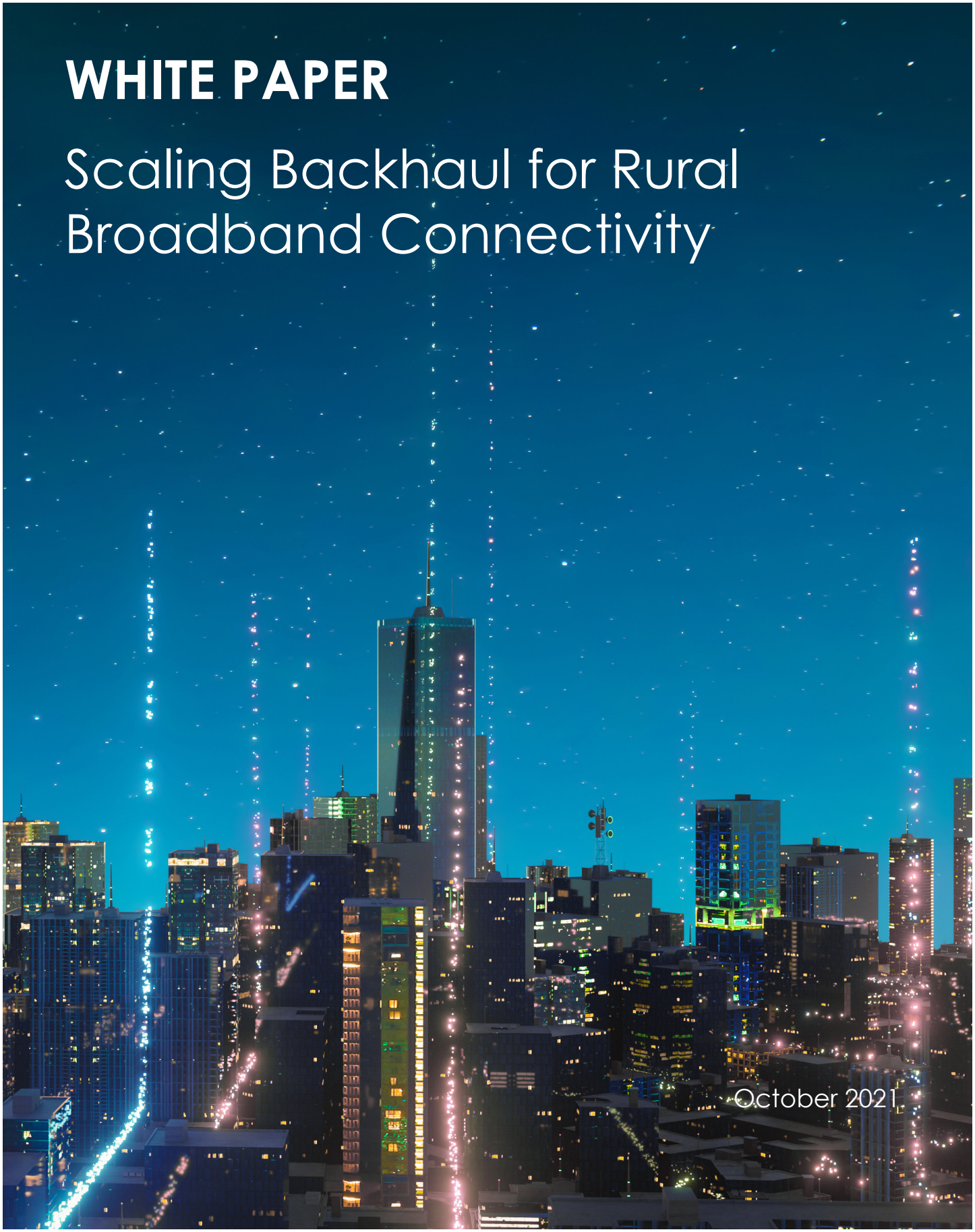
Empowering Networks

WHITE PAPER

Scaling Backhaul for Rural Broadband Connectivity



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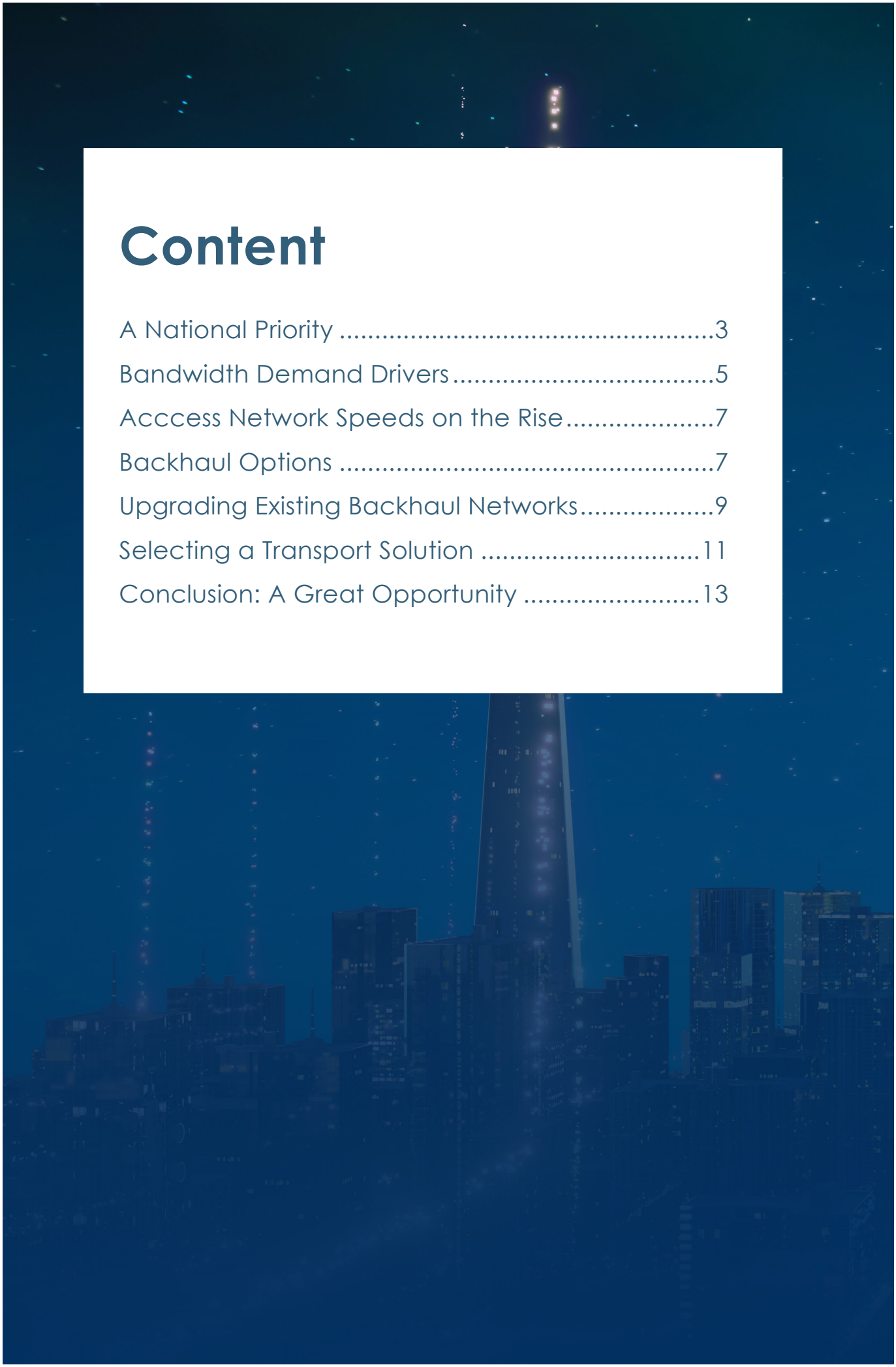

Content

The U.S. has made ensuring that all Americans have high-speed broadband available to them a policy priority. Increasingly, funding is being made available to large and small service providers to cover some of the costs of deploying service in underserved and unserved markets as a result. Before service providers pursue rural buildouts, they need to determine the best network architecture to meet their goals and the best approach to building it. And as they make those decisions, they must consider not only the speed and quality of the connectivity to individual locations, but also the capacity and scalability of the backhaul connectivity to the internet itself. Without this important piece, even the best access network is going to deliver poor service.

In this white paper, we look at the requirements for these backhaul networks, the funding available for them, and the deployment options service providers have for improving their 'middle mile' bandwidth.

A National Priority

Two recent examples of how serious the U.S. has become about universal broadband are the U.S. Department of Agriculture (USDA) ReConnect program and the Federal Communications Commission (FCC) Rural Digital Opportunity Fund (RDOF) program.

