber Routing Plan	$0.2M	$0.3M
Overall Project Plan	$0.2M	$0.3M
Data Center Equipment	$2.2M	$2.5M
OSP Construction	$18.8M	$24.9M
Remote Hub	$1.6M	$2.0M
Fiber Splicing/QA	$2.0M	$2.0M
FDCs and Splitters	$1.2M	$1.2M
Total	**$26.2M**	**$33.2M**
Cost per Homes Passed	**$1,609**	**$2,040**

Homes Connected Costs

	Low	**High**
Drop Fiber and Install, Including ONU	$800	$900
WiFi6 Router VOIP Port, Including Install and Test	$200	$500
Cost per Homes Connected	**$1,000**	**$1,400**

Figure 13. Estimated Project Costs

11 ESTIMATED TIMELINE



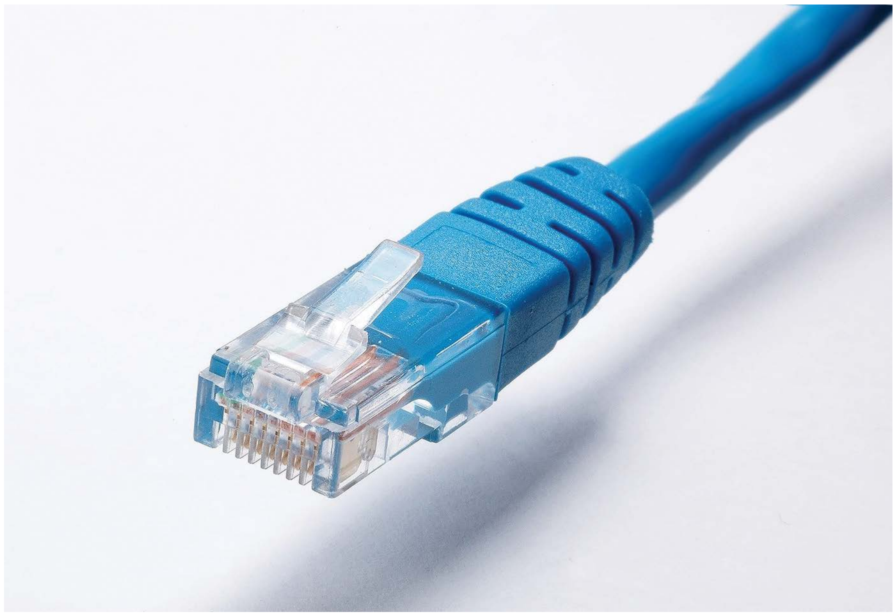
ESTIMATED TIMELINE

A preliminary view of the project timeline, consistent with other Fiber to the Home builds of comparable size, would indicate a total project timeline of three years from project launch to completion of the final neighborhood in the build.

Many of the individual steps have dependencies on prior steps. For example, a Fiber Route Plan cannot begin until the Data Center site selection is finalized, and OSP construction cannot begin until vendors are selected. An overall project timeline is shown in Figure 14.

Figure 14. Preliminary Project Timeline

12 MAJOR SUPPLIER AREAS



MAJOR SUPPLIER AREAS

There are a number of reputable vendors focusing on Fiber to the Home projects in the size range of Dublin. They can be categorized as follows:

Outside Plant (OSP) Design/Construction/Fiber and Passives.

Fiber to the Home Equipment (OLTs and ONTs/Routers).

Systems integration and commissioning.

If the services set to be offered includes voice and/or video services, a number of solutions are available to address these. Once the business model is chosen for this deployment (see Section 13), then appropriate partners can be identified.

13 BUSINESS MODEL CONSIDERATIONS

13.1 SERVICE PROVIDER

The most common business model is for the owner and builder of the FTTH network to operate the network as the service provider. For public entities such as municipal governments and rural electric co-ops, this has been commonly the most challenging aspect of their Fiber to the Home project, and it has caused some to fail or incur significant losses.

