AMBEENT

Wi-Fi with a Spectrum Broker is More Resilient to COVID-19 Surge

WHITE PAPER

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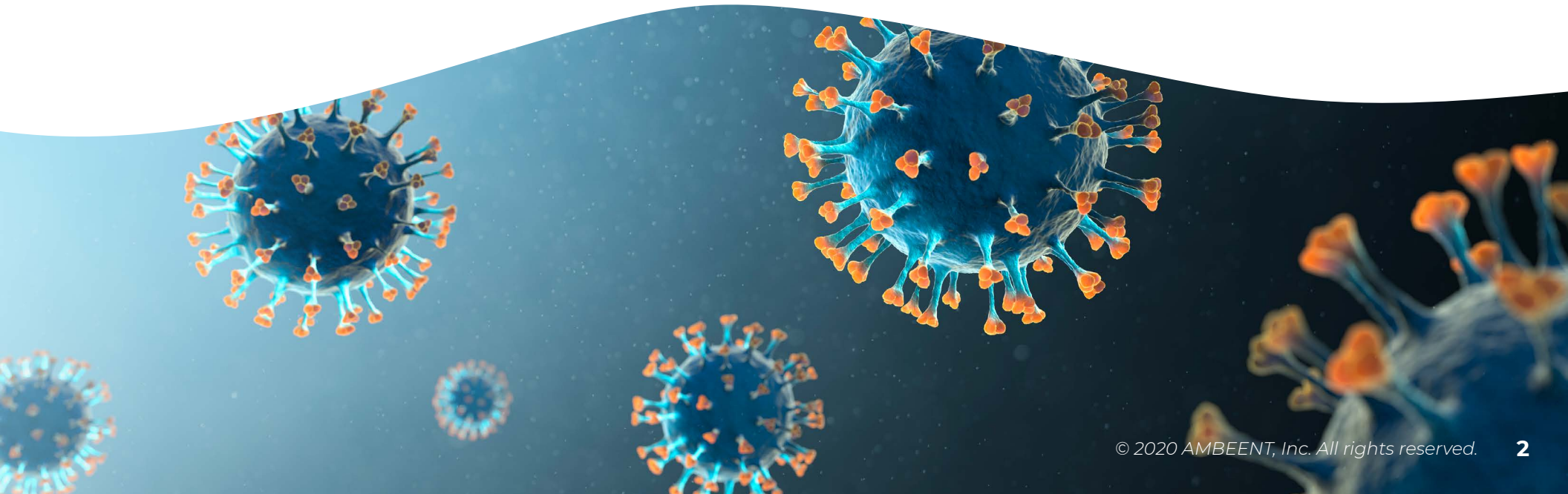
Table of Contents

Executive Summary

One in three human beings are currently confined at home as per government-imposed restrictions due to COVID-19. As businesses and consumers around the world adjust their routines amid the new social restrictions, the Internet is being used at a scale that the world has never experienced before. Fast and reliable broadband at home has become the lifeline to millions for work, education, socialization, and entertainment. Various sources referenced in this paper have reported average growth of internet traffic at 40% and a decrease in download speeds of more than 13% in various countries as a result of school closures and shelter-at-home orders.

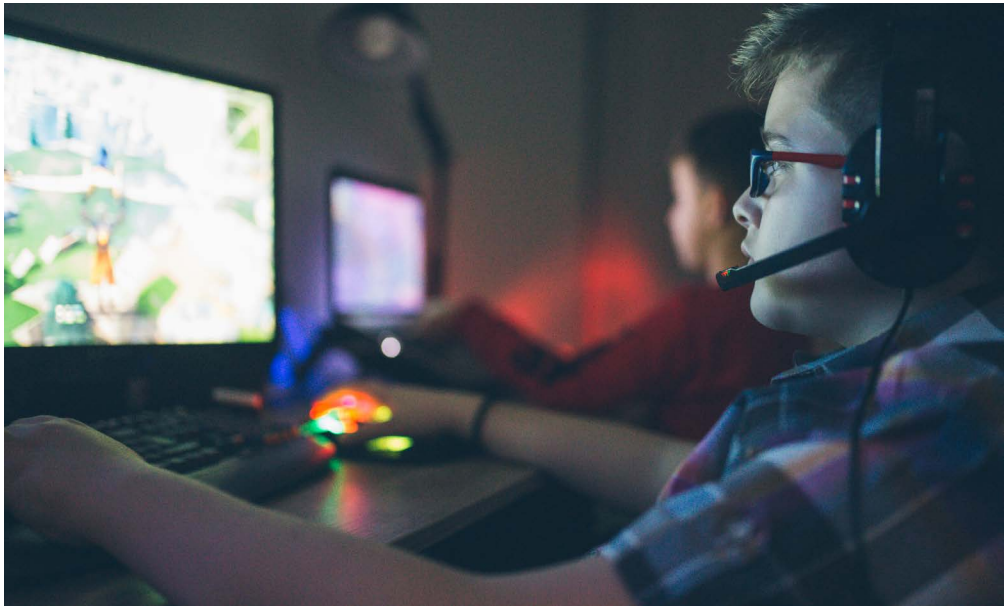
Managing the quality of broadband experience in the home is more than ever a priority for service providers, and Wi-Fi is at centerstage of that effort. Quality of Experience (QoE) now goes beyond speed to include lower latency required to support 4/8K, gaming, video, and collaboration applications. As a result, service providers are now increasingly taking ownership of the Wi-Fi experience, while OTTs (such as Netflix and Zoom) are innovating with video techniques to guarantee a better QoE. Innovation is also running at a furious pace among equipment vendors to ensure every Hertz in the spectrum is fully optimized.



