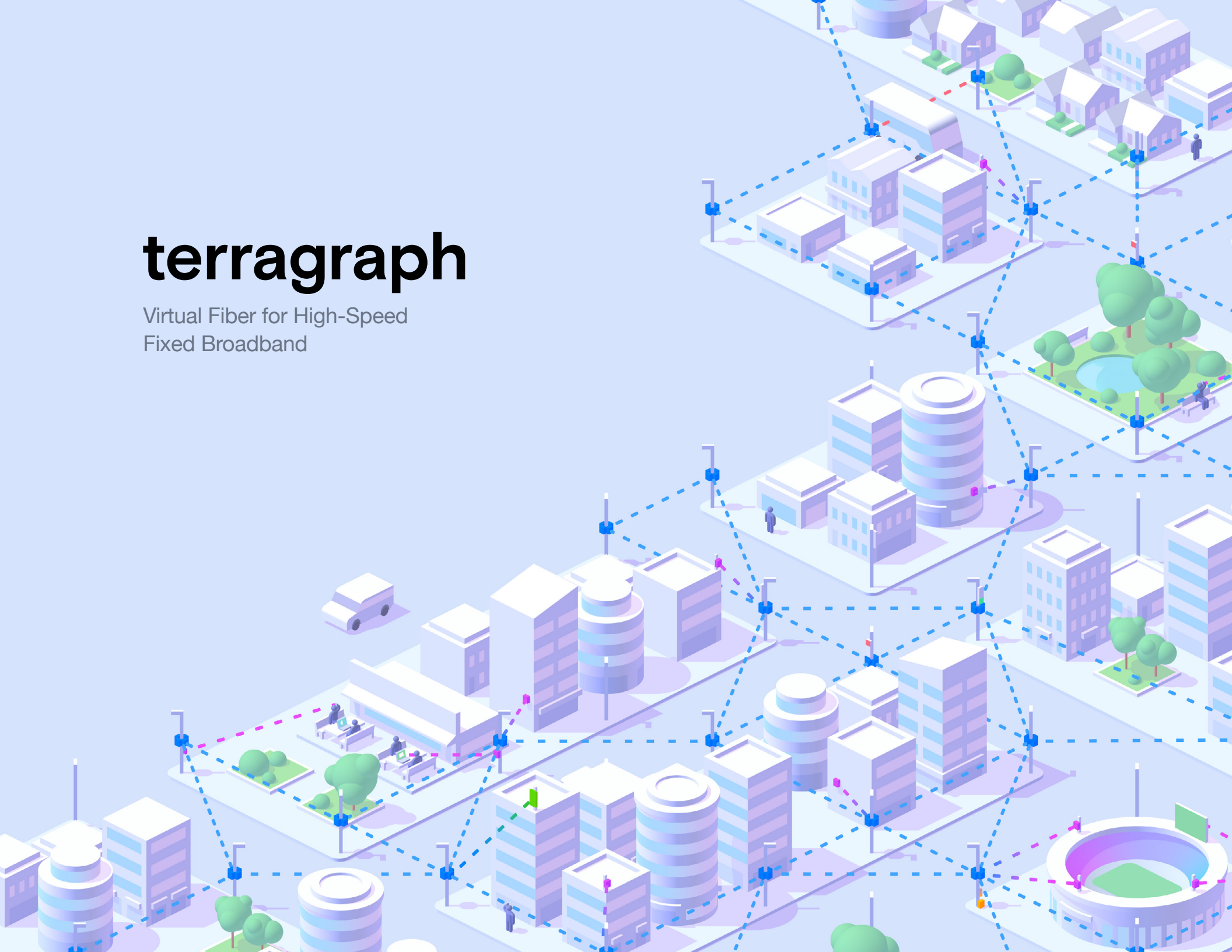# terragraph

Virtual Fiber for High-Speed
Fixed Broadband

Executive Summary

Facebook Connectivity's mission is to bring more people online to a faster internet. Terragraph serves this mission by reducing the time and cost for service providers to deploy high speed connectivity through the use of millimeter wave technology.

To help evaluate Terragraph as a solution for high speed fixed broadband connectivity, Deutsche Telekom and its subsidiary Magyar Telekom - the largest Hungarian telecommunications firm - conducted trials in Hungary, using the technology to connect homes that had only copper/DSL for broadband formerly. This effectively raised the speeds by over two orders of magnitude (from ~5 Mbps to ~650 Mbps) and dramatically changed the internet experience for customers in the trial.

The trial demonstrates Terragraph's viability as a commercial fixed wireless access solution.

This paper describes the trial deployments in detail, outcomes to date, and highlights the opportunity to use Terragraph for rapid and cost-effective deployment of Gigabit speed broadband connectivity.

Key take-aways from the trial to date include:

Deployment Speed
The time to deploy Terragraph was significantly faster than it would have been to deploy buried fiber.

Performance
Terragraph delivered gigabit-per-second connectivity with high reliability increasing speeds from ~5 Mbps to ~650 Mbps.

Total Cost of Ownership
The infrastructure cost is a fraction of that of an equivalent buried fiber solution.

Forward-Looking Opportunities
The trial experience highlighted opportunities to enhance the Terragraph value proposition with solutions ranging from automated planning tools to publishing deployment best practices.

Background

State of Broadband and the Emergence of Millimeter Wave

With the rapid growth of internet services touching virtually every aspect of life, reliable high speed broadband has become essential. Access to broadband is now deemed an essential service to participate in the global economy. In 2015, the U.S Federal Communications Commision in the US redefined the definition of "broadband speeds" from 4 Mbps to 25 Mbps download, increasing the number of households without broadband to 13% in the US.