Electric utilities are at a relative advantage during the launch of a Fiber to the Home project because they already have many of the resources needed to operate as a service provider, including outside plant staff and trucks, construction experience, a customer service team, a public-facing office, and a billing system.

For municipal governments who don’t operate their own electric utility, the challenge of ramping up as a broadband service provider is the greatest. This is the case for the Dublin City government.

The first issue to consider is the service set. As noted above, since Dublin is a greenfield build, most residents already have a broadband service and may have voice and/or video services as well. To be successful, some version of a triple play offering is needed. Ramping up the resources and processes needed to support the Broadband offering is relatively straightforward. Partners, however, would likely be needed to offer Voice and/or Video services.

Looking at the categories of resources needed to operate as a service provider, one example of a successful municipal provider of the size of Dublin, OH, is Cedar Falls, IA. Information about their team, although not public, has been approved for use in this report by the Cedar Falls Chief Technical Officer. From a staffing point of view, their team is as follows:

Network Engineers	Six
Service Technicians	Four
Customer Service Reps	Three
Help Desk	Three
Marketing	Two
Management	One
TOTAL	**Nineteen**

In addition to this level of qualified staff, service trucks, a tech support office, and a public-facing office for marketing and billing are required. This is a very simplified view of requirements, but this team would have to be built up and trained during the first year, so that customers coming online can be supported as the Dublin system is launched.

13.2 OPEN ACCESS

Some public owners of Fiber the Home systems, whose motive is broader than private entities, are looking to provide their residents a choice of service providers operating over the publicly owned common Fiber to the Home infrastructure.

Since Fiber to the Home is a shared service, with up to 32 subscribers sharing a single access fiber, it is not practical to allow multiple private service providers to physically share the same network, with each, for example, providing their own ONU to a subscribed customer.

The notion of Open Access then becomes one of software-based sharing. In this arrangement, the physical Fiber to the Home network is operated by the municipal, and software in the Data Center can direct the traffic of a particular residence to the appropriate service provider the customer has chosen. It would, in theory, be possible for each service provider to supply additional CPE in the home for Voice and/or Video services, but it is not evident that any network with this additional CPE model has been deployed anywhere.

For software-defined Open Access, a number of municipal Fiber to the Homeowners have announced their intent to use this type of model, and some have recently begun to deploy services. The principal objection to this model is one of maintaining service during fault conditions. Responsibility for service restoration becomes more complex without a clear owner of the problem. Although there is a lot of press around Open Access, no one, to our knowledge, has yet ramped up an Open Access system to volume and operated successfully.

For the city of Dublin, as a new service provider, in a greenfield build, it is not recommended to consider this capability initially. At some future time, once the network is operating smoothly and the city has built their service provider capability, such a model could be considered.

13.3 PUBLIC-PRIVATE PARTNERSHIP

This model assumes the municipal Fiber to the Home buildout achieves its goals for the well-being of its residents by entering into a partnership with a private entity skilled at building and operating a Fiber to the Home network.

A recent example of this type of business model is the Medina County, OH system, as noted above. In this case, two private entities, Lit Broadband and Peak Communications, have formed a partnership with the county government to design, build, fund, and operate the network.

This model eliminates the risk of ramping up internal capabilities as a service provider. Other private entities such as Point Broadband appear to be pursuing this model as well.

Success for this type of partnership will be dependent on reaching an agreement between the profit-driven goals of the private partner and the public service goals of the municipal government. Like the Open Access model, the public-private partnership is a new construct, without significant data yet for gauging its overall success.

13.4 FIBERHOODS

Since the outside plant construction is such a major part of the overall cost, it is worthwhile trying to optimize the build in sync with the greatest number of customers likely to sign up for service. Google Fiber pioneered a process called “fiberhoods,” which surveys residents in each neighborhood to determine intent to sign on. Customers signing on would have their connection fee waived. This process is really an effort to get income flowing into the financial model as soon as possible.

