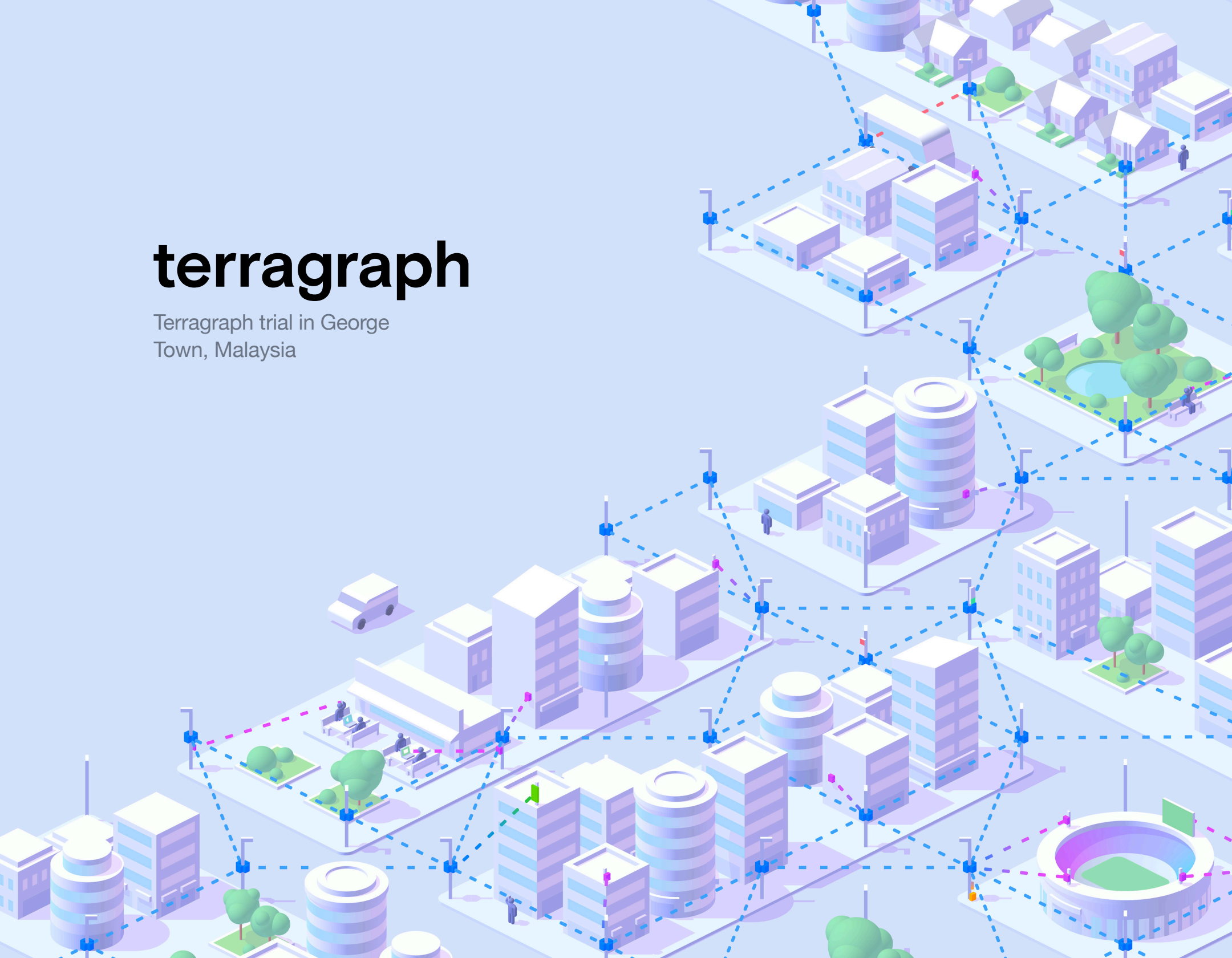
terragraph

Terragraph trial in George Town, Malaysia



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.

YTL Communications is a Malaysian telecommunications operator that has been working to help Malaysia close its digital divide by building the country's first and only nationwide all-IP, all-4G network under the service brand of "YES".

To help evaluate Terragraph as a solution for high-speed fixed broadband connectivity and public Wi-Fi, YTL Communications conducted a large-scale trial in George Town, Malaysia, using the technology to connect businesses and offices that had only copper/DSL connections formerly.

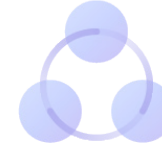
During the trial period 120 users where served with fixed wireless access (FWA) and 50 public Wi-Fi hotspots were provided in the George Town heritage area. Fixed wireless access users were experiencing speeds 10-172 times faster than their previous copper-based connections, while the public Wi-Fi service has so far provided connectivity to over 33,000 unique users with a high-quality Wi-Fi experience.

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:

Time and Cost to Deploy

Terragraph has enabled Gigabit level speeds using existing street furniture and power assets with a rapid deployment time of 2.5 months for an area of 2.5 square km. 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 40% of that of an equivalent buried fiber build in some markets.



Public/Private Partnership

This trial employed a unique value exchange model in cooperation with the local government. Access to street furniture during the trial period was provided by the local government in exchange for YTL Communications offering a free public Wi-Fi network in the George Town heritage area.

mmWave Feasibility in APAC Urban Environments

Terragraph, with its street level deployment, was also proven to be an efficient and high performance way to provide connectivity in an environment where fiber deployment would have been challenging.

Availability and Performance

The Terragraph network in George Town has achieved availability of 99.5%, which is viewed as a reasonable threshold for broadband internet service.

Background

Access to reliable high speed broadband has become an essential part of modern life, society and business. Availability of broadband also underpins digitization of the economy and the wider adoption of Industry 4.0 technology. Improved connectivity will also help communities access online commerce, education, entertainment, healthcare and government services. At the same time, new technologies and use cases continue to drive demand for data. Cisco estimates that IP traffic in the Asia-Pacific region will grow at a compound annual rate of 26% and constitute of 12.2 billion networked devices by 2021.

The demand for broadband network speeds and capacity will continue to grow. The Economist Intelligence Unit's Inclusive Internet Index 2019 found the average mobile speed in Asia to be 22.2Mbps (download) and 10.8Mbps (upload). While this represents significant progress in recent years, continuing this trajectory will require significant investments, new technology solutions and partnerships.

Solving the speed shortfall is the goal of many in the connectivity ecosystem. This is true for the service providers, as well as national and local governments. The Malaysian Government has set a target of achieving average speeds of 30 Mbps in 98% of populated areas by 2023 as part of the National Fiberization and Connectivity Plan.