Globally, there has been tremendous progress towards that speed goal with over 60 countries exceeding the average. The fastest speeds are in high population density areas, including Singapore (182 Mbps) and Hong Kong (146 Mbps). However, in most of the world, the average is below 25 Mbps download, with many under 10 Mbps.

Solving this connectivity speed shortfall is the goal of many in the telecom ecosystem. This is true for the service providers, as well as national and local governments. Higher speeds will help communities access online commerce, education, entertainment, healthcare and government services.

Currently there are two methods to provide truly "gigabit" fixed broadband speeds: traditional fiber and emerging millimeter wave wireless networks. The latter is widely recognized as having a crucial role to play in next generation networks, as evidenced by 5G plans to use millimeter wave technology for both fixed and mobile access.

Wireless networks employ radio frequencies (RF) for a variety of uses and operate in different frequency bands. These range from cellular networks (0.7 - 3.5 GHz), Wi-Fi access points (2.4 & 5 GHz), Bluetooth (2.4 GHz), high capacity fixed long-range point-to-point microwave links (6 GHz to 23 GHz) and more. Generally speaking, there is more speed and capacity at higher frequency bands.

Developments in radio technology have opened up new opportunities to create innovative new products that operate at higher frequency bands. These are the bands in the "millimeter wave" range, so-called due to the fact that over 30 GHz, the wavelength is less than 1 cm. Strictly speaking, the millimeter wave band is from 30 GHz - 300 GHz. Most of those bands have approximately 500-800 MHz of spectrum. However, even more exciting are the possibilities offered by the V-Band (60 GHz) and the E-band (70-80 GHz), with the former operating with at least 7 GHz of spectrum, and potentially even 14GHz. This makes the V-band the largest commercial radio band ever used.

Introduction to Terragraph

Facebook developed Terregraph starting with a basic problem statement: "How can we contribute to the telecom ecosystem with a solution providing cost-effective, ultra-high speed connectivity?" Fiber is the de-facto standard today for delivering connectivity in excess of Gbps in some cases, yet fiber is often prohibitively expensive to deploy due to right-of-way and trenching costs. As such, Terragraph seeks to address the problem using millimeter wave technology.

> "**Terragraph is able to deliver fiber-like speeds over metro-scale service areas at a fraction of the cost of fiber.**

Terragraph uses millimeter radios to create both a scalable distribution network, as well as a home access link. Terragraph is able to deliver fiber-like speeds over metro-scale service areas at a fraction of the cost of fiber. Terragraph radios operate in the 60GHz V-Band where there is an abundance of available, unlicensed spectrum, and employ a TDD/TDMA MAC structure which enables extremely efficient use of of this spectrum even in highly congested scenarios. The radios are able to inter-connect to form a Layer 3 mesh which can be scaled over large geographic areas and offers redundant and reliable connectivity between end-points. Terragraph radio nodes can be deployed on abundant physical assets such as street furniture, for example to provide last-mile gigabit-per-second connectivity between a service provider's fiber presence and subscriber residences. The deployment of street-level radios mitigates the high costs associated with fiber rights of way and trenching, thus lowering the cost-barrier for service providers to bridge the demand for high speed connectivity.

Attributes of Terragraph

- Operates in the unlicensed V-band: 60 GHz

- Uses standardized 802.11ad and 802.11ay, enhanced with TDD/TMDA for MAC efficiency at scale

- Current proof-of-concept system has a peak data rate of 4.6 Gbps (one direction) and and average peak user throughput of over 1 Gbps

- Single link maximum range is approximately 250 meters

- The network can be deployed in days rather than months

- Highly cost effective vs buried fiber

- Small, lightweight and low power - suitable for street level deployments

- Supports highly scalable layer-3 mesh, powered by Open/R routing software

- Uses IPv6

Terragraph is focused on enabling and supporting the ecosystem of silicon vendors, OEMs, and service providers to build and deploy the technology to deliver high-speed connectivity. To demonstrate Terragraph and provide the ecosystem with a proof of concept in advance of commercial product availability, Facebook has developed a reference radio design as well as a suite of tools to aid network design, deployment, and management. Terragraph trials with service providers are an important step in demonstrating the technology's value proposition and allow the ecosystem to learn what it takes to deploy services over Terragraph.
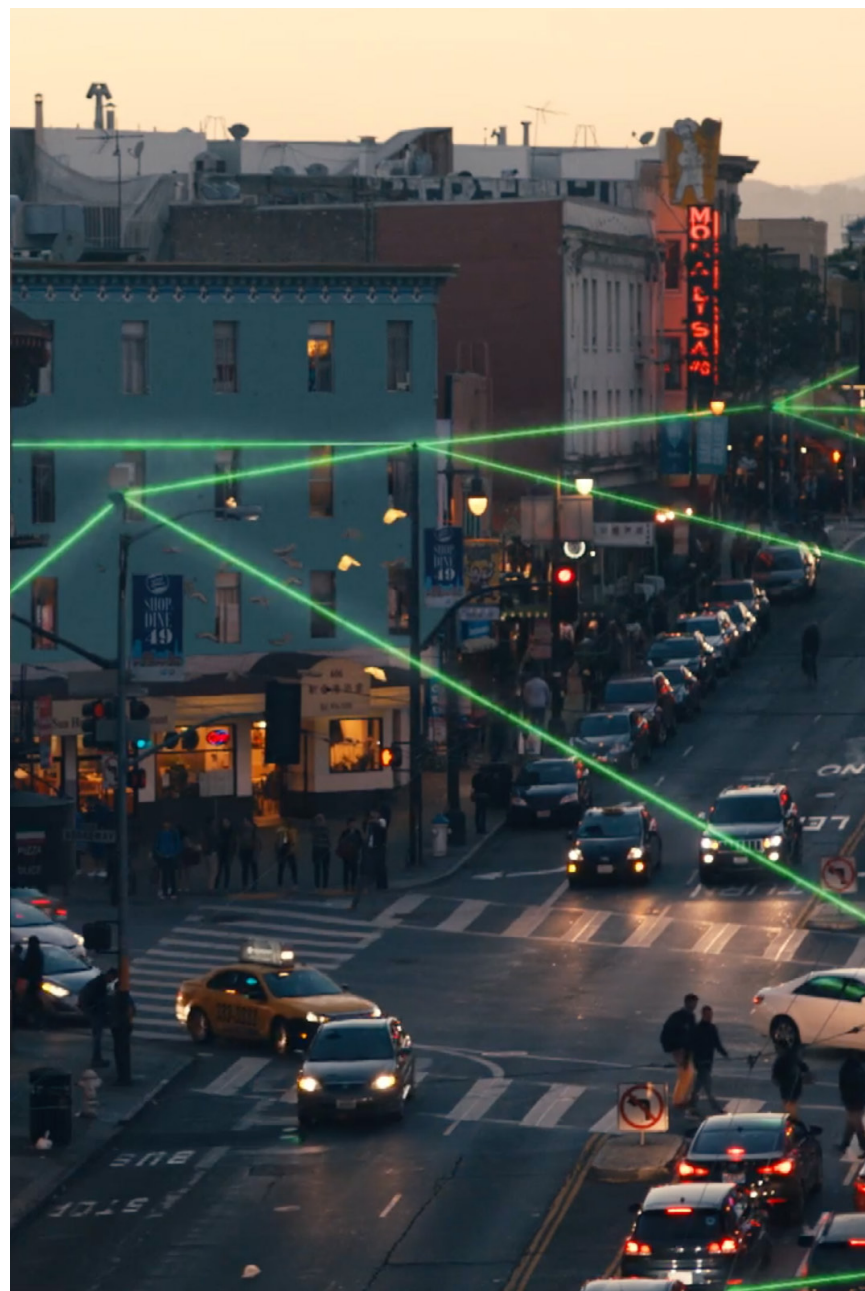
Facebook and Deutsche Telekom Collaboration