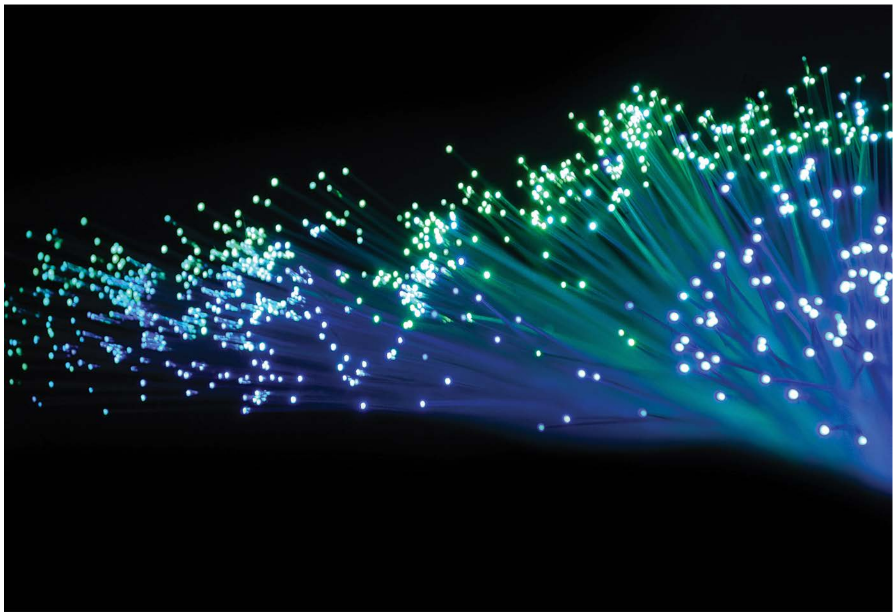
13.5 SUBSIDIES

Some municipals have raised property taxes to fund Fiber to the Home builds, and some have taken out long-term bonds. As noted above, many of the early Fiber to the Home builders have not yet been able to achieve financial viability. Some major property developers have partnered with service providers to allow only Fiber to the Home based access in their developments. This is the principal reason MSO’s have developed Fiber to the Home based solutions.

13.6 COMPLEMENTARY USE CASES

There are a number of benefits to building a Fiber to the Home system, which is complementary to the principal goal of Broadband provision to the residences. First, smart grid partnerships with the electric utility provider can make use of the fiber to the home network. Secondly, smart city partnerships can drive a whole range of services and benefits. This is outlined in Appendix A of this report. Thirdly, as the wireless providers launch their 5G offerings, including mmWave-based services, they will need significantly more cell towers with a corresponding need for fiber connection. The Fiber to the Home network, by over provisioning the transport fiber internal requirements, is ideally situated to address this potentially lucrative need.

14 CONCLUSIONS AND RECOMMENDATIONS



14.1 CONCLUSIONS

The stated purpose of this study is to determine, given the nationally recognized success of Dublink as a transport ring for enterprise users, whether a similar benefit to the city could be incurred by building a Fiber to the Home system for use by residential customers. This study concludes that a FTTH system, if properly designed and constructed, could indeed provide significant benefit to the city and its residents.

Further, the study was tasked to answer if a Fiber to the Home system were to be constructed, what would its characteristics be, what would it likely cost, and how long would it likely take to construct.

The answers to these questions are as follows:

1. A 10G XGS-PON based system is STRONGLY recommended to be the basis of the Fiber to the Home network. Furthermore, a ring-

based design, using a second hub in addition to the primary Data Center, is recommended for physical route redundancy and equipment redundancy to maintain a high service uptime for high network reliability.

The XGS-PON, capable of providing up to a 10 Gb/s symmetrical service for each residence, presents a clear differentiator to the DOCSIS 3.1 cable-based systems currently serving Dublin residents and GPON service from AT&T.

The city-wide 10Gb/s second service capability will position the city of Dublin on the leading edge of service providers anywhere in the country.