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 the next generation networks, as evidenced by 5G plans to use millimeter wave technology for both fixed and mobile access.

Developments in radio technology have opened up new opportunities to create products that operate in high-frequency bands. These are bands in the millimeter wave range, from 30 GHz – 300 GHz. Most of these bands have approximately 500-800 MHz of spectrum. However, even more exciting are the possibilities offered by the V-band (60GHz) operating with at least 7 GHz of spectrum (57-64GHz), and potentially even 14 GHz (57-71GHz), making it the largest commercial radio band ever used.

Millimeter wave spectrum can address the growing demand for bandwidth by delivering gigabits of capacity more quickly, easily and cost-effectively compared to deploying fiber.

Introduction to Terragraph

Facebook developed Terragraph 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 and time consuming to deploy due to right-of-way constraints and trenching costs. As such, Terragraph seeks to address the problem using millimeter wave technology.

Terragraph uses millimeter-wave 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 buried fiber. Terragraph radios operate in the 60 GHz 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. While originally envisaged for indoor use as a version of Wi-Fi known as “WiGiG”, the system was adapted for outdoor use and a global standard was created - IEEE 802.11ay.

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

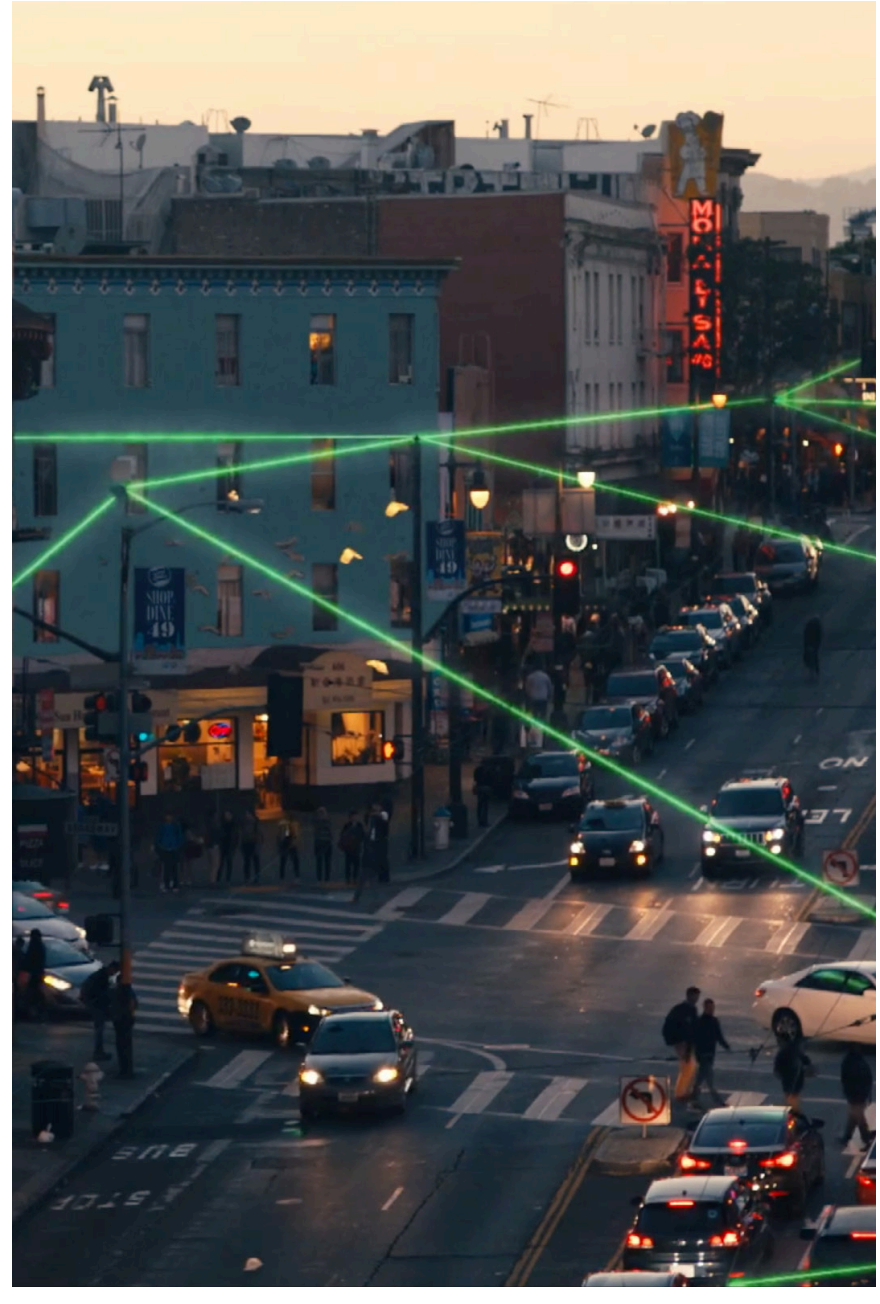
The radios are able to interconnect to form a layer 3 mesh which can be scaled over large geographic areas and offers redundant and reliable connectivity between end-points. Terragraph radio nodes can be deployed on abundant physical assets such as street furniture, for example, to provide last-mile 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.

The wireless mesh design in Terragraph allows for route diversity which provides high network availability. If a link goes down (because of obstruction, interference, a power issue, etc.), the Open/R routing protocol will automatically find another route through the network to the destination node. With a higher number of average sectors per node, the mesh becomes more reliable and can support greater increases in bandwidth. This way, bandwidth augmentation on the distribution network can be done seamlessly.

Attributes of Terragraph

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. Some key attributes of Terragraph are:

- Operates in the unlicensed V-band: 60 GHz
- Uses standardized 802.11ay, enhanced with TDD/TMDA for MAC efficiency at scale
- Current proof-of-concept system has a peak phy data rate of 4.6 Gbps (one direction, single channel) and average peak user throughput of over 1 Gbps
- Single link maximum range is approximately 250 meters in the current system
- 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



Facebook and YTL Communications Collaboration

YTL Communications and Facebook are collaborating as part of the Telecom Infra Project (TIP). The aim of TIP is to create a new approach to building and deploying telecom network infrastructure. That means collectively working with a community of over 500 members to design and build technologies that are better, more efficient, and more interoperable.

YTL Communications partnered with Facebook to evaluate Terragraph for public Wi-Fi and fixed wireless access solution. YTL Communications visited the Terragraph lab at Facebook HQ in May 2018, and subsequently Terragraph radios were brought to Malaysia for extensive technical testing at YTL's technical lab in July 2018.

The collaboration began with YTL Communications controlled lab trial at its Technology Center in Kuala Lumpur.