The ReConnect program had a budget of $550 million for its most recent fiscal year and $700 million for the previous year. The USDA used a point system to make awards to service providers to cover some of the costs of deploying broadband to unserved rural areas.

Last year's RDOF auction also targeted unserved rural areas, tentatively awarding $9.2 billion to help cover the cost of deploying service. Funding is intended to go to the bidder that committed to deploying service at the lowest level of support, with a weighting system favoring bids to deliver higher-speed lower-latency service.

There were 180 winning bidders in the auction but some of those bidders were consortia. The FCC allowed consortia to later break up winnings by individual member, a process that yielded a final total of 417 winning bidders covering approximately 5.2 million locations. This means, on average, each winning bidder was awarded $22 million to serve roughly 12,500 locations, or about $1,760 per location. Considering that the average cost of deploying Fiber-to-the-Home (FTTH) is $1,250 per location[1], only about $510 per customer can go toward upgrading the rest of the network.

Some of that funding will need to go toward the backhaul on-ramps that connect providers to internet points of presence that can be hundreds of miles away. For providers that already offer service in funded areas or areas nearby, existing backhaul connections will need to be upgraded to support higher volumes of traffic. In some cases, the RDOF winning bidder may not already have backhaul infrastructure to a community and backhaul connections will need to be established.