Just as the diversity of wireless use cases and the demands they make on networks are exploding, so is a radical expansion of Wi-Fi capabilities underway to meet those demands. The centerpiece of this transformation is Wi-Fi 6, based on IEEE 802.11ax standards, which delivers a step change in Wi-Fi capabilities and performance.

At Ambeent, we believe that through more effective optimization of the Wi-Fi spectrum, Internet quality and reliability can be improved instantly to meet the urgent requirements of the surge in Internet demand. In this paper, we discuss the various factors affecting Wi-Fi performance, including neighbor interference; poor Wi-Fi performance not only affects users, but also results in higher costs for the operator and OTT providers. We present and make the case for an innovative approach to tackle this Wi-Fi inefficiencies that collaboratively synchronizes Wi-Fi device signals to prevent neighbour interferences and maximize Internet quality and speed. Along with this, we highlight how these novel Wi-Fi optimization solutions are synergetic with the new wave of 5G technologies, and in particular the progressive usage of unlicensed wireless technologies.

It is possible that the coming months will effect a permanent change in working practices, to the benefit of connectivity providers, as more people and organizations change their habits. With this new opportunity comes new responsibility as service providers will have to ensure new levels of reliability, security, and trust with their customers. In the future, the need for quality and reliable Internet shall become even more pronounced, and it is our aim to continue to support progress toward this target by providing instant solutions for each and every Internet user, as well as for companies.



Home Wi-Fi Became Mission-Critical Overnight

As referenced above, one-third of the population of the world became required to “shelter at home” effective in early April of 2020 as a result of the COVID-19 pandemic. In the process of individuals and businesses around the world drastically adjusting their routines as a result, the Internet is being taxed as it never has been before.

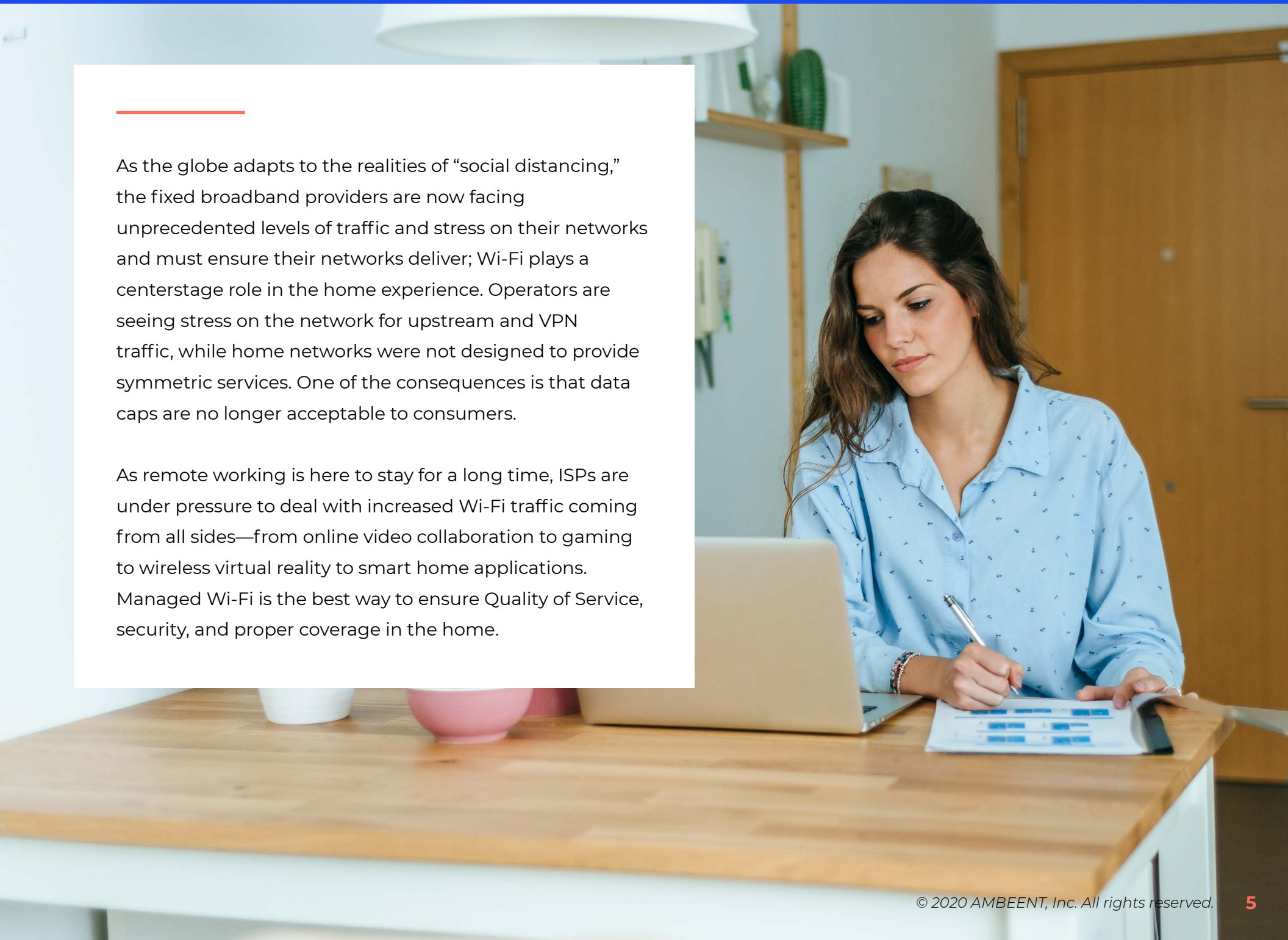
Well before COVID-19, the home was already becoming a highly Wi-Fi-dense environment with many connected devices. While the average number of connected devices in the home is estimated to range from seven to ten, depending on the region, the trend is clear toward an increase to twenty, thirty, or more in the next few years due to the proliferation of devices and IoT.