Figure 01 | YTL Communications Technology Center in Kuala Lumpur

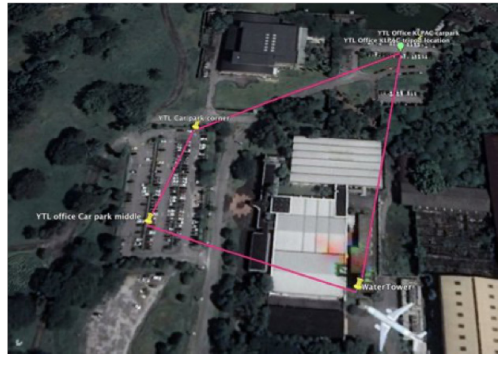


Figure 02 | Initial Terragraph trial network topology

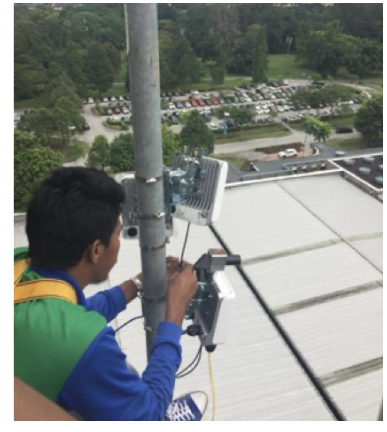


Figure 03 | Installation of Terragraph nodes

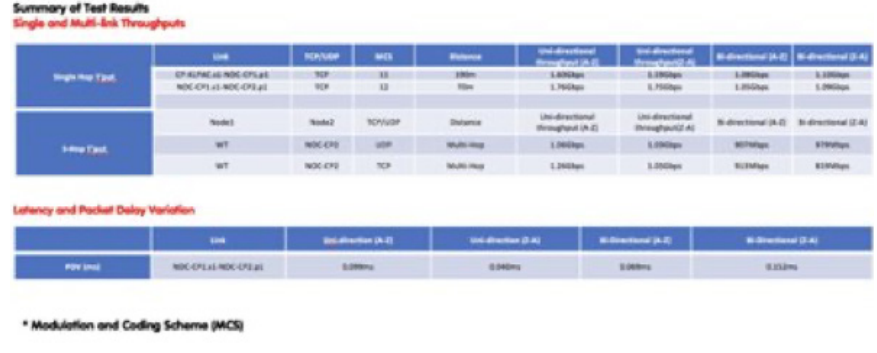


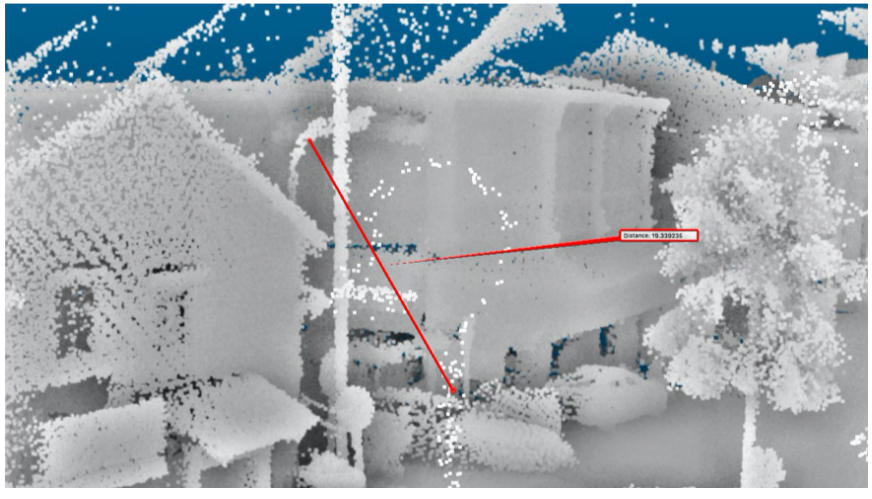
Figure 04 | Summary of trial network test results

YTL Communications trial in George Town, Penang

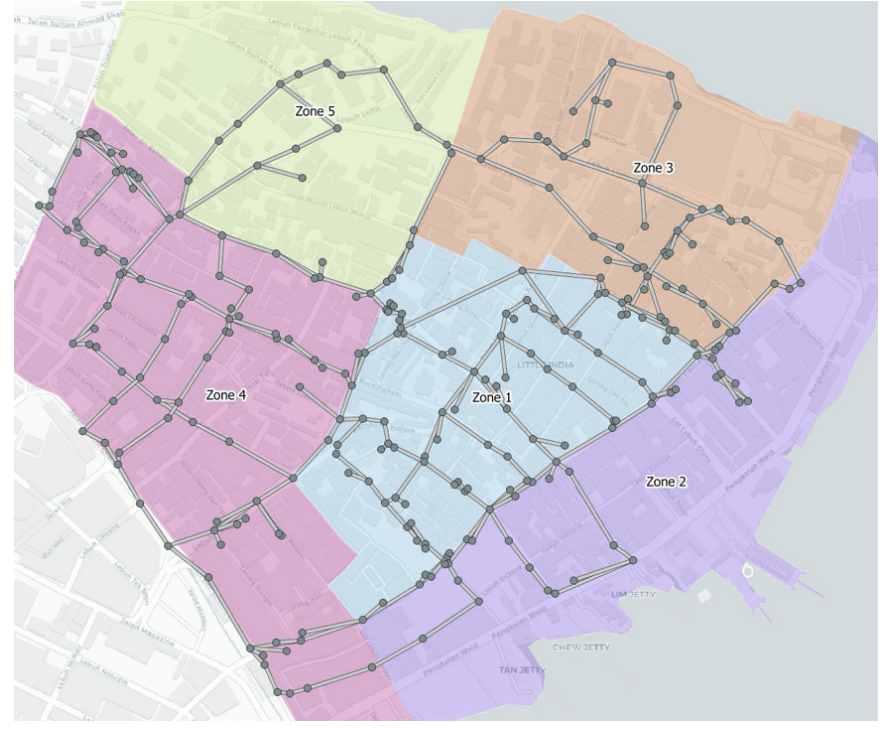
After the successful trial at its lab facility, YTL Communications worked with Facebook to deploy a Terragraph trial network using the reference design radios. The UNESCO heritage zone in George Town, Penang, was selected as the trial location and after thorough planning, engagements with city and state authorities, the trial was announced in February 2019 and launched on March 1, 2019.

Trial Location and Radio Network Planning

Facebook worked with YTL Communications to plan and design the network collaboratively. Facebook utilized advanced LiDAR data of George Town collected by driving every street in the trial location. The data was used to determine the Line of Sight between Terragraph nodes and as input for network planning algorithms. Subsequently a design of the coverage area was created using the LiDAR data and artificial intelligence for site identification and selection.