The danger here is underestimating what that volume of traffic is today and how quickly it will grow. Adequately sizing capacity to meet demand is more art than science but it needs to be understood that backhaul requirements will be substantial, as 99.7% of winning RDOF bidders committed to deploying service at speeds of at least 100/20 Mbps, including 85% that committed to deploying gigabit level service. Companies winning bids to provide 1 Gbps service committed to using fiber-to-the-home for at least some of their projects, although some may use fixed wireless for a portion of the projects. Just some back-of-the-envelope math shows that to serve those 12,500 locations, providers deploying 100 Mbps service would require up to 1.25 Tbps while those deploying 1 Gbps service, maximum usage would be 12.5 Tbps. In either case, it's a lot of bandwidth.

[1] Fiber Home Broadband Association Fiber Deployment Cost Study letter, September 2019

Of course not every subscriber will sign up for gigabit speed or even 100Mbps service but the number who will may be higher than you think and is growing quickly. According to data analytics firm OpenVault[2], more than 10% of broadband subscribers were provisioned for gigabit speed service as of the second quarter of 2021 (2Q21). That was an increase of 121% from 2Q20 and 75% from 4Q20 while about 80% of today's broadband subscribers are provisioned for service at speeds of at least 100 Mbps, including 32.4% that are provisioned for at least 200 Mbps.

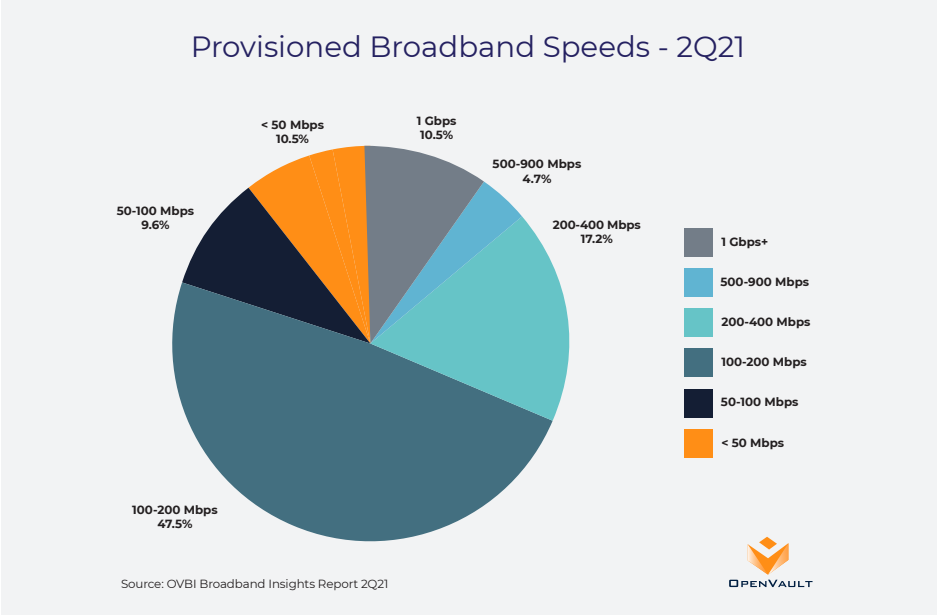

Figure 1 - Provisioned Broadband Speeds -2Q21
(Source: OpenVault Broadband Insights Report (OVBI) 2Q21)

The OpenVault report also shows that data usage levels are rising commensurate with higher speed connectivity proving that if you give people bigger pipes, they will use them. Over the last three years, the top usage tiers—those over 500 gigabytes (GB) per month—have increased in size to where they now account for nearly one-third (31.9%) of all data consumption.

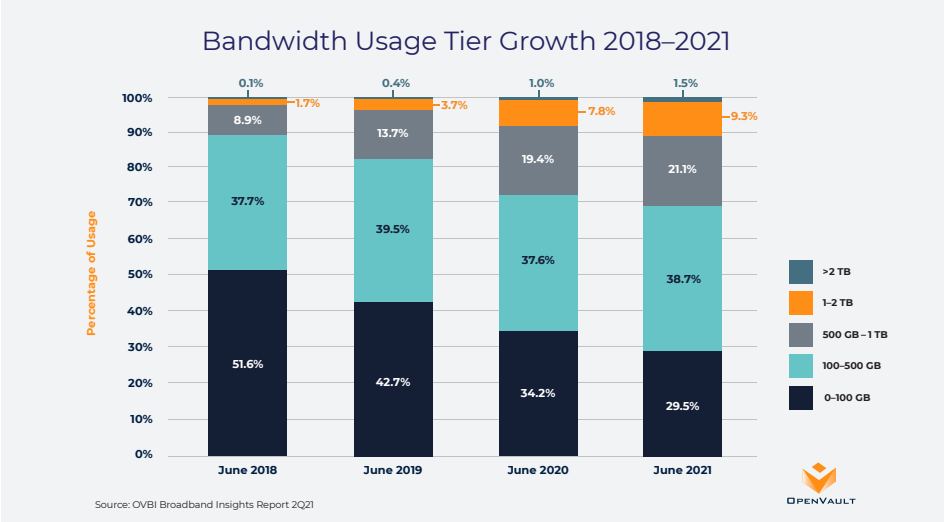

Figure 2 - Bandwidth Usage Tier Growth 2018-2021
(Source: OpenVault Broadband Insights Report (OVBI) 2Q21)

[2] OpenVault Broadband Insights Report (OVBI) 2Q21

Bandwidth Demand Drivers

The COVID-19 pandemic has accelerated bandwidth demand, which already was climbing pre-pandemic and a range of applications are contributing to the increased bandwidth requirements. In this section, we examine how some of the most important of these would impact the average RDOF winner.