Facebook and Deutsche Telekom have collaborated as part of the Telecom Infra Project (TIP) since early 2016. TIP was started with the goal of accelerating the pace of innovation in the telecom industry. TIP seeks to drive innovation across the entire telecom landscape. That means collectively working to design and build technologies that are better, more efficient, and more interoperable.

Magyar Telekom Trial in Mikebuda, Hungary

Deutsche Telekom partnered with Facebook to evaluate Terragraph as a fixed wireless access solution. Deutsche Telekom and its subsidiary in Hungary, Magyar Telekom, worked with Facebook to deploy a Terragraph trial using the reference design radios.

Two towns in Hungary were selected for trial locations with Magyar Telekom. The town of Mikebuda was selected for the first pre-commercial trial, and the town of Marko was selected as a second location. The Mikebuda trial began in May 2018, and the Marko trial in October 2018.

Figure 01 | Teacher with her students in Mikebuda, Hungary

Trial Location Selection

Facebook worked with Magyar Telekom's team in Hungary to plan and design the network collaboratively. The planning began in early 2018 with a review of locations, from which Mikebuda and Marko were ultimately selected.

The following attributes were considered during the trial location selection phase:

- Magyar Telekom presence
- Existing broadband was DSL
- Fiber availability
- Sufficient street lights and utility poles for mounting radio equipment
- Light suburban density of homes

Mikebuda was deployed first, as the smaller of the trial locations, such that insights gained from this trial could be subsequently applied in the Marko deployment.

The goal of the installation in Mikebuda was to provide coverage to the entire small town about 0.4 sq km in size. There are approximately 150 single family homes in the town.

Existing Services in Mikebuda

Prior to the trial, Magyar Telekom had about 100 subscribers of their DSL service in Mikebuda and they were all approached for participation in the Terragraph trial. Of the 100 subscribers, 25 were also subscribing to IPTV Multicast services. The network in Mikebuda had two DSLAMs with about half the traffic on each. The peak speed out of the DSLAMs was approximately 15 Mbps and 40 Mbps peak, with the higher capacity version providing sufficient speed to support the multicast IPTV.

Service Model

With point-to-point layer-2 tunnels in place between the BNG and subscriber CPEs, it is possible for the service model to be exactly the same as it is for other fixed access platforms in Magyar Telekom's portfolio. Once connected to the Terragraph network via a client node, the Mikrotik CPE establishes 2 pseudowires to the EoIPv6 tunnel terminator: one for HSI and one for IPTV. A PPPoE dialer in the CPE establishes connectivity to the BNG using pre-configured user credentials, thus enabling Internet access. Simultaneously the DHCP client running over the other pseudowire acquires an IPv4 address, activating the IPTV service. CPE management & configuration runs over TR-069 (over HTTPS) which can either run on the HSI connection or can be run on a separate tunnel or PPPoE session.

Network Integration Design

The Terragraph network had to be integrated with Magyar Telekom's existing network offering internet and IPTV service. The goal of the integration approach was to re-use existing elements to the extent possible, to avoid having to re-design standard operating functions.