The planning was followed by field surveys of streets and poles to verify the AI based design and check infrastructure prior to deployment.



Existing Services in George Town

There were no existing fixed access or public Wi-Fi services offered by YTL Communications in George Town prior to this trial. YTL Communications has existing 4G/LTE coverage in the region, operating on TD-LTE in Band 38 (2600MHz) and 40 (2300MHz). The key fixed access (FTTH) players in the city of George Town are Unifi/Telecom Malaysia and TimeDotCom. There are limitations on the deployment of fiber in George Town due to its UNESO heritage zone status.

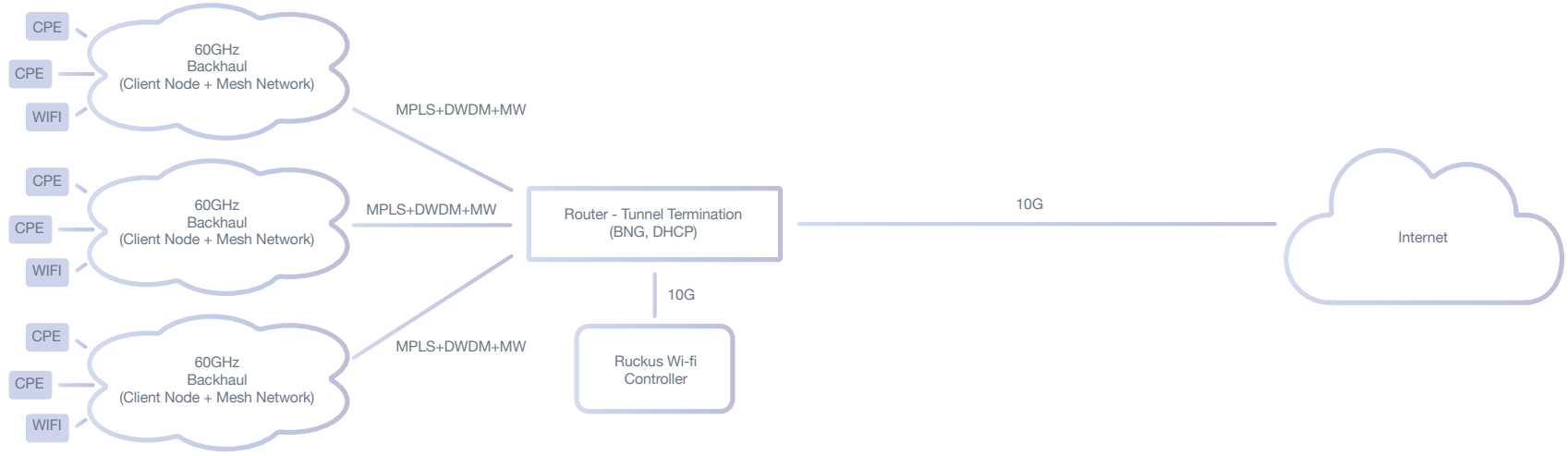
Network Integration Design

The Terragraph network had to be integrated with YTL Communications existing network offering 4G/LTE and other in-building W-iFi services. The goal of the integration approach was to reuse existing elements to the extent possible, to avoid having to re-design standard operating functions. To make the integration simple with minimum impact and changes to YTL Communications existing network elements, a pair of demarcation routers dedicated for the George Town Terragraph network were hosted at YTL Communications data center in Kuala Lumpur.

The two services offered over the Terragraph network were fixed wireless access to businesses and households and Public Wi-Fi access, within the George Town city. The primary functions of demarcation routers are BNG, DHCP server, IPv6 L2 tunnel terminator and core routing.

For the fixed wireless access service, PPPoE sessions are terminated between the CPE and the BNG (demarcation routers). Since Terragraph is a routed IPv6 only transport, a tunneling overlay was needed for ethernet connectivity to the demarcation routers from these CPEs.

Similarly for public Wi-Fi access, a tunneling overlay was needed for ethernet connectivity between the WiFi access point and the demarcation router/Wi-Fi Controller. This was achieved by using vendor proprietary tunneling mechanisms like Ruckus soft GRE or Mikrotik EoIPv6 over the Terragraph IPv6 only network.



CPE Platform

Fixed Wireless Access:

Two different Mikrotik CPE models were selected for this service, again based on our requirement to support L2 tunneling over IPv6. Below are the two CPE models and their details:

1. **RB750GL**: Supports a vendor-specific implementation of ethernet over IPv6 (EoIPv6). The device features 5 x 1G copper ports and is able to forward upto 100Mbps over stacked tunnels (tested)
2. **RB750GR3 hEX**: Supports a vendor-specific implementation of ethernet over IPv6 (EoIPv6). The device features 5 x 1G copper ports with 1G passive PoE in port and is able to forward upto 100Mbps over stacked tunnels (tested)

Public Wi-Fi :

Three different AP make/models were selected for this service based on our requirement to support L2 tunneling over IPv6. Below are the three AP models and their details:

1. **Ruckus T300**: Supports Ruckus Soft GRE (L2) tunneling over IPv6. The device features dual-band 2x2:2 Wi-Fi omni directional, 1Gbps PoE in port, Multi rate, multi channel support and is able to forward upto 1Gbps over stacked tunnels (tested)
2. **Mikrotik WAP AC**: Supports a vendor-specific implementation of ethernet over IPv6 (EoIPv6) and capwap over IPv6. The device features dual-band 2x2:2 Wi-Fi omni directional, 1Gbps PoE in port, Multi rate, multi channel support and is able to forward upto 300Mbps (tested).
3. **Mikrotik mANTBox 2 12s**: Supports a vendor-specific implementation of ethernet over IPv6 (EoIPv6) and capwap over IPv6. The device features Long-range 12 dbi, 120° integrated Base Station for 2.4 GHz, sector antennas, 1Gbps passive PoE in port, Multi rate, multi channel support and is able to forward upto 300Mbps (tested).