Let us consider Netflix, the most ubiquitous and popular video streaming service on the planet. Over half of North American households (74 million out of 140 million in the U.S. and Canada) now subscribe to Netflix with the average U.S. Netflix subscriber using 9.6 GB of data per day in 2020. For our average RDOF winner with 12,500 locations, that's equivalent to 6,625 locations subscribing to Netflix, using an aggregate of 63,600 GB per day or 5.9 Gbps every second of every day.

Since subscribers don't stream videos all day long, we need to adjust our figures to account for how they do use it. Put another way, we have to squish all that data into a three-hour window. The result is that during peak hours (typically 8pm-11pm), aggregate demand would be 63.6 Gbps for Netflix alone.

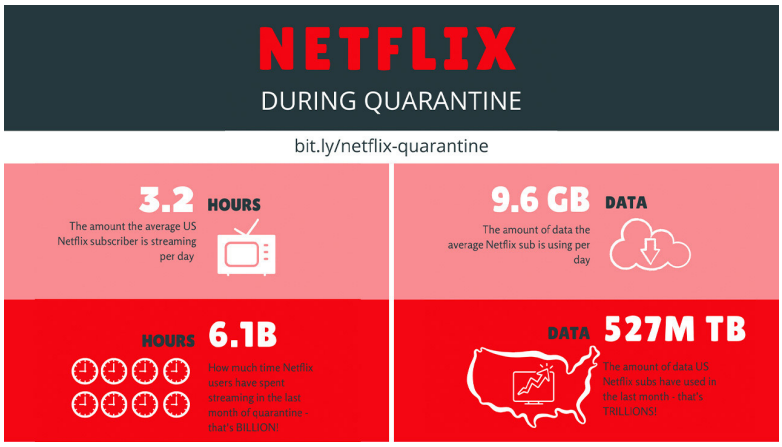

Figure 3 - Average Netflix usage in 2020
(https://www.pcmag.com/news/us-netflix-subscribers-watch-32-hours-and-use-96-gb-of-data-per-day)

Data revealed by Charter Communications on an April 2021 earnings call provides a bigger picture of consumer broadband usage. According to its statement, the average Charter customer uses 700 GB per month (about 23 GB per day), approximately two-and-a-half times our Netflix figure. Usage is highest among those who don't subscribe to Charter's video offering, averaging more than 1 terabyte (TB) per month or 33 GB which is nearly three-and-half times the Netflix usage. Based on these figures, we can estimate that peak aggregate internet traffic on the backhaul network could reach anywhere from 154 Gbps to 220 Gbps which, without an adequately sized backhaul network to support it, will result in degraded performance and unhappy customers.

Factors other than increased entertainment streaming need to be considered as well. The COVID-19 pandemic also drove more people to work from home putting additional strain on broadband networks. According to Pew Research, over 70% of Americans now work from home and three out of four of those people would prefer to continue to work remotely as much as possible indicating that this is not merely a temporary bump in usage levels but is, in fact, the 'new normal' level of broadband use.

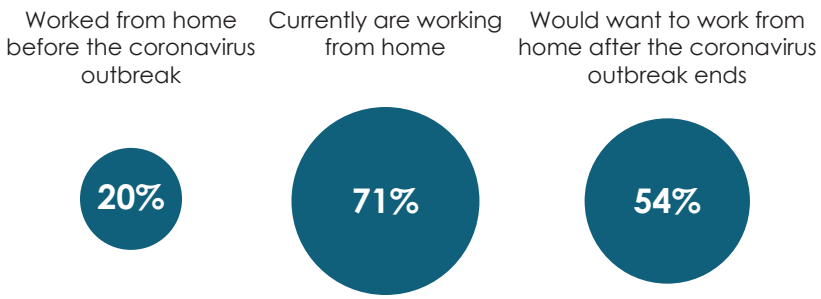

Figure 4 - Work from home statistics (Source: Pew Research)

Among those employed adults who work from home all or most of the time, 81% say they use video calling or online conferencing services such as Zoom or Webex at least some of the time, including 59% that use such services often. Services such as these require large amounts of bandwidth, both upstream and downstream.

The impact that teleworking (and remote learning and telehealth) has is that it frees people from having to live within commuting distance of their physical workplace which, based on identified trends, is expected to drive an increase in people living in rural areas. In fact, between 14 million and 23 million Americans intend to relocate to a different city or region now that the trend toward telework has made that an option, according to research from employment consultancy Upwork.