Not only is the number of connected devices in the home growing, but the proportion of high capacity devices—such as VR and 4K TVs—is also increasing, requiring high bandwidth and driving multi-AP growth. Those devices and related applications also require lower levels of latency, an increasingly important measure of QoE for home Wi-Fi.

Millions of people are now working from home who were not previously. Students all over the world are going online to continue their studies. Governments are increasingly leveraging the Internet to communicate with their citizens. Vast amounts of commerce have moved online. Houses of worship are streaming their services to keep their communities connected. And entertainers are engaging with their audiences online to provide an escape from the isolation that so many people and families are starting to feel.

Unfortunately, many home Wi-Fi users are still using legacy Wi-Fi equipment such as 802.11n and are experiencing a poor experience, especially with upload which has increased as much as 80% among many service providers.

Some equipment vendors have reported congestion on home Wi-Fi networks in both the 2.4 and 5 GHz bands, thus reminding us of the importance of the new 1200 megahertz of spectrum in the 6 GHz band.



As the globe adapts to the realities of “social distancing,” the fixed broadband providers are now facing unprecedented levels of traffic and stress on their networks and must ensure their networks deliver; Wi-Fi plays a centerstage role in the home experience. Operators are seeing stress on the network for upstream and VPN traffic, while home networks were not designed to provide symmetric services. One of the consequences is that data caps are no longer acceptable to consumers.

As remote working is here to stay for a long time, ISPs are under pressure to deal with increased Wi-Fi traffic coming from all sides—from online video collaboration to gaming to wireless virtual reality to smart home applications. Managed Wi-Fi is the best way to ensure Quality of Service, security, and proper coverage in the home.

How COVID-19 Impacts Internet Usage

In the US alone, over 72 million homes and businesses subscribe to broadband delivered by cable providers. The NCTA - The Internet & Television Association—which represents a fair number of cable providers (including Charter, Comcast, Cox, GCI, and Midco)—has released some interesting preliminary data about the stark impact of COVID-19:

- National downstream peak grew **20.1%** while upstream grew **27.7%**.
- Upstream peak hours in many regions have shifted from late evening towards afternoon.
- Downstream peak hours are still primarily during the evening.
- Wi-Fi data traffic and Wi-Fi calling are increasing as compared to mobile; networks are supporting more Wi-Fi connected devices.
- Comcast reported a **32%** surge in peak traffic; a **24%** increase in mobile data use over Wi-Fi on Xfinity Mobile; VoIP and video conferencing is up **212%**; and VPN traffic is up **40%**.

In turn, the WISPA (who represents wireless ISPs in the US) conducted their own survey and shared with us their top-line findings:

- Members have experienced **36%** more traffic at “peak” hours.
- **90%** reported they are experiencing requests for more capacity or speed from their end-customers.
- **75%** have lifted data caps, increased speeds, or suspended cut-offs.