Magyar Telekom traditionally provides high speed internet service using PPPoE over xDSL and GPON. PPPoE sessions are terminated on a BNG router. To integrate with this service architecture, an ethernet transport is required between the CPE and the BNG. Since Terragraph is a routed IPv6-only transport, a tunneling overlay is needed for ethernet connectivity to the BNG. For Magyar Telekom's IPTV service, a similar tunneling mechanism is needed over Terragraph.
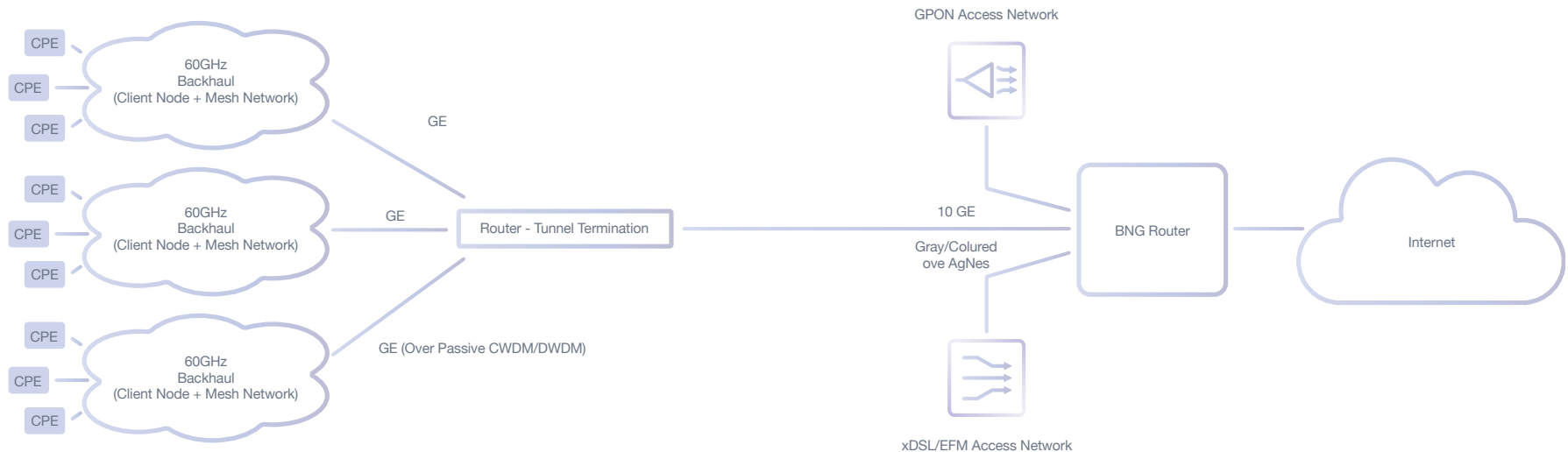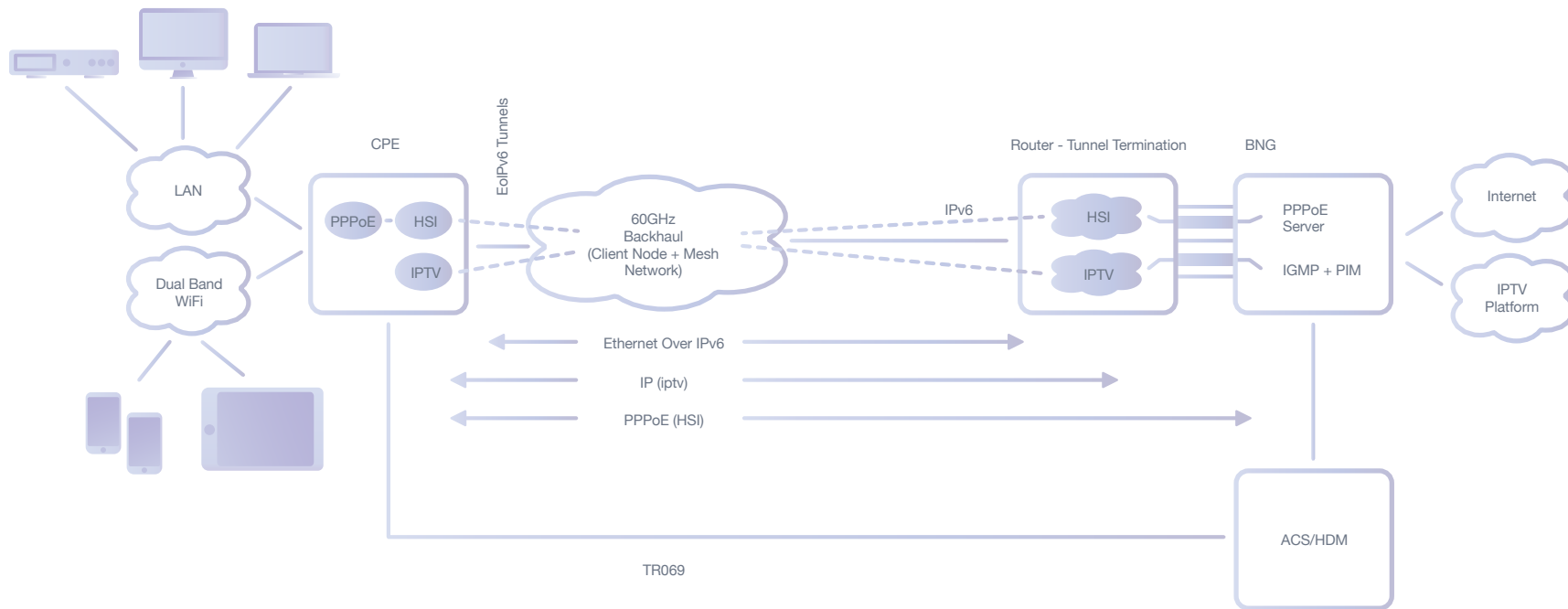
CPE Platform

The Mikrotik hAP ac2 was selected as the CPE for this trial, primarily due to its support for layer-2 tunnels over IPv6. This device features dual-band 2x2 WiFi, 5 Gigabit ethernet ports, IGMP/IGMP proxy, customizable GUI, and is able to forward up to 1Gbps over stacked tunnels.