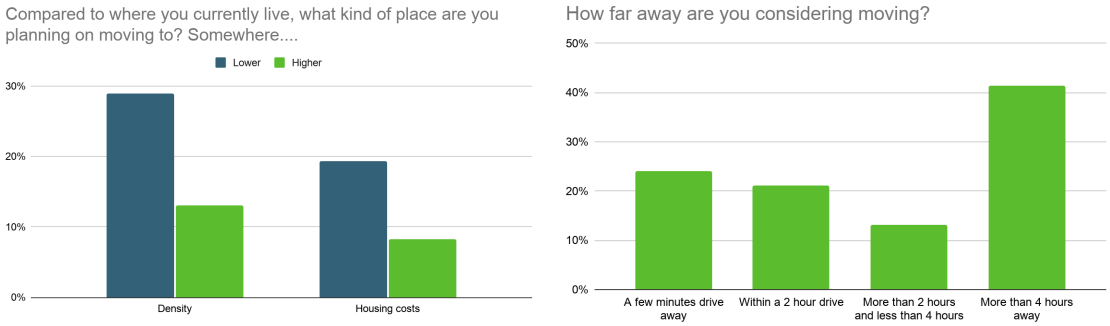

Figure 5a & 5b: - Work from home living preferences
(Source: https://www.upwork.com/press/releases/economist-report-remote-workers-on-the-move)

As shown in Figure 5a, people prefer to live in areas with lower population density and lower cost of living while Figure 5b shows that more than half of those who aim to relocate want to move at least two hours away from their current home to find affordable housing, with four out of five of those looking to move more than four hours away. These figures provide a strong indication that this migration will flow from more expensive urban areas to rural communities.

In addition to the sheer numbers, one also needs to consider *who* is moving. According to the US Bureau of Labor Statistics, the Millennial generation (b. 1981 to 1996) now makes up a vast majority of the working population with 65.2 million employed in 2020 compared to only 35.3 million for the Baby Boom generation, those over 55 years of age during that time.

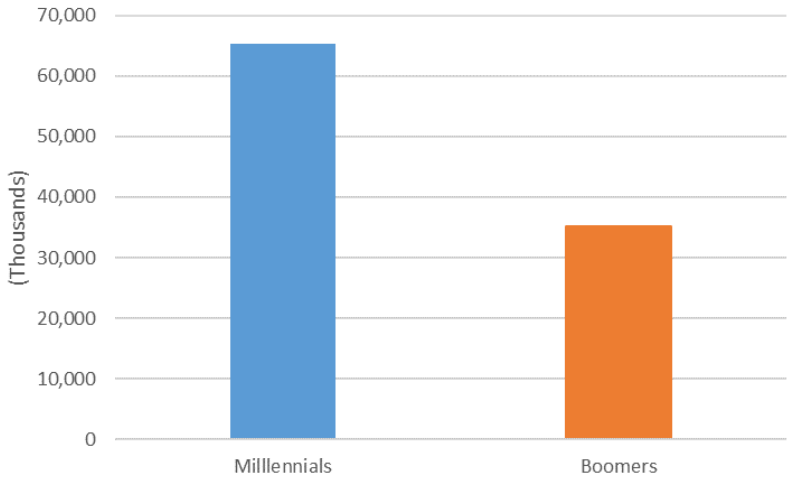

Figure 6 - 2020 U.S. workforce demographics (Source: U.S. Bureau of Labor Statistics)

This is an important distinction to understand since the Millennial generation is more tech savvy and, perhaps more importantly, more tech dependent than their parents and grandparents. As such, the availability and quality of high-speed broadband will be a key factor in their relocation decisions.

Access Network Speeds on the Rise

Considering these drivers of bandwidth demand, service providers increasingly will be interested in deploying XGS-PON broadband networks that can support speeds of 10 Gbps per customer symmetrically. In the future, operators are expected to deploy even higher-speed PONs. High-speed PON (HSP) technology is being designed to support speeds up to 50 Gbps, and NGPON2 supports speeds up to 80 Gbps. A similar trend is occurring among cable operators, who are upgrading their networks to support DOCSIS 4.0, which can support speeds up to 10 Gbps.

As we saw above, if you give customers higher speed connections, they will use them so as service providers make these upgrades, they will also need to upgrade their backhaul infrastructure to keep pace and avoid potential bandwidth bottlenecks.

Backhaul Options

Service providers have several different backhaul options to support fiber network deployments and upgrades. Providers moving into new areas may need to essentially start from scratch – an option known as a greenfield build. A greenfield build also may be appropriate for a provider that relies on a leased service to provide backhaul connectivity, as the company may be able to save money by building its own backhaul network.

Rural communities often are located a considerable distance from internet points of presence (POP). The average distance between rural broadband provider members of NTCA—The Rural Broadband Association—and an internet POP is 95 miles (150 kilometers), according to a recent NTCA member survey.

A survey of selected service providers conducted by Ekinops showed that the average monthly recurring cost (MRC) of a 10Gbps lit wavelength service able to cover that distance to be $2000 for a term of 36 months with a one-time setup fee of $7500. This works out to $26,500 per year or $2650 per Gbps annually.