2. The cost question is a more difficult one to answer, and this study can only provide a reasonable estimate of a range of cost levels. The primary contributor to overall project cost is the outside plant (OSP) construction, both in terms of where the fiber should be routed and how much per linear foot it will cost to install.

   At this point, with only general assumptions, the project estimates range from $26.2 million to $33.2 million, not including "success-based" capital of $1000 to $1400 per connected subscriber. Narrowing this cost estimate will require some time and effort, as outlined in the study, to do a fiber route plan, and get qualified bids on constructing the outside plant for this routing plan.

3. The project timeframe can be reasonably estimated at three years from project launch to completion of the outside plant for the final neighborhood. First customers can reasonably expect to have service 12 to 15 months after project launch. This estimate is consistent with a number of similar-sized projects built around the country.

14.2 RECOMMENDATIONS

1. Establishing the Data Center site, if possible, in leased space, is the critical first step, driving all other steps in the project.

2. Given the lack of internal expertise by the city government in building a Fiber to the Home system, and with the process used of obtaining multiple bids for services, getting a project plan established for the next few steps is critical. This plan would drive the details and partner selection for the Fiber Route plan and OSP construction.

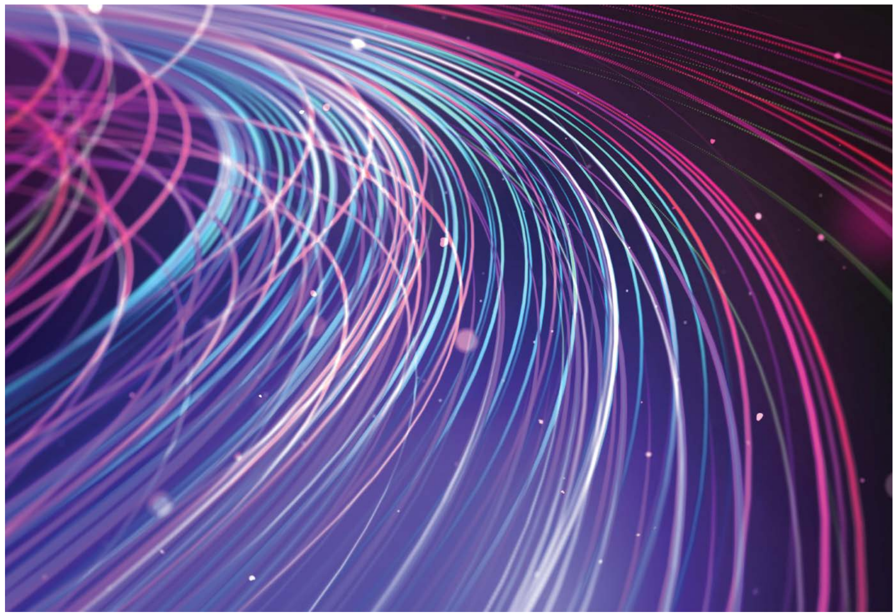
   If the decision to proceed requires refinement on the OSP cost estimate, some preliminary work could be done by qualified OSP contractor firms, but the fiber plan would be needed to drive this.

   This project plan should also encompass selection of a design prime, equipment vendors and a systems integrator, who would then take ownership for project execution and completion.

3. In addition to the basic design and network construction, two additional decisions need to be made. First, the business model selection, as outlined in Section 13 above, needs to be finalized. Second, the service set with respect to voice and/or video services needs to be finalized. This decision will possibly modify the network equipment requirements as well. The prime selected for the project plan as outlined in step two above could also provide assistance to answer these two questions.

4. Additional reporting modules, outside the scope of this study, can be provided on critical infrastructure cybersecurity, deeper 5G system impact, and comprehensive financing.

A1 INTELLIGENT CITIES



BROADBAND AND ECONOMIC GROWTH: A BRIEF REFLECTION BASED ON THE OUTCOMES OF INTELLIGENT COMMUNITIES

Broadband as enabling infrastructure for economic growth and business attraction has been a subject of discussion among local governments for nearly two decades. For the most part, cities and communities have settled on the answer. It is necessary. What has been in question is, "Who pays?" And secondly, what type of access should be given. Open networks? Carrier-based? Municipal?