In US rural areas, OpenVault, a company that specializes in the collection and analysis of household-level broadband usage data, found that downstream usage rose 53.3% and upstream usage surged 41.9%.

Fastly, a cloud computing services provider reported some interesting numbers for different countries which were hit hard by the spread of the pandemic:

Country or State	Traffic Change	DL Speed Change
France	↑ 38.4%	↓ 13.9%
Italy	↑ 109.3%	↓ 35.4%
Japan	↑ 31.5%	↑ 9.7%
Spain	↑ 39.4%	↓ 8%
United Kingdom	↑ 78.6%	↓ 30.3%
USA - California	↑ 46.5%	↑ 1.2%
USA - Michigan	↑ 37.9%	↓ 16.1%
USA - New York & New Jersey	↑ 44.6%	↓ 5.5%

Source: Fastly

According to Fastly, ISPs have had little time to react to the surge but overall, the internet has fared well thanks to the regionality of these degradations and the elastic nature of modern websites and internet applications. Those users who had poor internet connections to begin with may notice greater degradation than those who had good-quality broadband.

Statistics provided by Internet companies and service providers in a variety of countries show a similar upward trend in Internet traffic:

- Network-monitoring company Sandvine reported that YouTube traffic is up by more than **10%** worldwide.
- British Telecom reported that daytime usage on the network rose to 7.5 Tbits/s from the normal 5 Tbits/s.
- Bell Canada reported that traffic was up **60%** during the day, with video, Netflix and video conferencing accounting for most of the surge, and with peak time still occurring in the evening.
- Orange in France reported that WhatsApp audio usage was multiplied by 5, video conferencing usage doubled, while transatlantic traffic surged because of streaming demand, in turn putting a lot of stress on Wi-Fi network.
- Turk Telekom and Vodafone in Turkey reported a **50%** increase in home Internet usage in just a few days after the start of quarantine measures.

In parallel to the rise in usage, Internet performance suffered. Ookla Speedtest analyzed Internet performance data in China, Italy, and the US over the past several weeks, providing the following statistics:

- In Hubei, China, Internet speeds began to decline the week of Jan. 13, approximately ten days before the population was locked down on Jan. 22-23.
- In Italy, lockdowns started on March 9, and Ookla saw notable speed declines in both the province of Lombardy and in Italy as a whole that week.
- Speedtest's results show more marked speed declines of up to 25% in US rural and suburban areas in which people have traditionally commuted to offices in or near cities but now may be working from home.

Applications Driving Home Internet Data Usage

The most impact we have seen from the imposed stay-at-home orders is a greater use of distributed services, including teleconferencing, home health care, and home/remote assisted education. The need to support higher resolution video, for example, is critical in eHealth applications and highly beneficial in home-based education. All these applications are putting enormous stress on home Wi-Fi networks which often are poorly deployed and managed by unsophisticated customers.

The exhibit below from a September '19 Sandvine report shows the share of each major application in the overall internet usage pre-COVID-19. With video dominating all traffic on the internet, operators clearly need visibility into which providers are dominating their network, as each provider has different requirements for bandwidth at different resolutions. According to the aforementioned report (and below), video was 60.6% of total downstream volume of traffic on the Internet in 2019, up 2.9 percentage points from 2018. Web traffic was the next biggest category, with 13.1% share of downstream bits consumed globally, followed by gaming at 8.0%, social media at 6.1%, and file sharing at 4.2%. The coronavirus pandemic is exacerbating the use of the bandwidth-hungry video streaming and conferencing.