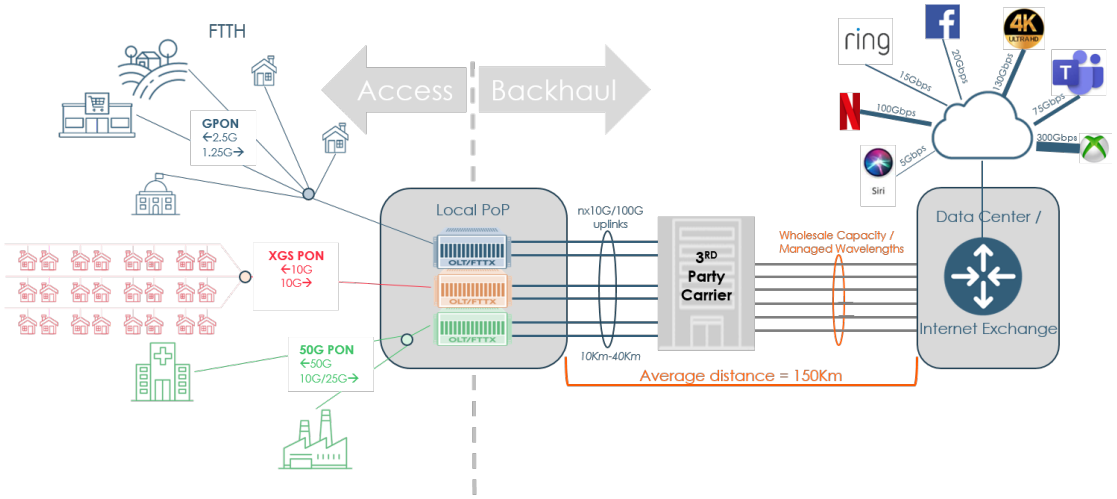

Figure 7 - Backhaul reference architecture

Now let us compare that to a greenfield build based on a point-to-point 200Gbps (chosen to address the peak bandwidth usage of 154 Gbps to 220 Gbps estimated above) WDM system consisting of equipment chassis (including common equipment such as fans and management cards), line cards, aggregation cards, amplifiers, filters and optics. Such a configuration works out to just $62 per Gbps annually, assuming a five-year amortization for the equipment.

On top of that we must add the cost of the fiber itself. Leasing existing dark fiber is the least expensive method with a typical cost of $15.63 per strand per kilometer per month, or $56,250 annually to lease a 150Km fiber pair which yields $281 per Gbps per year based on the same 200 Gbps. The most expensive option is deploying your own fiber at an average cost of $18 per meter (which includes the cost of both the fiber and construction), or $2,700,000 to build a 150Km span. Assuming a 20-year amortization, this provides an annual fiber cost of $135,000, or $675 per Gbps at 200 Gbps. Together with the equipment, this gives a total cost range of $343 to $737 per Gbps annually which is 87% to 72% less expensive respectively than lit wavelength services, a substantial savings by any measure.

Upgrading Existing Backhaul Networks

Broadband providers that already have their own backhaul infrastructure will likely need to upgrade that infrastructure as they upgrade or expand their access networks. As they upgrade the backhaul network, they may want to consider alien wavelengths that not only provide the quickest and most cost-efficient way of adding bandwidth but also allow the provider to reclaim capacity on existing spans.

Alien wavelengths are typically deployed in point-to-point configurations to increase capacity on a specific span. They are deployed using a WDM terminal at either end of the link and run over the existing line system (amplifiers, ROADMs, etc.).

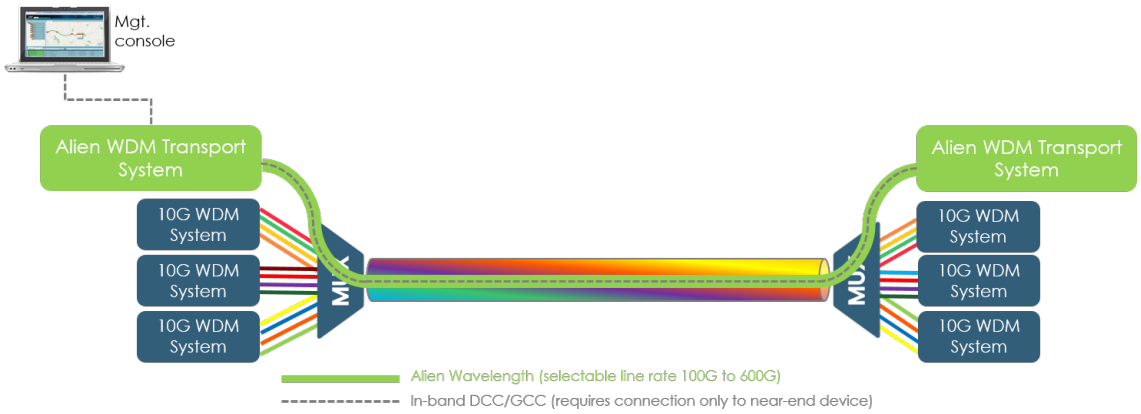

Figure 8 - Alien wavelength deployment

The line output of the new transponder card (one at each end) is added to an empty port on the optical mux (i.e., the filter) and the laser is tuned to the channel corresponding to that port. At that point, the channel corresponding to the alien wavelength is aggregated with the existing channels and sent out over the fiber link to the far end node where it is demuxed and directed to the far end line card. Importantly, the new WDM terminals do not have to be from the same vendor that manufactured the system onto which the alien wavelength is being added.