One of the primary considerations for FTTH and the government's role as the enabling agent to the private sector, in our view, is the ability to enable "home-grown" businesses. This concept, from Eindhoven, the Netherlands to Waterloo, Canada has been fundamental in the rise of Intelligent Communities and their success. These communities are not just "connected cities." That is nearly insulting to say. Rather, they are places where the government and private sectors AND citizens collaborate to ensure that the community's economic destiny is seized and ensured for generations.

The performance of these places has outpaced those of many other cities and communities.

The unofficial start of this transformation of the places people call "home" began back in the mid-1990s. We identified Stockholm as a city that had the concept of broadband right[1].

During the early Nineties crisis, the City of Stockholm decided to pursue an unusual model in telecommunications. The city-owned company Stokab started in 1994 to build a fiber-optic network throughout the municipality as a level playing field for all operators. Stokab dug up the streets once to install conduit and run fiber, closed them up, and began offering dark fiber capacity to carriers for less than it would cost them to install it themselves. One decade later, when they become the world's top Intelligent Community, we confirmed that it had a 1.2-million-kilometer (720,000-mile) network with more than 90 operators and 450 enterprises as primary customers and was in the final year of a three-year project to bring fiber to 100% of public housing, which was expected to add 95,000 households to the network. Stockholm's Mayor set a goal of connecting 90% of all households to fiber by 2012. The goal was met.
As an information utility, the Stokab network has become an engine for driving efficiency in every aspect of government. The City's Web site hosts a huge range of applications through which citizens can request and receive service online, from applying for social housing for the elderly to a portal that facilitates collaboration among students, teachers, school administrators, and parents or guardians. Over 95% of renters use the housing department's portal to find apartments, and the library portal provides online access to the content of 44 individual libraries. After pilot projects in 2005, the city also instituted a contact center to handle inquiries and complaints from offline citizens and to support users of e-services. There is a special telephone line for the elderly to call.

Much efficiency happened inside the walls of government offices which had a net positive impact on people being governed. Confidence in the local government, which has fallen in the USA, grew.

In 2007, the City of Stockholm published *Vision 2030*, identifying the key characteristics the city aimed to have by that year. In 2030, according to the plan, Stockholm would be a world-class metropolis offering a rich urban living experience, the center of an internationally competitive innovation region, and a place where citizens enjoyed a broad range of high-quality, cost-effective social services. All employees of the city receive online training three times per year on the goals of the program and the changing nature of their responsibilities. The city also uses Web-based tools to track progress toward its goals and publishes good examples on the city-wide intranet to inspire others.

The "Stockholm Trend" accelerated when the Intelligent Community Forum identified, significantly influenced, and studied communities such as Dublin, Ohio. This city of under 50,000 seized its destiny after creating a municipal fiber network and embracing a holistic approach to connectivity, business, and social growth. As a result, Dublin is thriving, and during its ascension to one of the world's top seven communities, had more Fortune 1000 companies on a *per capita* basis than any other place in the USA. Because of its expansion of broadband and its successes, it has become the hub for an "Intelligent Ohio" initiative. Inspired by the cities of Taiwan, which were declared the building blocks of former President Ma's "Intelligent Island" initiative, Dublin has brought Ohio cities such as Hudson and Westerville to the concept. These cities have municipal data centers and open networks, and it seeks to have full coverage in order to benefit from the technology.

The correlation between connectivity to both businesses and homes – a category which for the sake of wage-earning is becoming increasingly indistinguishable – seems obvious. It was not a coincidence that, for example, Waterloo, Ontario (Canada), in 2007, was a community with about 115,000 residents. It committed itself to the Intelligent Community Method, which begins with adequate broadband. In addition to creating a profound ecosystem that produced startup after startup from places like the University of Waterloo (where the founders of Blackberry got their start), Waterloo[2] found itself with 10% of ALL of the publicly traded companies on the Toronto Stock Exchange in the tech sector. Not bad when you consider that there are over 30 million people in Canada, and this one "broadband" community had an outsized percentage.