For layer-2 transport, the Mikrotik hAP ac2 supports a vendor-specific implementation of of ethernet over IPv6 (EoIPv6). In order to terminate the layer-2 tunnels and forward the decapsulated ethernet traffic to the BNG, the Mikrotik CCR1016-12S-1S+ router was selected. This router features 12 x 1G fiber connections, making it well suited to connect Terragraph "fiber point-of-presence" nodes. The Mikrotik CPEs and routers would book-end the Terragraph IPv6 mesh, effectively making it transparent to MT's layer-2 service model.

Service Model

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RAN Planning

The process of planning a Terragraph network includes both the skills of microwave design and cellular system design: the links must be clear line of sight and within the high capacity operating range of the radio system. Unlike mobile networks, the RAN planning for a fixed network can be targeted precisely in the area of interest prior to marketing and sales. For example, in a large city an operator can select a small region and deploy their first Terragraph to hone the process and test the market.

Figure 02 | Terragraph Network Installation in Mikebuda, Hungary

Planning process:

- **Identify Target Location for Coverage:** Magyar Telekom chose to cover the majority of streets in the town. They did this based on their own market knowledge of the town, and where their existing customers were located.

- **Fiber POP location:** A Terragraph network requires at a minimum 1 fiber PoP (point of presence) to connect to the operator's network. A better practice is to deploy multiple PoPs to eliminate single points of failure, as well as provide additional capacity in anticipation of subscriber growth. For the Mikebuda trial, a second PoP was created by running aerial fiber in the network over a 250m range across town.

- **Site Acquisition/Pole identification:** In a Terragraph network "site acquisition" requires identifying the owners of the street furniture: street lights, signal lights, utility poles and any other vertical structure with power suitable for a Terragraph Radio. A fully provisioned (four sector) Terragraph site requires up to 100 W of power. Typically power requirements are less than this, given a fully provisioned site is seldom required. In Mikebuda the power poles were identified that would be suitable to cover their service area. Access to the poles was negotiated between Magyar Telekom and the local utility company which owns the poles.

    - **Line of Sight:** For each pole the line of site was verified by the network engineers so that there were no obstructions between the poles and the homes that were to be served by the network

    - **Existing equipment:** The status of the poles was evaluated in terms of size/space, power and other equipment already mounted on them.

    - **Mounting:** The size/shape of the poles were examined and found to be unique compared with typical cylindrical poles. Magyar Telekom worked with a system integrator (SI) to create a custom mounting bracket for some of the poles.

- **Capacity planning** - In addition to supplying broadband internet access, Magyar Telekom was providing IPTV to customers in the area and wanted to extend that service to the new high speed customers. However, since the existing service available was DSL and the subscribers were constrained to 5 Mbps the trial was used to measure and determine the capacity needs over time in such an environment.

    - A rough approximation with a peak of >500 Mbps and a sustained average throughput estimated at 10X the current speed (50 Mbps) indicated that 50 subscribers could be served with 2.5X over-subscription with the 2 PoPs in the network.

Figure 03 | Network Planning Diagram for Mikebuda Trial

Permitting and Related Permissions

To meet regional regulatory requirements, a set of permits was required prior to installation of the equipment, this included:

- **License for 60 GHz operation:** Currently, outdoor use of 60 GHz must be operated under a temporary license, which was secured early in the process. Note that once ETSI grants the unlicensed use of the 60GHz band, anticipated in 2019, this requirement will go away.

- **Utility Poles:** The utility company in Mikebuda owns and operates the poles employed in the design. Many of the poles already had 3rd party service equipment. Additionally, maintenance of the poles is typically performed using a ladder rather than a utility vehicle ("bucket truck"). This required that the radios be mounted in such a way to not impede this process. Both the utility company and the other firms operating the poles granted permission to the team.

- **POP site:** Magyar Telekom required permission from the municipality to use the local buildings as the POP site and to install radio equipment.

- **Foliage Issues:** In some cases there were minor obstruction from local foliage. In these areas, permission was required from the municipality to trim the foliage to remove the obstruction.

Installation

After collection of the appropriate permits and permission completed, the installation of the radios commenced.

Deployment was completed in two phases:

1. Deployment and optimization of the distribution network - i.e. the mesh network which covers the entire service area, including the fiber PoPs

2. Deployment of subscriber equipment

The deployment of the distribution network was accomplished in less than 2 weeks. Each site installation took approximately 2 hours.

Once the distribution network had been deployed, the ~106 homes within its coverage area were then eligible for high speed fixed wireless access.

Milestones	Timeline
E2E Controller Installed & Tested	25/5/2018
Start Installation of DNs	25/5/2018
Fiber POP Deployed & Internet Connectivity Validated	30/5/2018
Ignite First DN: DN Links	30/5/2018
Finish DN Installations	6/6/2018
Finish DN Ignitions	7/6/2018
Validate DN: Internet Functionality	8/6/2018
Installation of Friendly User	11/6/2018
Design Complete	14/5/2018
Validate CPE: Internet Functionality	15/6/2018
Start Installation of Household CNs and CPEs	18/6/2018
Ignite 1st Household CN: DN Link	19/6/2018
1st Household User Served	20/6/2018
Finish CN & CPE Installations	1/8/2018
Finish CN & CPE Validations	1/8/2018

Subscriber Activation

With a goal of signing up to 50 subscribers, the Magyar Telekom sales team employed a five-step approach to activate the service. Going forward, there are opportunities to optimize and accelerate these steps, and ultimately the desire would be to consolidate the site survey, installation, and activation into a single visit for the majority of customers.

Step 1 - Contract Signature

The sales team went door-to-door in Mikebuda offering a free trial service for a 6 month period. The service offering included both broadband internet as well as IPTV service (with the initial limitation of 20 customers). After the contract signature, the installation subcontractor contacts the customer within 3 days to agree on a date and time for an on-site survey.