So why introduce a second-source equipment vendor if you already have an existing WDM network? There are several reasons. First, the existing optical platform may be obsolete. WDM systems are typically deployed for a long period of time—ten years or more—so while it may not be "end of life", the current system may be in support mode only. Secondly, the existing optical platform simply may not support the latest coherent line rates like 200G/400G 600G, etc. and services such as encryption or 32G Fibre Channel. It may also be that the required optical characteristics (i.e. OSNR) cannot be achieved over the existing fiber, or even that the entire network needs updating with new software / hardware / management releases that have been ignored for too long to the point where it is too costly and time consuming to now perform. Lastly, the service provider can actually achieve a better price point from the new vendor since the incumbent vendor will likely take the opportunity to recover profit margin on the heavily discounted deal it used to win the business originally.

Reclaiming Capacity on Existing Spans

Another benefit of alien wavelengths is the ability to reclaim capacity on existing spans. If you consider a fully filled 40-channel system with wavelengths operating at 10 Gbps (Figure 9a), adding a single 200G alien wavelength can free up 19 ports on the optical mux that can then be used for new traffic

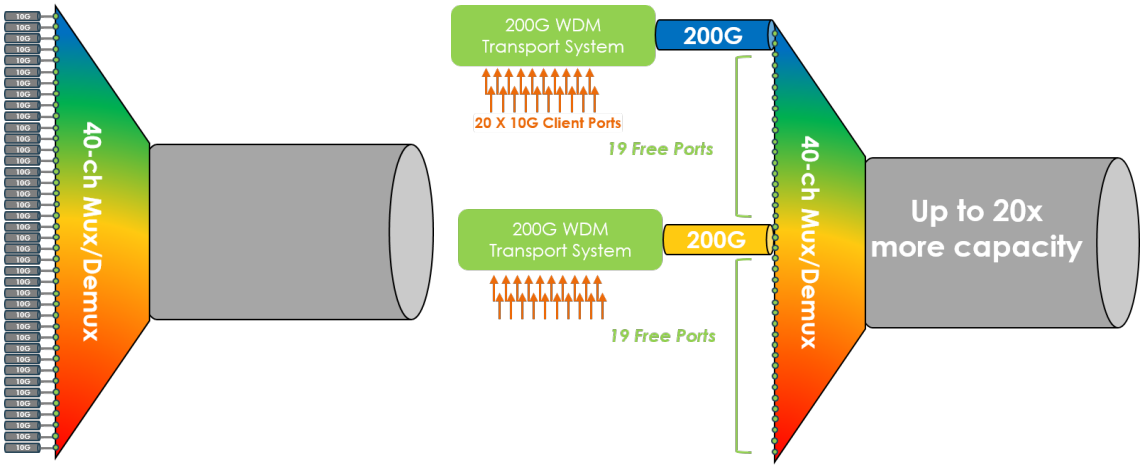

Figure 9a & 9b - Reclaiming capacity on an existing WDM system using alien wavelengths

This can be done by simply rolling up to 20 existing 10G channels over as clients to a 200G muxponder line card and connecting that output to one of the freed ports on the mux. Doing it a second time replaces all the capacity on the line and frees 38 ports for additional traffic (Figure 9b).

Potential Roadblocks

As service providers plan their backhaul networks, they may encounter certain roadblocks, but fortunately, each of these roadblocks has a solution.

A network with spans exceeding 80 kilometers may need one or more inline amplifiers (ILAs). Each of these requires an intermediate facility, typically a cabinet or unconditioned hut, which requires that the equipment must withstand extreme temperature variation.

If there is no intermediate location suitable for an ILA or if deployment is urgent and there is insufficient time to establish an ILA location, there are also some extended reach options available. One option is to use erbium doped fiber amplifiers (EDFAs) with counter-propagating Raman amplifiers or with co-and counter-propagating (also known as dual) Raman amplifiers.

There also may be situations where a service provider is only able to access a single fiber strand in certain areas or may want to use each fiber in a pair for different purposes, such as for metro and long-haul connectivity or for working and protect connections.

To address either of these situations requires equipment capable of using a single fiber for bi-directional communications. This option also can be used to increase revenue by enabling a provider to use both fibers in a pair independently to support services.

Selecting a Transport Solution

As a service provider, there are several important things to consider when selecting a WDM transport solution. For a green field installation, service providers will likely need a wide range of WDM equipment and will want to make sure that the manufacturer chosen has a full line of equipment that supports specialty capabilities such as the extended reach and bi-directional communications options outlined in the previous section. Below is a list of other considerations for selecting an optical transport solution.

- **Control of product development**:

Service providers also should consider an equipment provider that develops its own components, such as coherent optics, rather than using a supplier that relies on third-party vendors for turn-key solutions that include optics, digital signal processing, connectors and control software. The downside to the latter approach is that the equipment provider does not control product development and therefore has no way to differentiate itself. Depending on the size of the equipment vendor, it may have longer product lead times and may face supply chain risk as component makers prioritize their largest customers. Depending on mass-market pluggable optics may help keep the cost of the system down but they will always lag integrated solutions by two to three years in terms of performance due to the natural development curve in the industry.