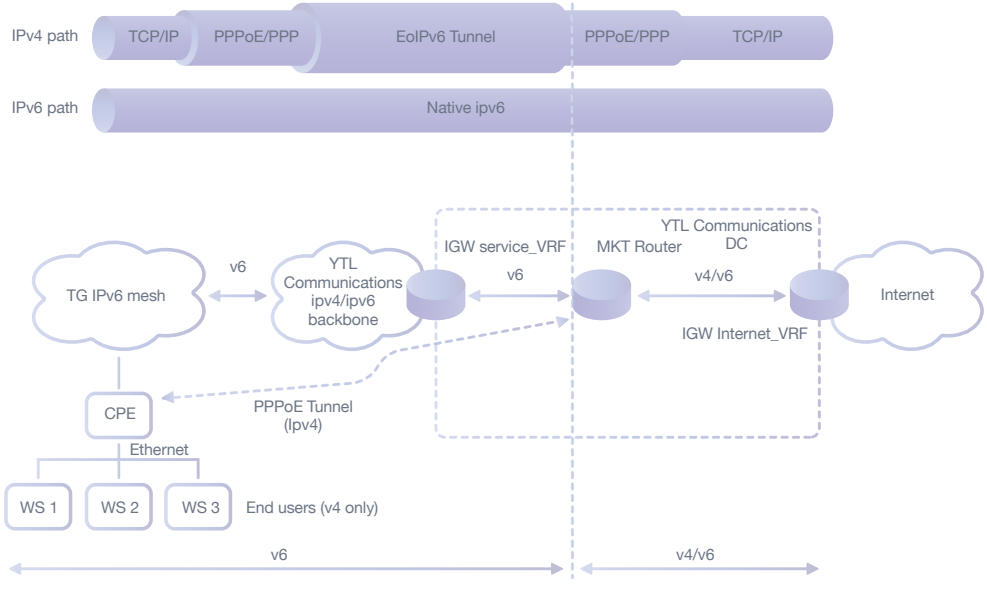
For layer-2 transport, the Mikrotik APs and CPEs support vendor-specific implementation of ethernet over IPv6 (EoIPv6). In order to terminate the layer-2 tunnels at the core, a pair of Mikrotik CCR1036-8G-2S+ demarcation routers were selected. This router model features 8 x 1G copper connections and 2 SPF+ (10G) making it well suited to connect Terragraph “fiber point-of-presence” nodes. The Mikrotik APs/CPEs and routers would book-end the Terragraph IPv6 mesh, effectively making it transparent to YTL Communications network by making simple L2 circuits. Similarly the Ruckus T300 APs terminate soft GRE L2 tunnels at the Ruckus Wi-Fi Controller that’s connected behind the demarcation routers.

Service Model

Two different service models were deployed in the George Town trial: Fixed Wireless Access (FWA) and Public Wi-Fi.

Fixed Wireless Access

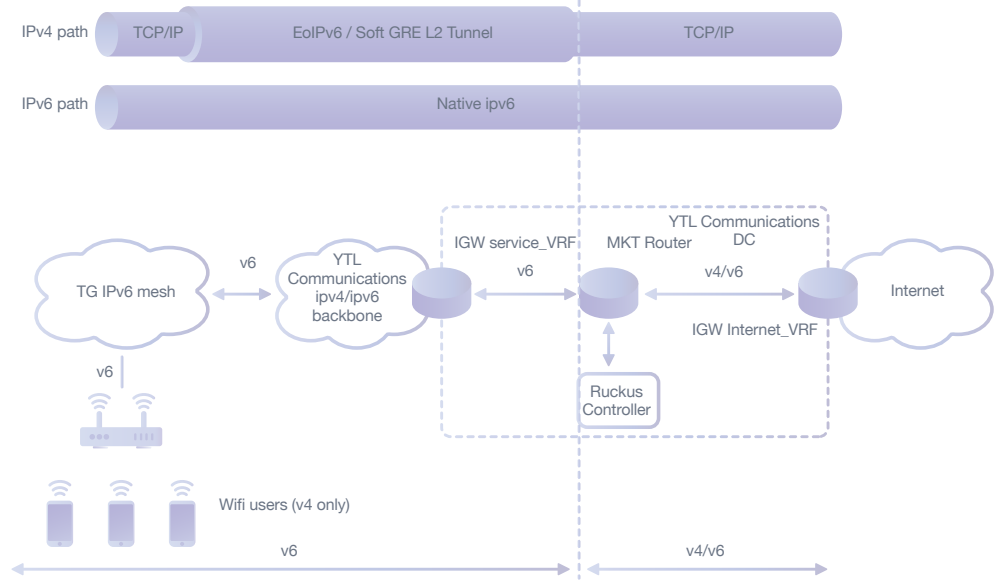
With point-to-point layer-2 tunnels in place between the BNG (demarcation routers) and subscriber CPEs, the service model is exactly the same as it would be with any other fixed access solution. Once connected to the Terragraph network via a client node, the Mikrotik CPE establishes pseudo-wires to the EoIPv6 tunnel terminator (Mikrotik demarcation routers in YTL Communications Data Center). A PPPoE dialer in the CPE establishes connectivity to the BNG (demarcation router) using pre-configured user credentials, thus enabling internet access. User profiles with different rate limits are created in the BNG and the CPEs are provisioned according to the user subscription.



Public Wi-Fi

Similar to Mikrotik CPEs, the Mikrotik Access points serving Public Wi-Fi access to users establishes pseudowires to the EoIPv6 tunnel terminator (Mikrotik demarcation routers in YTL Communications Data Center). The Ruckus APs on the other hand, establishes Soft GRE tunnels with the Wi-Fi Controller connected behind the demarcation routers.

The demarcation router does DHCPv4 allocation and further does NAT44 allowing internet access to Wi-Fi users. User are redirected to a captive portal login page , where they can login through their social media login credentials to access the internet.



Permitting and Related Permissions

To meet national and state specific regulatory requirements, YTL Communications had to obtain certain permits prior to initiation of the trial, this included:

- **Equipment type approval**: the Terragraph radios required type approval from SIRIM for importation to Malaysia.
- **Local authority**: Given that George Town is a UNESCO heritage zone deployment of any equipment in the area requires approval by local authorities and deployment is to be done in line with guidelines from UNESCO and the City Council of Penang Island and its Technical Committee and City Council Engineering Department. The project was also presented and approved by the Penang State Executive Council.

In terms of the spectrum usage, the V-band in Malaysia is under class assignment for short range devices and does not require a license for an operator to utilize.

Installation and Customer Provisioning

A key advantage of Terragraph is the compact and lightweight design and the ultra-low power consumption characteristics of the nodes. As a result, there is no need to erect new telco structures for the sake of deployment. YTL Communications instead opted to use existing structures such as lamp posts to co-locate the Terragraph nodes on to them.

All in all, YTL Communications used 163 poles in the George Town heritage area to support:

- 472 Terragraph nodes
- 50 Public Wi-Fi Hotspots
- 120 Fixed Wireless Access (FWA) points

The deployment of the Terragraph nodes was staged in five of George Town covering approx. 2.5 square kilometers. By resourcefully splitting the day into two halves - night time for installation and day time for fine tuning and commissioning - the YTL Communications team was able to complete the entire deployment in 2.5 months.