As I said in my 2012 TED Talk[3], there are social consequences to having adequate community fiber

1 https://www.intelligentcommunity.org/stockholm

2 https://www.intelligentcommunity.org/waterloo_ontario

3 https://www.youtube.com/watch?v=5d4ZEgZU9Aw

that drive economic futures. Those most cited include kids staying home to live, businesses staying put and expanding and the community becoming far more desirable as each of its key pillars, from schools to public health and safety. This attracts capital investment and builds social trust, which also has economic consequences.

Over the long-term cities that have made investments in six critical areas identified by ICF as the main Factors[4] have achieved greater results over the course of years. Recently, for example, 8 of the top 10 safest cities in Canada were identified as “Intelligent Communities.” [5]

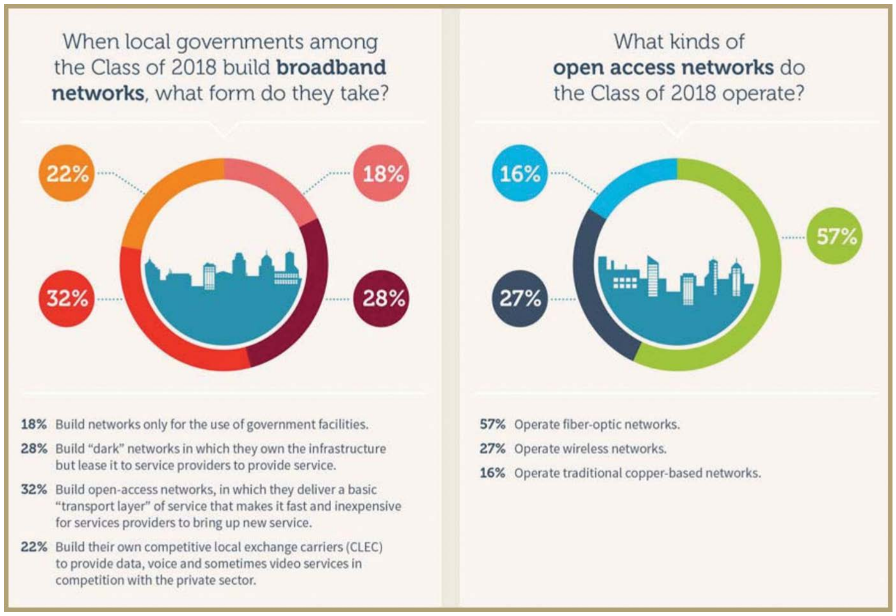
There are several models now for getting fiber to where it needs to go in the community (see the attached publication, *Connecting Your Community*). What is fundamental is to employ an approach that encompasses every aspect of the life that people live in a place, and to understand the culture, connections, and formation of the local economy. Cities are like people. They share similar traits, but they are diverse in ways that inform their economic expression.

***Lou Zacharilla*, Co-Founder**
Intelligent Community Forum
June 23, 2021

4 https://www.intelligentcommunity.org/method

5 https://icf-canada.com/eight-of-the-top-10-safest-cities-in-canada-are-icf-recognized-smart21-and-top7-communities/