- **Hidden costs**:

Some manufacturers require customers to pay a license fee to upgrade systems to higher speeds. This is of particular concern, considering that the current generation of coherent optics supports selectable line rates from 100G to 800G. Equipment is designed so that the line rate can be changed from the network operations center using a network management system, but a software key – available only to those who pay a license fee -- may be required to unlock this capability.

Some manufacturers also use keyed optics that are designed to prevent their service provider customers from using optics purchased from other suppliers. With this approach, the WDM management software will only recognize optics that have a built-in software key and are only supplied by the system vendor.

- **Product training and support**:

Service providers should find out if the manufacturer they are considering offers classroom options for service provider technicians who have limited WDM experience.

Service providers also should find out about a manufacturer's technical support capabilities. Some manufacturers outsource their call center to third parties. In this case, the primary support personnel have limited training on and knowledge of the equipment and little or no hands-on experience. That can lead to delayed responses if the support personnel must go to the vendor for help in troubleshooting a service provider customer's problem.

Some manufacturers also outsource logistics depots and these may be outside the U.S. Warehousing products in the U.S. can avoid shipping delays, including those caused by customs issues.

- **Lead times**:

The COVID-19 pandemic led to component shortages that are expected to impact availability of high-tech products into the future. Service providers should ask manufacturers about delivery lead times, as lead times of six to nine months are becoming more common among DWDM manufacturers.

- **Vendor commitment**:

Finally, service providers should take a manufacturer's size into account when selecting a vendor. Working with a large vendor may not be the best choice for smaller service providers because the large vendors may be focused primarily on their largest customers. While you may know them, they don't know you or really understand your business and network needs. Non-Tier 1 customers tend to get 'best efforts' service and, because they lack the requisite scale and buying power, they will never receive the best pricing discount the vendor has to offer so will always pay above market price.

As a rural service provider, working with a vendor scaled to service your requirements often leads to a better experience. A 'right-sized' vendor will truly value your business, be more attentive to your needs and responsive to requests and is more likely to be a true partner in helping you meet your network objectives.

Conclusion: A Great Opportunity

As the U.S. pursues the goal of universal broadband, more funding is being made available to service providers to deploy broadband to unserved and underserved rural areas and to re-architect their networks for the next generation of bandwidth demand.

Rising subscriber usage levels and changing population demographics have the potential to stress these networks, and as service providers plan rural deployments, they will need to install or upgrade backhaul capacity to meet these increased requirements.

In planning those backhaul networks, service providers need to anticipate current and future capacity needs, while remaining within the budget available for backhaul. Eliminating or reducing reliance on leased lines can save money. And providers that already have backhaul networks have a range of solutions available to them to upgrade capacity, including using alien wavelengths and reclaiming capacity.

As service providers select a WDM equipment provider to support their backhaul requirements, they should consider the size of the manufacturer, recognizing that bigger may not be better. They also should consider the breadth of the manufacturer's line, as well as the vendor's tech support capabilities, warehousing, and lead times. Service providers also should watch out for hidden fees, and service providers whose technicians have limited WDM experience should find out whether a manufacturer offers training on the technology.

Building rural broadband networks today is a better opportunity than ever, and selecting the right backhaul solution and the right vendor can help ensure that a service provider's rural deployment is accomplished on time and within budget.

About Ekinops

Ekinops is a leading provider of open and fully interoperable Layer 1, 2 and 3 solutions to service providers around the world. Our programmable and highly scalable solutions enable the fast, flexible and cost-effective deployment of new services for both high-speed, high-capacity optical transport networks and virtualization-enabled managed enterprise services

Our product portfolio consists of three highly complementary product and service sets: Ekinops360, OneAccess and Compose.

- Ekinops360 provides optical transport solutions for metro, regional and long-distance networks with WDM for high-capacity point-to-point, ring and optical mesh architectures, and OTN for improved bandwidth utilization and efficient multi-service aggregation.

- OneAccess offers a wide choice of physical and virtualized deployment options for Layer 2 and Layer 3 access network functions.

- Compose supports service providers in making their networks software-defined with a variety of software management tools and services, including the scalable SD-WAN Xpress.

As service providers embrace SDN and NFV deployment models, Ekinops enables future-proofed deployment today, enabling operators to seamlessly migrate to an open, virtualized delivery model at a time of their choosing.

A global organization, with operations in 4 continents; Ekinops (EKI) - a public company traded on the Euronext Paris exchange - is headquartered in Lannion, France, and Ekinops Corp., a wholly-owned subsidiary, is incorporated in the USA.

EKINOPS360 Dynamic Optical Transport

COMPOSE

ONEACCESS Fast Network Virtualization

Contact Ekinops today to learn how Ekinops can help.

Ekinops has nearly 20 years of experience assisting Tier II and Tier III service providers just like you overcoming the technical, operational and economic difficulties that come with rural broadband delivery.

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