Step 2 - Site Survey

The survey team visits the customer household, identifies the install location, and designs the complete solution. The subcontractor schedules the installation date and time with the customer. The required time for the site survey was approximately two hours per household. This included taking measurements, creating a basic drawing for material calculation, and finalizing a Build of Materials (BoM) for the install.
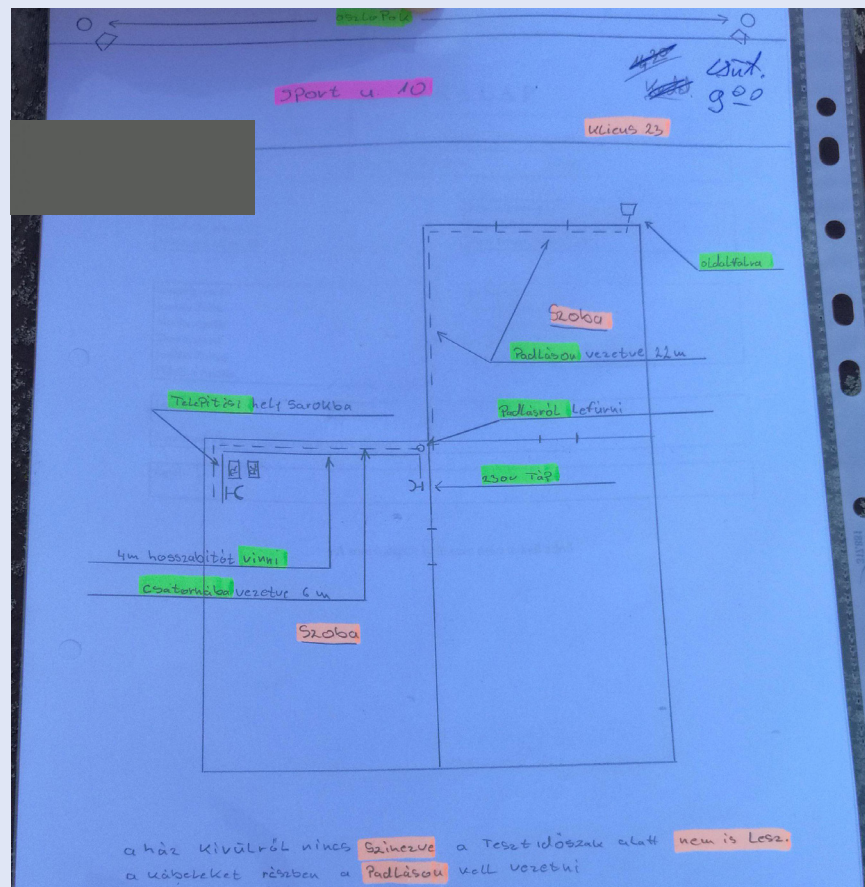

Figure 04 | Sample Site Survey for Terragraph home installation

Step 3 - Physical Installation

The installation team included two technicians. They collect all the required material, consumables and equipment, and visit the customer at the agreed time. Once on-site, the team confirmed the install location with the customer and cross-checks the measurements in the drawing. The team also confirmed the approximate direction that the CN (customer) will point to establish a connection with the DN (distribution node). The average time required for the installation was on average 2 hours/per household with a two person installation team.

Figure 05 | All parts required for one installation: antenna mount, virtual fiber radio link, router, converter, power supply, IPTV STB for some customers, cable ducts and Ethernet cable, etc.

One of the technicians prepared the necessary cables (ethernet and power) while the other colleague installed the antenna mount and the radio link to the predefined location. For all installation, the preferred install location is just under the eaves, since this minimizes damage to the facade. The radio is oriented so that the face aims toward the nearest line of site DN. The cables are then installed between the radio and the end point, using cable ducts for protection. Once connected and fastened, the technicians validated the ethernet cable with a cable tester. Finally the interior equipment was placed and powered.
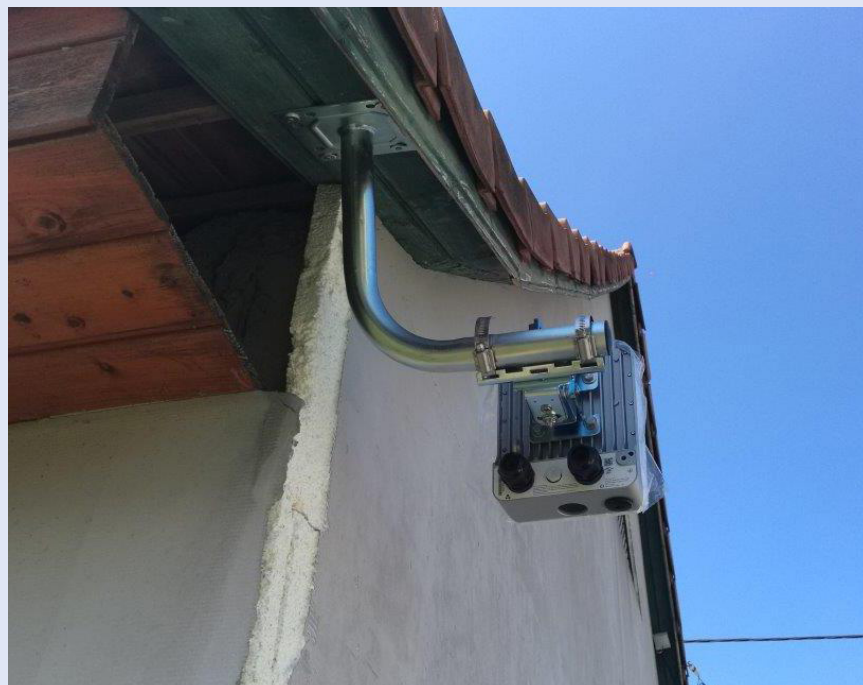

Figure 06 | Installed Terragraph receiver outside a customers home

Step 4 - Customer Provisioning

After physical installation was completed, the service provisioning team arrived at the customer site. They checked and scaned the MAC address/serial number of the client radio node, and it is added to the network management system. The wireless link was activated between the customer home and the DN radio (currently completed with some manual steps, but this process will be fully-automated in the future). Once a connection was established, a representative from Magyar Telekom sent the customized configuration to the router (this process will be fully-automated in the future). After the internet service was established, a unique sticker is placed on the router including the number of Magyar Telekom's customer care and the identification number of the router. In case of an incident, the customer can call this number and identify their router by the ID number.