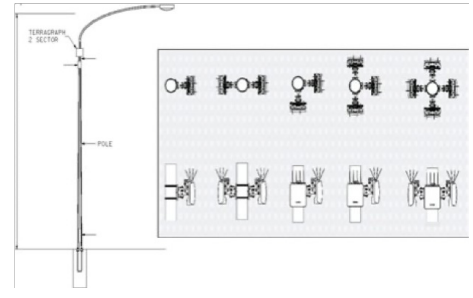


Figure 05 | Deployment options for a given lamp pole

Figure 06 | Location of all the Terragraph nodes

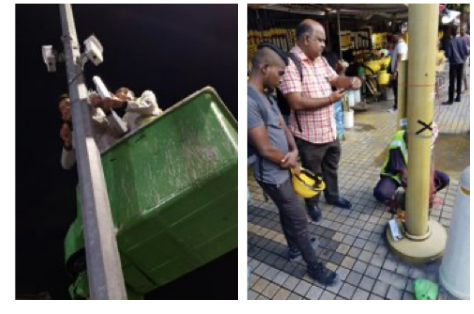


Figure 07 | YTL Communications used skylifts to install at night, and used daytime to perform electrical remediation and power commissioning

Figure 08 | Electrical remediation and power commissioning

Customer Provisioning

As this is a new technology, the YTL Communications team opted to recruit trial customers based on their existing broadband quality and performing site assessment of coverage. The process can be broken down into 3 steps:

Step 1 - Expression of Interest

YTL Communications staff visited businesses in the coverage area offering a free trial service for fixed wireless access for a duration of 6 months. The YTL Communications staff would start by performing a basic line of sight check from the premise to the existing distribution node (DN) network. Businesses whose premise had line of sight and that wished to participate then signed a trial agreement and a time for installation was booked. An initial desktop analysis of the location was performed to determine if any additional DN was required to be installed in order to connect to the client node (CN) location.

Step 2 - Site Survey and Physical Installation

If an additional DN installation was required to provide connectivity to the premise this would be installed during low foot traffic hours (between 10pm and 6am). For the customer premise installation a team of 2 installers would attend the location to identify and agree with the customer on the CN installation location and cable run to the desired CPE location. The physical installation would then take place and would take up to 2 hours, mostly depending on the complexity of the cable run. Once the physical installation was completed the CN was powered on and the installer app used to upload the node details to the NMS, bringing the Terragraph link online. If any issues occurred with this process the technician would contact the network operations center to provision the link.

Step 3 - Customer Provisioning and Testing

A second visit to the customer would be made by a provisioning technician to connect and configure the CPE device. This step could be collapsed into step 2 with additional training of the installation staff, or even completely automated, however for the purposes of the trial it was more straightforward to have this as a separate step. The technician would connect the CPE and execute a template based configuration file, as well as perform any configuration changes required on the head end router performing tunnel termination of the CPE devices. Once end to end connectivity was established the connection would be tested for throughput and stability, and after successful completion the service would be handed over to the customer.

Corporate Social Responsibility

As George Town is a historic city, the YTL Communications team encountered a number of issues during the installation process. YTL Communications took the opportunity to repair and provide a complete health check of the utilities as a corporate social responsibility service to Penang:

- 450 MBPP poles had been remediated to allow for safe and stable supply of electricity
- 35 Feeder Pillars remediated to allow continuous power supply
- Physical isolation of electrical phases for existing lamps and new Terragraph nodes for all 450 poles
- Replacements of faulty underground cables with new overhead power cables of up to 3000 meter in length
- 150 units of street light poles refreshed with new service boards
- 450 new sets of neutral link bars replaced
- Physical inspection and electrical 'health check' for all 450 units of street light poles

Product and Network Improvements During Trial Period

Given the size and length of the trial there were numerous opportunities to conduct tests, gain learnings and introduce product and network improvements, such as:

- Several Terragraph software version upgrades
- Feature enhancements including improvements to Automatic Beam Forming, automation of network optimization procedures, and network performance statistics and events to aid in troubleshooting
- Major software bug fixes to increase network stability and improvements to re-routing

There were several changes to the network topology undertaken during the trial period to improve performance, in addition to continuous maintenance activities related to power, foliage trimming and equipment replacement.

We believe the trial in George Town has contributed to evolving the Terragraph technology, the enhancements made will improve the performance and robustness of the product. During the trial 8 major updates to Terragraph software were released which included 48 feature enhancements and 25 software fixes. Along with this the deployment guidelines were enhanced to capture what was learned from the trial in George Town, particularly related to the deployment of CN nodes in narrow streetscapes.

Trial Outcomes

YTL Communications has operated the Terragraph network in George Town for over 6 months providing free public Wi-Fi coverage at 50 locations and fixed wireless access services to 120 premises. The network consists of 472 Terragraph nodes connecting 283 locations (163 light poles + 120 customer premises) in a mesh network consisting of 296 links. The network was deployed in 2.5 months, including remediation of the electrical connection to the poles to provide 24hr power, deploying the Terragraph distribution network and then the customer premise equipment.

A - Free Public Wi-Fi

As of 1st November, 2019, the public Wi-Fi service has so far provided connectivity to over 33,000 unique users with a high-quality Wi-Fi experience, with peak download speeds of up to 190mbps and average speeds of better than 50Mbps.

To ensure fair usage, YTL Communications created a social login experience that supports Android, iOS plus all popular desktop browsers. Once authenticated, users are given one hour of login, but YTL Communications does not restrict the number of times a user can login in each day and there is no speed cap to ensure the user will experience the best speed his device is capable of.