Global Application Category Traffic Share

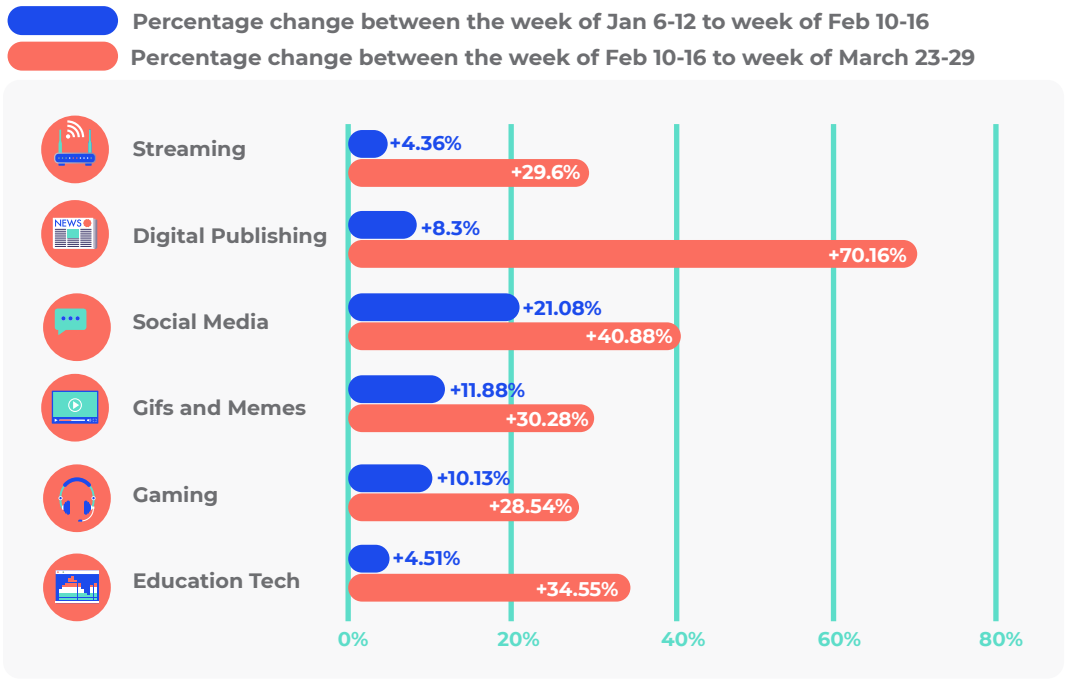
1	Video Streaming	60.6%(+2.9)⬆	22.2%(-0.1)⬇
2	Web	13.1%(+3.8)⬆	10.3%(-10.6)⬇
3	Gaming	8.0%(0.2)⬆	4.9%(+2.2)⬇
4	Social	6.1%(0.2)⬆	7.6%(+3.8)⬇
5	File Sharing	4.2%(+1.4)⬆	30.2%(+8.1)⬇
6	Marketplace	2.6%(-1.9)⬆	1.6%(-0.2)⬇
7	Security and VPN	1.6%(+0.2)⬆	5.3%(-2.1)⬇
8	Messaging	1.6%(+0.1)⬆	8.3%(-0.1)⬇
9	Cloud	1.4%(+0.01)⬆	9.0%(-0.3)⬇
10	Audio Streaming	0.4%(-0.5)⬆	0.3%(-0.1)⬇

Source: The Global Internet Phenomena Report September 2019, Sandvine

Fastly reported on top of regional trends, which types of apps and sites comprised the new, sustained traffic load. To do this, Fastly broke down traffic by industry vertical, looking at average percentage increases of requests per second (RPS) — a metric that correlates to overall internet activity — over February and March as shown in the following exhibit.

Traffic Trends By Industry:

Changes in Average Requests Per Second (RPS)

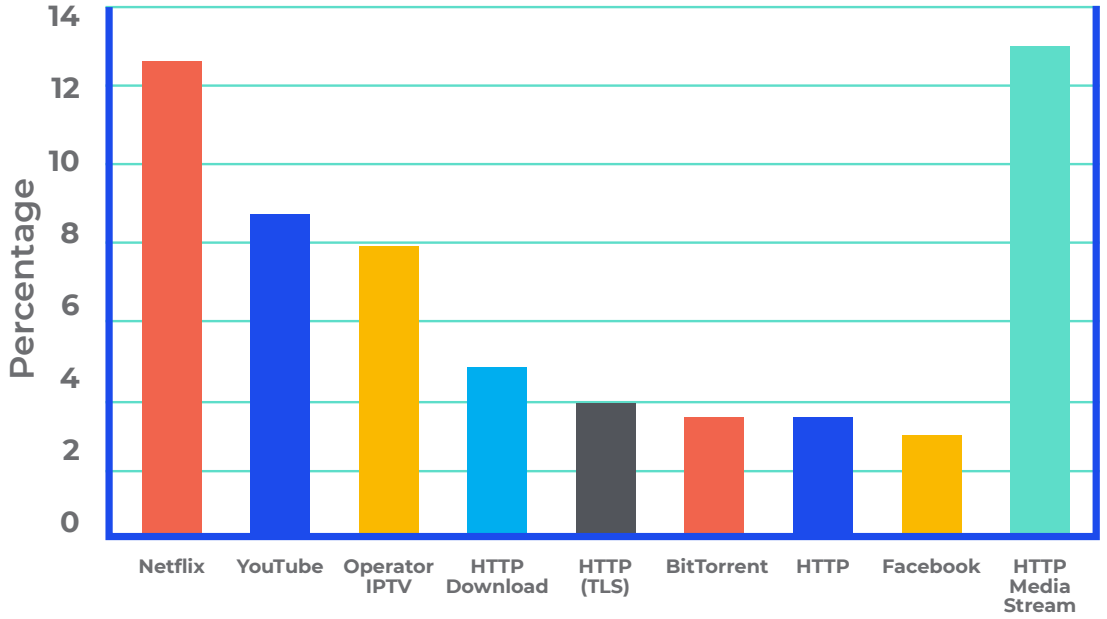


Source: Fastly

In the next sections, we will dive into the each of the main applications driving Internet home usage and its implications on Wi-Fi.