A2 BROADBAND CONNECTIVITY



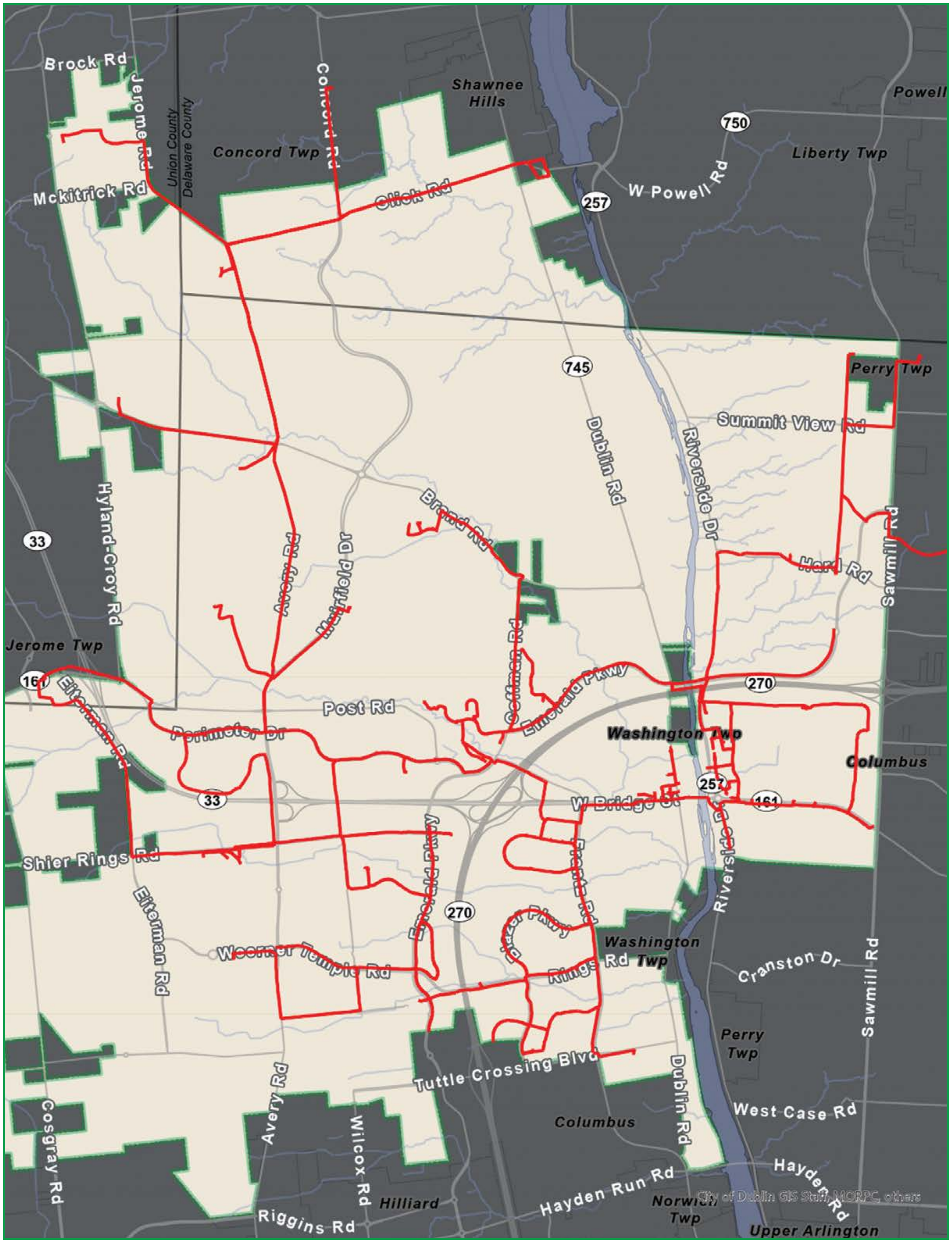
BROADBAND CONNECTIVITY

Broadband in the new essential utility is as vital to economic growth as clean water and good roads. Intelligent Communities express a strong vision of their broadband future, encourage deployment and adoption, and deploy their own networks where necessary.