Step 5 - Testing

Finally, when the service was activated, a speed test for the 2.4GHz and 5GHz Wifi interfaces is performed. The technician took a picture of the installation outside of the home, filled out a form including the serial numbers of the equipment distributed (TG Radio, Router, DC/DC converter, IPTV STB), and the form is signed by the customer.

Figure 07 | Terragraph Network Installation in Mikebuda Hungary

Trial Outcomes

Network Summary

The Terragraph network in Mikebuda has been operating for multiple months now, delivering high speed broadband connectivity to approximately half the households within its coverage area. Some statistics at a glance include:

- 50 customers connected as of the writing of this paper

- 106 homes covered over a service area of approximately 0.4 sqkm

- Peak measured speeds in the trial have been measured as ~1Gbps at the Terragraph client nodes, and 650 Mbps at the indoor CPE (wired). Note that the CPE speed limitation relative to the Terragraph CN is due to the limited rate at which the CPE can perform the tunnel encapsulation & decapsulation for EoIPv6. Peak in-home Wi-Fi speeds are in the range of 300 Mbps, limited by the Wi-Fi air interface itself (2x2 802.11ac over 40MHz channels).

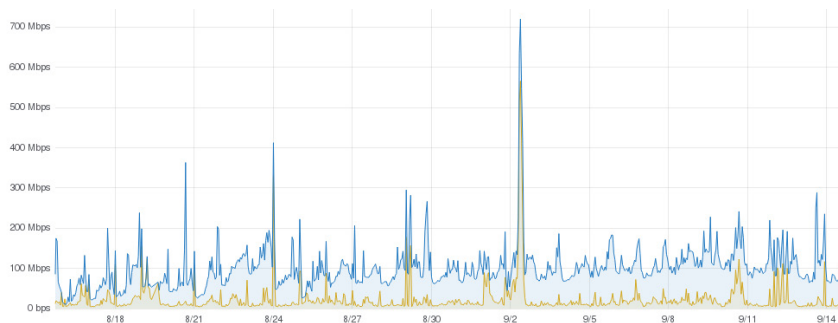- Average service availability of 99.5% or better.

Figure 08 | Mikebuda network utilization - 49 subs connect - as of 14 Sept 2018

Customer Experience

Customers are experiencing speeds up to 10-100 times faster than their previous connections (5-10 Mbps with DSL to 500 Mbps with Terragraph). Likewise, the IPTV customers have been impressed with the service. The first customer noting, "This is pristine clear! The one we had before was a mess."

Figure 09 | Image quality improvements post Terragraph installation

Mikebuda Trial Takeaways

Terregraph offers a huge advantage in terms of time to deploy

The speed at which the Terragraph network was deployed in Mikebuda was noteworthy. In just two weeks, over a hundred households were covered with the option to subscribe to services. Subsequent customer connections were completed on the order of hours each. Alternative infrastructures capable of delivering similar connection speeds - i.e. fiber - would likely have taken several times longer to deploy.

Of course this being the first fixed wireless access trial deployment for Terragraph, there were multiple opportunities identified to further reduce the time to deploy - e.g. through refinement of best practices and workflow - as well as enhancements to the software tools used during deployment. These learnings will be put into practice for the Marko trial, which is therefore expected to demonstrate even faster deployment speed.

Terragraph offers Gigabit-speeds with a much higher flexibility of deployment than fiber

Based on the results from the trial and projected commercial costs it is estimated that Terragraph CapEx per home covered will be as low as 30% of that of an equivalent buried fiber build in some markets. Now that the Mikebuda trial has reached operational "steady state", OpEx will also be measured and factored in to the cost analysis.

Availability of the Terragraph solution lives up to the requirements of fixed broadband service

The Terragraph network in Mikebuda demonstrates availability in excess of 99.5%, which is viewed as a reasonable threshold for broadband internet service. One of the main challenges in terms of availability is power interruption. For example, power outages that affect sections of the town including the poles from which the Terragraph nodes draw power or subscribers unplugging power to the client node mounted to their house.
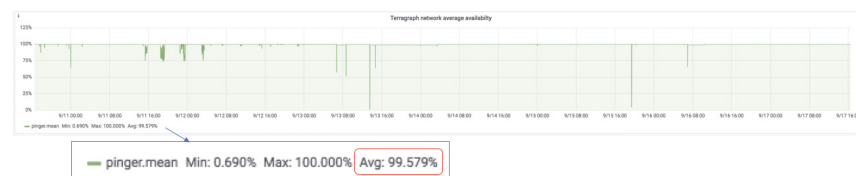

Figure 10 | Network reliability test snapshot

The line of sight requirement for mmWave links is manageable

Mikebuda was not without its line of sight challenges. Careful sight survey and network design was required to avoid placing Terragraph nodes in locations with limited visibility to other nodes and/or subscriber households. A small amount of tree-trimming was also required to clear line of sight for some links. The challenge was manageable, as evidenced by the resulting network with healthy performance, however there is clearly an opportunity for additional solutions. In Marko for example, the trial will experiment with sub-6GHz links to overcome foliage blockage in a handful of cases. Network planning tools will also play an important role in designing around line of sight constraints.