The Continued Rise of Video

Even before the COVID-19 outbreak, the video category was a top source of worldwide Internet traffic with HTTP Media Stream (the operators-combined streaming services competing with Netflix) leading, and Netflix ranking second in 2019. Netflix traffic has long accounted for a significant portion of the world's bandwidth usage; according to the September '19 Sandvine report, Netflix streams then made up about 13% of overall Internet traffic.



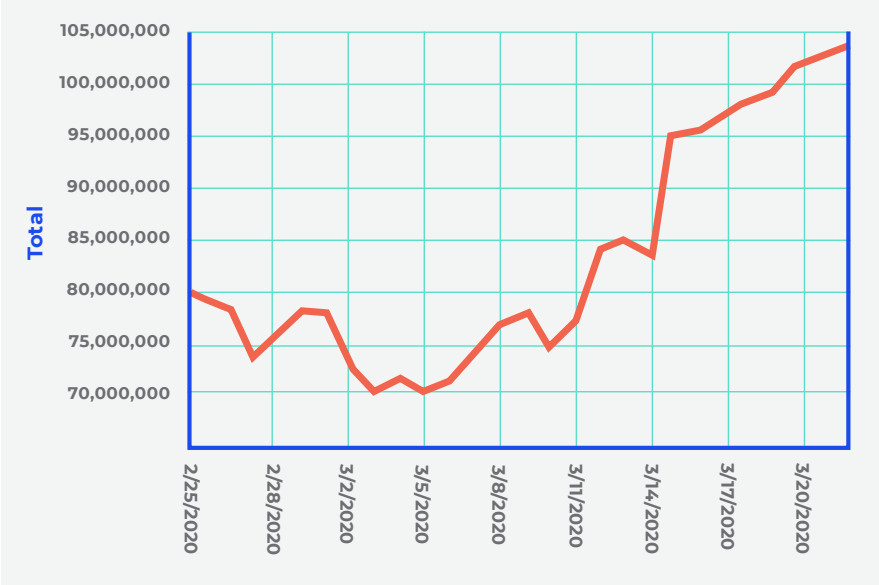
Source: The Global Internet Phenomena Report, September 2019

In this post-COVID-19 era, platforms are becoming more responsive to government concerns worldwide about the potential for the Internet being overwhelmed by surging use of video streaming during the pandemic.

During the last week of March 2020, after being urged to address the situation by the European Union, Netflix and YouTube began making standard definition their default mode in the EU for thirty days. Since then, Apple, Disney, Amazon, Facebook, and Instagram have also reduced their streaming speeds in the EU. For example, Comcast reported a 38% increase in streaming and web video consumption.

As the exhibit below from a recent Apptopia report shows, the global pandemic is transforming both streaming behavior and media. In March, we saw a **30.7%** increase in streaming sessions.

International Entertainment & Streaming Sessions Throughout the beginning of COVID-19



Source: Apptopia

Apptopia's data is based purely on usage of the application on smartphones and other mobile devices.

Needless to say, the rise in video traffic inside the home puts great stress on the Wi-Fi networks as more clients in the home compete for airtime. These networks must be optimized for interference to avoid congestion.

Collaboration Tools Leading Daytime Usage

Microsoft, Google, Slack, Cisco Webex, and Zoom are struggling to deal with a spike in remote tools, thanks to the coronavirus.