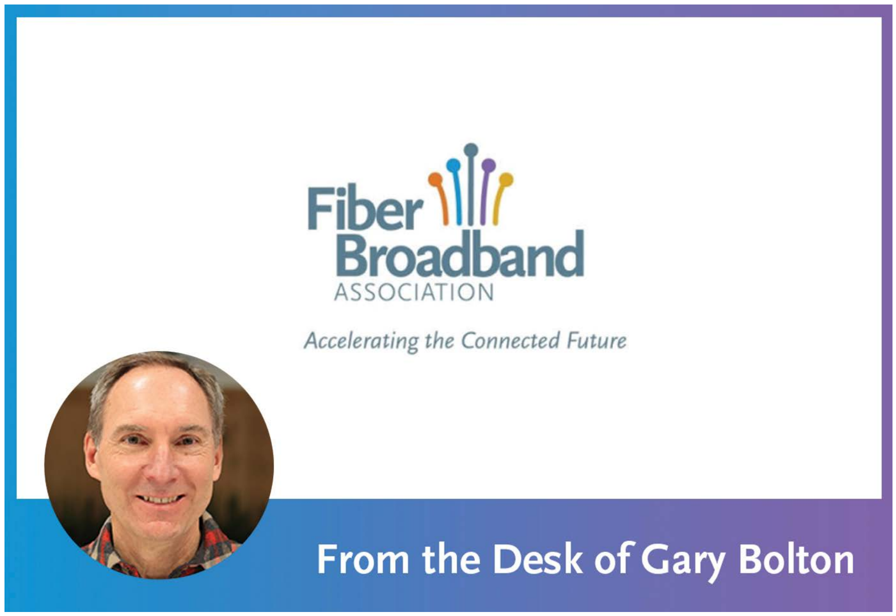
When you decide to act on broadband, you have a wide range of options. You will select among them based on their cost and difficulty, the public's understanding of the challenge, and your leadership's appetite for financial and political risk.

Access the report for more information:
Connecting Your Community: The Digital Infrastructure for Growth

A3 DUBLINK GENERAL MAP



A4 FIBER BROADBAND ASSOCIATION: PRESIDENT AND CEO PERSPECTIVE



July 12, 2021

Dear FBA Members,

The second quarter of 2021 got off to a strong start with a White House briefing on the American Jobs Plan that included $100B for broadband infrastructure as a means to finally bridge the digital divide and provide digital equity for all Americans. The President's plan aims to build "future proof" high-speed broadband infrastructure to provide 100% coverage. FBA took on the challenge to build bipartisan support for this broadband funding proposal, and we greatly appreciate our members' engagement during our Hill meetings over the past several months. A bipartisan group of Senators reached an agreement with the President on the framework for an infrastructure package that will include $65B in broadband funding. While it will not be the $100B initially proposed, this package is the single largest commitment of federal dollars ever for broadband infrastructure investment.

The $65B broadband funding package is currently broken down as follows (but changing on a minute-by-minute basis):

- $40B for broadband network construction
- $14B for USDA/RUS Reconnects
- $5B for affordability & adoption initiatives
- $6B for broadband financing program

A subset of Senators is currently negotiating the final details of the broadband section of the infrastructure package, including which agency will administer the funds, network requirements, and authorization amounts. We expect that there will be no mark up and the language will be added to the surface transportation bill when it is considered by the full Senate. The House will consider the package after the Senate.

While the infrastructure funding works its way through Congress, we do have billions ($US) of Federal and State broadband funding that has already been appropriated. The $9.3B of Rural Digital Opportunity Funds (RDOF) awarded on December 7 continues to work its way through the FCC's Long Form Application process. We expect RDOF approvals to be announced by the FCC in tranches, beginning with the FTTH-base projects. The first announcements should begin anytime now. The FCC still has not issued the contract for a vendor for Broadband Mapping to begin the process of identifying all broadband serviceable locations in the US by geocode. As a result, the earliest we are going to see more accurate and granular data is not until later next year.

We are starting to see RUS ReConnect awards in the form of grants for the second round, with two recently issued for FTTH builds. NTIA will begin receiving proposals for the Public-Private Grant program in mid-August and the Tribal Grant program on September 1st. With respect to the American Rescue Plan Act/ Local Block Grants, many States have adopted legislation to fund broadband deployment.

It is an exciting time for our industry as we are at the beginning of a major fiber investment cycle that will make a positive societal impact for generations to come.

Click here to view the letter.

entropy

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