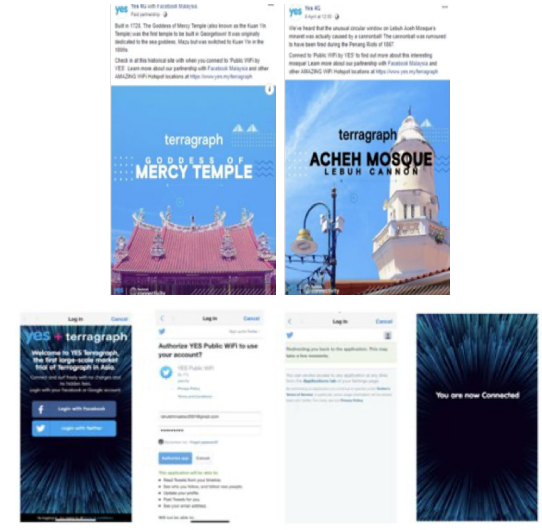


Figure 09 | Awareness campaign to promote the various locations we have installed Public Wi-Fi

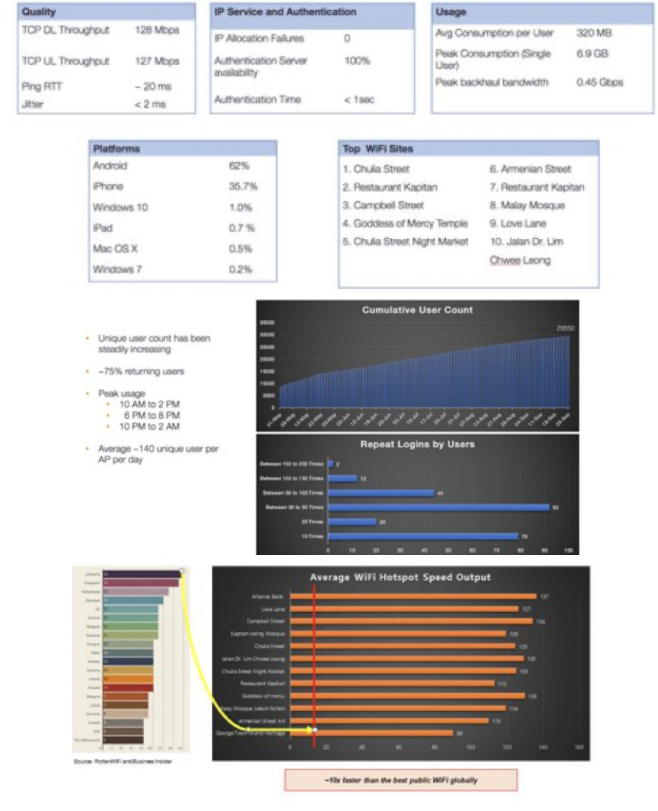


Figure 10 | Wi-FI usage metrics as of 26th September, 2019

B - FWA (Fixed Wireless Access)

During the trial period fixed wireless access (FWA) users were experiencing speeds 10-172 times faster than their previous copper-based connections. The number of FWA customers was restricted to 120 for the trial period due to the use of prototype hardware. However, given the size and density of the distribution network many more customers could be served from the existing footprint.

The Terragraph network was operational during the monsoon, rain, tropical heat and humidity with the network maintaining a high degree of availability and performance. Facebook has also previously conducted tests of rain fade on network performance in San Jose and Jakarta with satisfactory results.

A sample of trial Customer Testimonials:

"YES Terragraph really delivers the speed that we need. The staff is very responsive, courteous and helpful when you need help from them. Highly recommend to anyone in this area."

- Stephen Ng, Head of IT, Clan Kongsi Hotel

"We are satisfied with your service on the internet access"

- NL Loh, Managing Director, Hotel Hong Ping

"Service has been excellent!"

- Dr Ooi Kah Theang, Director, Klinik Ooi KT

"Using YTL YES around 6 months, never been uninterrupted connection like other ISP, smooth and faster, also the customer care act fast if any power failure occurred. Thank you for the excellent service."

- Ameen, Director, Crescent Fastprint

"YES Team has been very helpful with all support from setting until troubleshooting. Terragraph has provided consistent speed and reliability throughout the trial period."

- Pang Jia Woei, Director, Holly Group Sdn Bhd

"It was easy enough to get started with connecting and setup due do help from the 'YES' team. From then on it was just relatively plug and play. Great job 'YES' for this opportunity. Hope to see great things from you guys in the future."

- Jesse Tan, Owner, Mugshoot Café and Rainforest Bakery

"Its very fast, and stable. Appreciate the fast internet speed."

- Wayne Ng Yung Wei, Director, Spark Optics Sdn Bhd

"We have been using YTL YES Terragraph for the past few months now. The connection is quiet good and steady except for a few and rare glitches. For a service that's new in the market, it's quiet reliable and good to use."

- Mohamed Imran, CEO, S.M.N. Shaik Mohamed Sdn Bhd

"YES Internet has good coverage in whole property of Campbell House. Connection is Fast and reliable. Service support we receive from Mr Lim who introduced us to YES is excellent! He is 24hrs available to any questions and assistance we needed. George Town needs this kind of internet and service, especially to hotel accommodation like us. Keep it up YES TEAM!!"

- Vanessa Arzadon, Front Office Manager, Campbell House

"I am very satisfied with the service provided by YTL YES Terragraph Market Trail. They provide us with sufficient information and resources when we asked for aid. Our problems and feedbacks were entertained and resolved immediately when we give feedback. The Internet connection is strong and the speed is above average"

- Ooi Geok Choo, Resident

"YES Terragraph given a very consistence & fast speed. The staff very polite, efficient and deliver good service to customers. Overall performance very satisfied with this internet provider."

- Sariel Leong, Admin Executive, Penang Heritage Trust

"Thank you for your introducing the option to test YTL network services. We are, so far , satisfied with the performance of the network, thank you for giving special care during the initial phase. We hope YTL YES will continue to provide consistent quality service and I will definitely recommend your product for other users in the area."

- Lily Aziz, Property Management and Homestay, 95 Armenian Street

"We have been using YTL YES Terragraph Market Trial since Apr-2019, and I have to say that its excellent support. No more complaints about slow internet, internet down, can't do our work."

- Mandy Tan, Admin Executive, Lean Giap Group of Companies

"We are satisfy with YES terragraph to manage a higher speed and better stability Which has speed up our work day and their customer service/supports always so supportive, passionate and efficient. Good work, THANK YOU x 3000!"

- Chuah, Purchasing Executive, Sim Supplies Sdn Bhd

"Representing Loft 29 to appreciate Yes for letting us trying out the Terragraph that you have installed last few months. It was an amazing experience knowing that in Heritage area we could have fast speed internet."

-Timothy Poy, Event Officer, City Light Consulting Sdn Bhd

"Am happy to state that the speed of YTL Terragraph is very much better than what we had and much more stable. Also note that the response time and rectification is also excellent and hope this is sustained."

- Oo Huei Ying, Managing Director, SKI Wealth Sdn Bhd

"Very satisfied with our good service and fast respond. Hope continue to use your service for long term."

- Fang Siew Poh, Director, Islander Lodge

"Very satisfied with YES Terragraph and good feedback from Homestay guests"

- Jeffry, Owner, Nadyah Star Global (Zaras Gallery)

"Very Satisfied, will support YTL Terragraph."

- Mr. Neyvinthyran s/o gunasekaran, Director, NS Chulia Enterprise

"I am Satisfied with YES Terragraph."

- Ms Leong, Owner, HY Hai Lean Trading

"I am Satisfied with YES Terragraph."