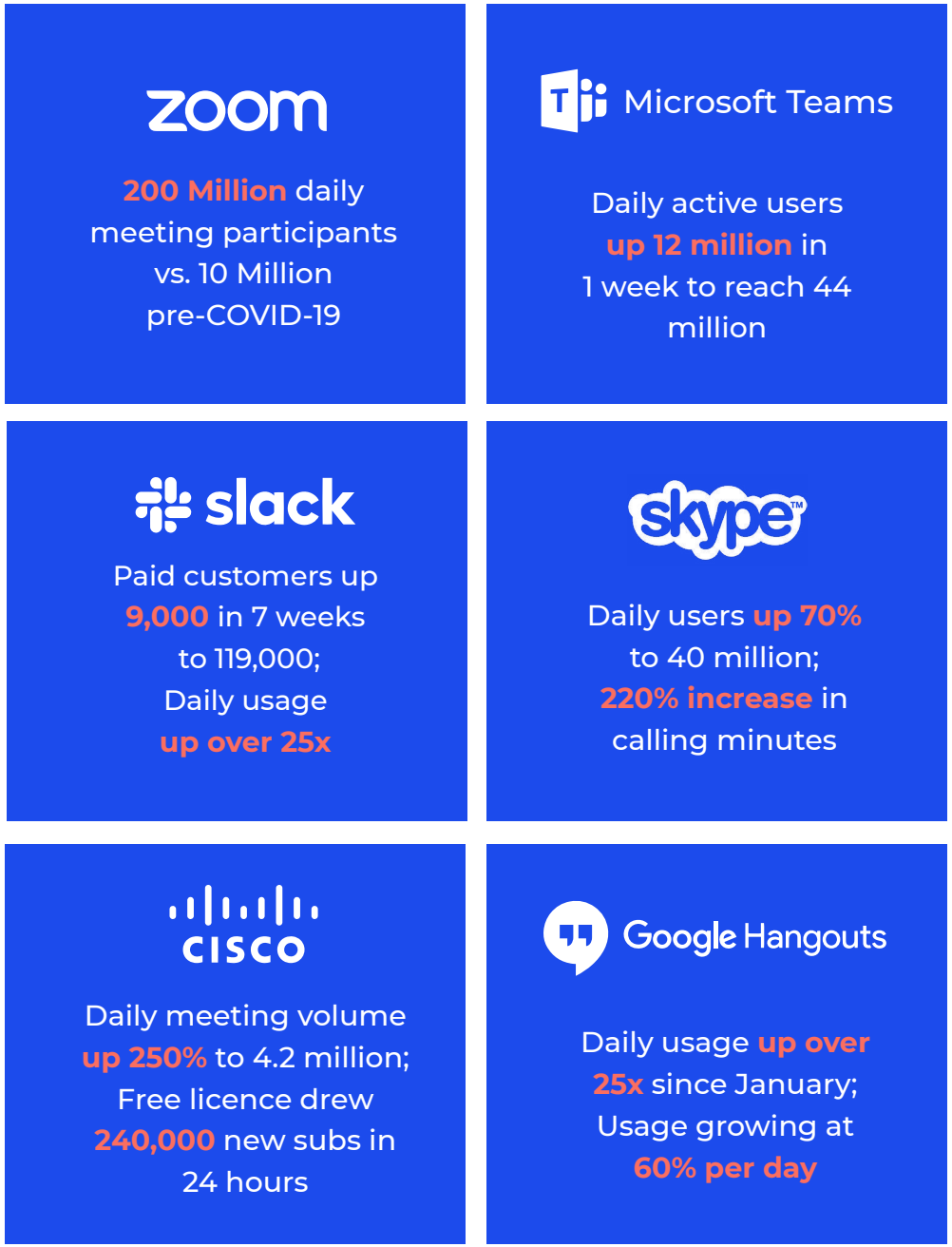
The Zoom app is currently in the top free downloads in the App Store, and analysts estimate that Zoom daily usage was up more than 300% from before workers were forced into their homes by the pandemic. As of March 22, 2020, the company's daily active user count was up 378% from a year earlier, while monthly active users were up 186%, according to data from Apptopia.

Microsoft is also seeing increased usage of its collaboration tools. Microsoft released their latest figures on April 9, 2020, announcing that Microsoft Teams set a new daily record of 2.7 billion meeting minutes, up 200% from the 900 million minutes it recorded on March 16, 2020, when many lockdowns were just going into effect.

Specifically, according to a Microsoft spokesperson, their Teams app has seen a 500% increase in meetings, calls, and conference usage in China since the end of January. Usage rose in the United States as well, at least among Microsoft employees, many of whom have been instructed to work from home. In the last week of March 2020, video and audio meetings were up 37% compared with only a week earlier. Microsoft has also disclosed more than 40 million daily active Skype users, up 70% from a month ago.

Cisco's Webex product, a rival to Zoom, hosted 73 million meetings in March 2020, although the company did not specify how much growth that represented.

There is so much these organizations can do to optimize their tools, including bit rate, resolution, and delivery mechanisms. In the last 10 meters, there is home Wi-Fi, and how well it is configured and managed will impact latency, throughput, and quality of the OTT experience. As such, OTTs have a lot at stake and would benefit from gaining more insights into the Wi-Fi performance for their own operations.



Bandwidth-Hungry Gaming

For the billions stuck at home during the global effort to flatten the curve, gaming is a welcome escape. But it is also a bandwidth-heavy one, and Microsoft, Sony, and others are working to make sure that millions of people downloading enormous games don't suck up all the bandwidth. Akamai is also working with leading distributors of software—particularly for the gaming industry, including Microsoft and Sony—to help manage congestion during peak usage periods. This is very important for gaming software downloads which account for large amounts of Internet traffic when an update is released; a software update for a modern game generates an amount of traffic roughly equal to 30,000 web pages.