Outlook

The trial in Mikebuda is a compelling demonstration of Terragraph as a fixed wireless access solution, delivering fiber-like speeds to residential customers at a fraction of the cost of buried fiber. The trial outcomes support the case for the commercial viability of Terragraph, and its potential to make a real impact towards the the connectivity goal of connecting more people to a faster internet. Leading OEMs are in fact already well underway towards commercializing the solution: Terragraph-certified product will be available from OEMs starting in 2019, enabling commercial deployment of the technology.

In the interim, field trials are of utmost value as they present an opportunity for the ecosystem to gain further solution insights, such as:

- **Deployment best practices**
- **Opportunities to reduce cost and/or time to deploy**
- **Product requirements and feature insights**
- **Business insights**
- **Insights related to location-specific deployment challenges.**

Facebook remains committed to supporting Terragraph trials, including the second trial with Magyar Telekom in Marko, Hungary, as well as trials with service providers in other parts of the world.

References

Magyar Telekom
www.telekom.hu

Magyar Telekom
MT - Customer installation

The FCC has changed the definition of broadband
Currently [2015], 6.3 percent of US households don't have access to broadband under the previous 4Mpbs/1Mbps threshold, while another 13.1 percent don't have access to broadband under the new 25Mbps downstream threshold.

https://www.theverge.com/2015/1/29/7932653/fcc-changed-definition-broadband-25mbps

Speedtest Global Index (from speedtest)
As of 13 Sept 2018, the average global fixed speed is 46 Mbps DL and 22 Mbps upload

http://www.speedtest.net/global-index

Digital 2018: World's Internet Users pass the 4 Billion Mark
Well over half of the world's population is now online, with the latest data showing that nearly a quarter of a billion new users came online for the first time in 2017

The average download speed on the planet

https://wearesocial.com/us/blog/2018/01/global-digital-report-2018

The Zettabyte Era: Trends and Analysis
Broadband speed is a crucial enabler of IP traffic. Broadband-speed improvements result in increased consumption and use of high-bandwidth content and applications. The global average broadband speed continues to grow and will nearly double from 2016 to 2021, from 27.5 Mbps to 53.0 Mbps. Table 4 shows the projected broadband speeds from 2016 to 2021.

https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/vni-hyperconnectivity-wp.html

Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2016–2021 White Paper
https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html

Industry bets on fixed wireless access for first 5G deployments
A real-world trial of 5G fixed wireless access (FWA) networks serving connectivity to paying consumers has taken place in Floreşti in Romania (https://en.wikipedia.org/wiki/Flore%C8%99ti,_Cluj).

The technology is in vogue at the moment (https://www.computerweekly.com/feature/Can-fixed-wireless-access-fix-business-connectivity-problems) partly because it needs little to no investment in infrastructure and is easier to deploy than a traditional fibre broadband network.

it has proven its ability to deliver ultrafast broadband services over a wireless network,

https://www.computerweekly.com/news/252444219/Industry-bets-on-fixed-wireless-access-for-first-5G-deployments

Fixed Wireless Enters Starring Role - May 2018

"From a cost perspective, the first indications are that it could be 20 to 40% less costly than pulling fibre all the way to the premises. Secondly, because it's wireless, it's very quick to deploy, which is something we're excited about,"

http://www.broadbandworldnews.com/author.asp?section_id=548&doc_id=742994

Fixed Wireless to Shine in 2018 Thanks to 5G, Cost Savings

favorable spectrum regulation, insatiable consumer demand for broadband, global 5G standards being set and new entrants and use cases coming into the market as key drivers of growth.

[estimates are that]...at the end of 2017 that the total number of subscribers for the U.S. fixed wireless broadband industry is set to reach 8.1 million in 2021, up from 4.0 million in 2016

in terms of capital expenditures per residential subscriber, the cost for fiber is about 7x that of fixed wireless, whereas cable is 4.5x more.

Oppenheimer analyst Tim Horan noted in a recent research report that avoiding "a bad capital structure by leveraging unlicensed spectrum instead of costly licensed spectrum" [has helped some operators with a combined sub-6 GHz/mmWave system]

Kagan analyst Jeff Heynen said in the past, fixed wireless has acted like "a mobile service that has been adapted to support fixed line replacement," meaning it came with the speeds and caps associated with traditional wireless. "But now with 5G and others, that's a pure wireless offering with bandwidth caps where, like with your fixed service, 90% of customers aren't ever going to come near those caps,"

https://www.risebroadband.com/2018/04/fixed-wireless-shine-2018-thanks-5g-cost-savings-sp-global/

Can fixed wireless access fix business connectivity problems?

Arqiva CEO Simon Beresford-Wylie – also a former Samsung man – returned to the UK after a stint in South Korea (https://www.computerweekly.com/news/4500256262/SK-Telecom-shows-5G-software-defined-network-management) a few years ago, and describes feeling a sense of "catatonic shock" at how poor the UK's communications infrastructure actually was, having been used to fixed broadband hitting 100Mbps

"Against that backdrop what we are doing here with the 5G fixed access trial is an important business opportunity for Arqiva and given the poor state of fibre here in the UK I think there is a market need, a market hunger, for a really fast alternative to [existing] fixed broadband,"

https://www.computerweekly.com/feature/Can-fixed-wireless-access-fix-business-connectivity-problems

Deeper Dive—Will growth in data traffic ever slow down?

[Cisco] expects IP traffic to grow globally by almost three times during the five years between last year and 2021. That's a compound annual growth rate (CAGR) of 24%.

the replacement of DVDs and other physical media by streaming video services is likely driving significant increases in data usage.

Indeed, IDC says that by 2025 the "global datasphere" will reach 163 zettabytes. That is ten times the 16.1 ZB of data generated in 2016

https://www.fiercewireless.com/wireless/special-report-will-growth-data-traffic-ever-slow-down

terragraph

learn more at terragraph.com