- Ong Seng Keat, Owner, Yin and Sourdough Bakery & Cafe

George Town Takeaways

Time and cost to deploy

The Terragraph network in George Town offered huge advantages in time to deploy and deployment logistics. Terragraph has enabled Gigabit level speeds using existing street furniture and power assets with a rapid deployment time of 2.5 months. Based on the results from trial and detailed analysis of commercialization costs we estimate Terragraph total cost of ownership (TCO) to be more than 40% lower than that of trenched fiber. With the George Town network now reaching operational “steady state”, OpEx will also be measured and factored into the cost analysis.

Public/Private partnership

This trial employed a unique value exchange model in cooperation with the local government. The local government saw value in YTL Communications offering a free public Wi-Fi network in the George Town heritage area and facilitated access to its street furnitures. Access to street furniture during the trial period was provided by the local government in exchange for YTL Communications offering a free public Wi-Fi network in the George Town heritage area. This is an example of a model that network operators and asset owners can engage in to provide greater value to both parties beyond that which could be achieved under a simple asset lease arrangement.

mmWave feasibility in APAC urban environments

George Town has a morphology of narrow streets, with 2+ story shop houses situated at the edge of the sidewalk. This is an environment that is quite common in the Asia Pacific region, but one which Terragraph had not previously been deployed. Through the use of advanced planning tools which optimized the point to point line of sight link design the network was able to be planned and deployed in a short time frame. Terragraph, with its street level deployment, was also proven to be an efficient and high performance way to provide connectivity in an environment where fiber deployment would have been challenging.

Availability and performance

The Terragraph network in George Town has achieved availability of 99.5%, which is viewed as a reasonable threshold for broadband internet service. One of the main challenges in terms of availability has been power interruption. Street furniture owners, and their operations teams, were not accustomed to the 24/7 power requirements of telecom networks as they conduct maintenance activities which led to outages. In George Town this was overcome by working collaboratively with the stakeholders to plan works and by leveraging Terragraph’s mesh network capabilities so that they could be completed without impacting service. Another area of learning is foliage management which is not specific to Terragraph but any millimeter wave technologies including 5G. Through the George Town trial, Facebook has tuned the system management tool to better detect radio feedback from foliage so that operators can take preemptive actions to trim excessive foliage when detected.

In case of a failed link or radio frequency impairment, Terragraph technology allows for layer 3 route convergence with Open/R in sub-100 milliseconds, resulting in no perceivable impact for users. In addition, Open/R allows for MCS (modulation and coding scheme) based routing that offers automatic path switching with changes in link performances. These features mitigate unexpected changes in the environment, such as weather, power instability and foliage.

5G Co-Existence and Standardization

5G is the next generation of mobile access technology. Promising gigabit level speeds to fixed and mobile terminals, early deployments have already commenced. Like Terragraph, some versions of 5G networks plan to operate in 24, 26 and 28 GHz mmWave bands, utilizing larger channel bandwidth than typical low-band spectrum to provide much higher data-rates and lower latencies than existing 4G networks.

Terragraph is a potential enabler for 5G. As 5G networks begin to deploy high speed services, Terragraph networks can provide Gbps-speed transport “fiber replacement” for both Wi-Fi 6 access points and some versions of 5G commercial deployments. Recently, a demonstration from a 5G vendor connected a mobile terminal using WiGiG as an access layer to Terragraph as a backhaul link to produce above 1.6 Gbps speeds in a commercial mobile terminal which perfectly matches the speeds from 5G commercial equipment that is being deployed.

Standardization often leads to widespread adoption, and this has been true for 802.11ad. The huge global demand for spectrum capacity is driving investment in 60 GHz band unlicensed technologies for fixed wireless access, wireless backhaul and short-range uses, particularly as the technology is evolving to allow for non-line-of-sight applications.

Building on the 802.11ad standard is one of the approaches that is being proposed that utilize the significant 60 GHz bandwidth and WiGig technology elements to form novel network topologies in addition to established point-to-point and point-to-multipoint topologies. Draft 2.1 of 802.11ay, the successor standard to 802.11ad, was released in October 2018 and defines support for a broad set of use-cases ranging from the mmWave Mesh Network Usage Model in support of Fixed Wireless Access deployment scenarios, as well as wireless virtual/augmented reality, networking, and mobile. The technologies defined in 802.11ay enable operation in both line-of-sight and non-line-of-sight environments. Non-line-of-sight operation exploits alternate paths generated by deterministic reflectors which exist at 60 GHz.

Subsequent improvements to 802.11ay specification include techniques for managing interference and coexistence in high density scenarios including those with multi-hop multi-point network topologies. Key innovations include scheduled media access control, more efficient beam-forming protocols catering to different usages, peak data rates in excess of 100 Gbps, support for cloud-based link planning, and advanced coding schemes that enable predictable performance in a complex mesh deployment with a single frequency network. Participation and support for 802.11ay have expanded to include not only semiconductor manufacturers but also communications system vendors, consumer internet and services companies and network service providers. Building on the work at IEEE, there is now an ongoing effort to create a certification program for fixed wireless in the Wi-Fi Alliance.

Outlook

The trial in George Town is a robust demonstration of Terragraph as a Public Wi-Fi and fixed wireless access solution, delivering high-speed Wi-Fi and fiber-like performance 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 connectivity goal of Malaysia's National Fiberization and Connectivity Plan.

The commercial outlook for widespread Terragraph networks is strengthening. First, Qualcomm is creating the world's first Terragraph chipset family (based on the IEEE 802.11ay standard). Not only Fixed Wireless Access (FWA) and Wi-Fi transport is provided, but mobile backhaul to 4G and some 5G architectures is supported on Day 1 and peak speeds at the physical layer of up to 10 Gbps will be possible. Second, a large and growing number of commercial Original Equipment Manufacturers (OEMs) have signed on to manufacture Terragraph products including: Radwin, Cambium, Siklu, IgniteNet and Mikrotik. These vendors will have commercial-grade Terragraph products based on the Qualcomm chipsets giving service providers a choice of standards based offerings. Third, the growing list of countries de-licensing the V-Band makes the trajectory look increasingly like the Wi-Fi marketplace: a growing ecosystem of devices, services and tools for deployment.

In closing, YTL Communications and Facebook would like to extend our appreciation to the Ministry of Multimedia and Communication of Malaysia, Malaysia Communication and Multimedia Commission, the State Government of Penang along with the City Council of Penang Island for the invaluable support to make this large scale market trial a reality. Their collective contributions to this trial has resulted in the acceleration of the commercialisation of Terragraph which we hope will benefit cities and communities globally.

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