In the US, Comcast reported gaming downloads are up 50% generally and 80% during new releases. Similarly, Verizon said it has seen a 75% increase in gaming during peak hours versus the previous week, along with a 12% boost in video streaming and a 20% rise in overall web traffic.

Unlike downloading games, playing games is a remarkably low-bandwidth task. It's important for packets to be traded quickly so players are in sync, but there aren't a lot of them compared with even a low-resolution streaming video.

In regions where demand is creating bottlenecks for customers, Akamai (who is the largest content delivery network) will be reducing gaming software downloads at peak times, completing the downloads at the normal fast speeds late at night. This approach will help ensure every Internet user and consumer continues to have the high-quality experience they expect across all of their Internet services, and that gamers will still get the download they want, though it may take longer than usual during peak usage times. Even more importantly, this will help ensure healthcare workers and first responders working hard to contain the spread of COVID-19 have continual access to the vital digital services they need.

Low latency is also very important in gaming, and as a result, the ability to adjust speeds and priority by device and application is essential to support Quality of Service for these gamers. Again, here the quality of the Wi-Fi network will dictate the end-user experience and application-aware spectrum management.

Generally speaking, the telcos are hosting more and more applications, such as gaming and IoT, closer to the edge, pushing down requirements on latency and hence traffic management on the access and home network.

VR and AR Will Come Next

Last year (2019) was a growth year for virtual and augmented reality (VR/AR), known collectively as extended reality (XR). The presence of these breakthrough technologies began to be felt far from the fields of gaming and entertainment where they first became popular.

Virtual reality (VR)—where users wear a headset and are fully immersed in computer-generated environments—has been developed to meet design, marketing, education, training, and retail needs. Augmented reality (AR)—where computer images are superimposed onto the user's view of the real world through a screen or headset—is a more complex challenge, as it requires the software to "see" what is in front of it.

Most people's first experiences with VR and AR today are likely to be in gaming and entertainment. However, these applications require vast amounts of throughput and very low latencies, while the average home broadband delivers well under 100 megabits per second. Increasingly VR and AR use cases expand beyond entertainment, as educational experiences in VR and AR will continue to become increasingly common throughout 2020 and beyond.

In education, the immersive nature of VR means that pupils can engage with learning in fun new ways, and AR brings new flexibility to on-the-job training. Already, students can take a trip through time to visit the ancient Romans, or through space to experience conditions on other planets. But as the technology moves away from niche and becomes part of the fabric of everyday education, we're likely to see growth apart from simply providing "experiences," into solving problems with current education systems.

Wi-Fi 6 uses a combination of technologies—including OFDMA and 1024 QAM modulation—to improve spectral efficiency and boost not just speed, but support for large numbers of devices in a confined area.

Distance learners could be taught in VR classrooms, meaning they don't miss out on the benefits of learning in a collaborative environment, while AR training aids can ensure that access to the information needed to carry out a job is always on hand. Considering also the new 6 GHz, selection of a band and channel for a particular device at home covered by all three bands has to be automated with a spectrum broker.

Wi-Fi 6 uses a combination of technologies—including OFDMA and 1024 QAM modulation—to improve spectral efficiency and boost not just speed, but support for large numbers of devices in a confined area. In early trials, that capability has mainly been demonstrated in stadium environments, but device density is also important in the home, where many appliances and previously dumb devices will start to be connected to the home hub, and where several users may be consuming high quality video, gaming, or AR/VR at the same time. Still, no matter how wide the broadband pipe or powerful the access point, real performance must be reflected at the device level, and that performance can be degraded by a number of issues.

Issues With Home Wi-Fi Performance

With more users in the home simultaneously active online, the Wi-Fi network can suffer overload and decreased performance. In its annual industry report, Maravedis[1] conducted an extensive survey on home Wi-Fi issues. The online survey took place during the September and October 2019 timeframe and gathered 218 responses, 42% of which were from service providers worldwide.

Poor Access Point Placement

Our research shows that poor access point placement is the #1 cause of poor Wi-Fi performance, followed by dead zones and neighbor interference. While there are many factors that can affect home Wi-Fi operation, the placement of wireless access points (APs) can be one of the most significant factors in performance. Good AP placement must provide not only adequate coverage for all clients on a network, but also provide adequate throughput, good connectivity, and minimal interference.

Latency vs Throughput: What is the most important for better QoE?

Throughput is the amount of data that is actually delivered across a network connection over a period of time, not a theoretical rate.

Latency is the time that it takes for an IP packet to make it across the network from the sender to the receiver and for a response to come back. Network latency is commonly measured as round-trip-time (RTT) and is sometimes referred to as "ping time." Applications that are more interactive or real-time, like web browsing, online gaming, and video conferencing/ chatting, perform the best when latency is kept low, and adding more bandwidth without addressing latency doesn't make things better.

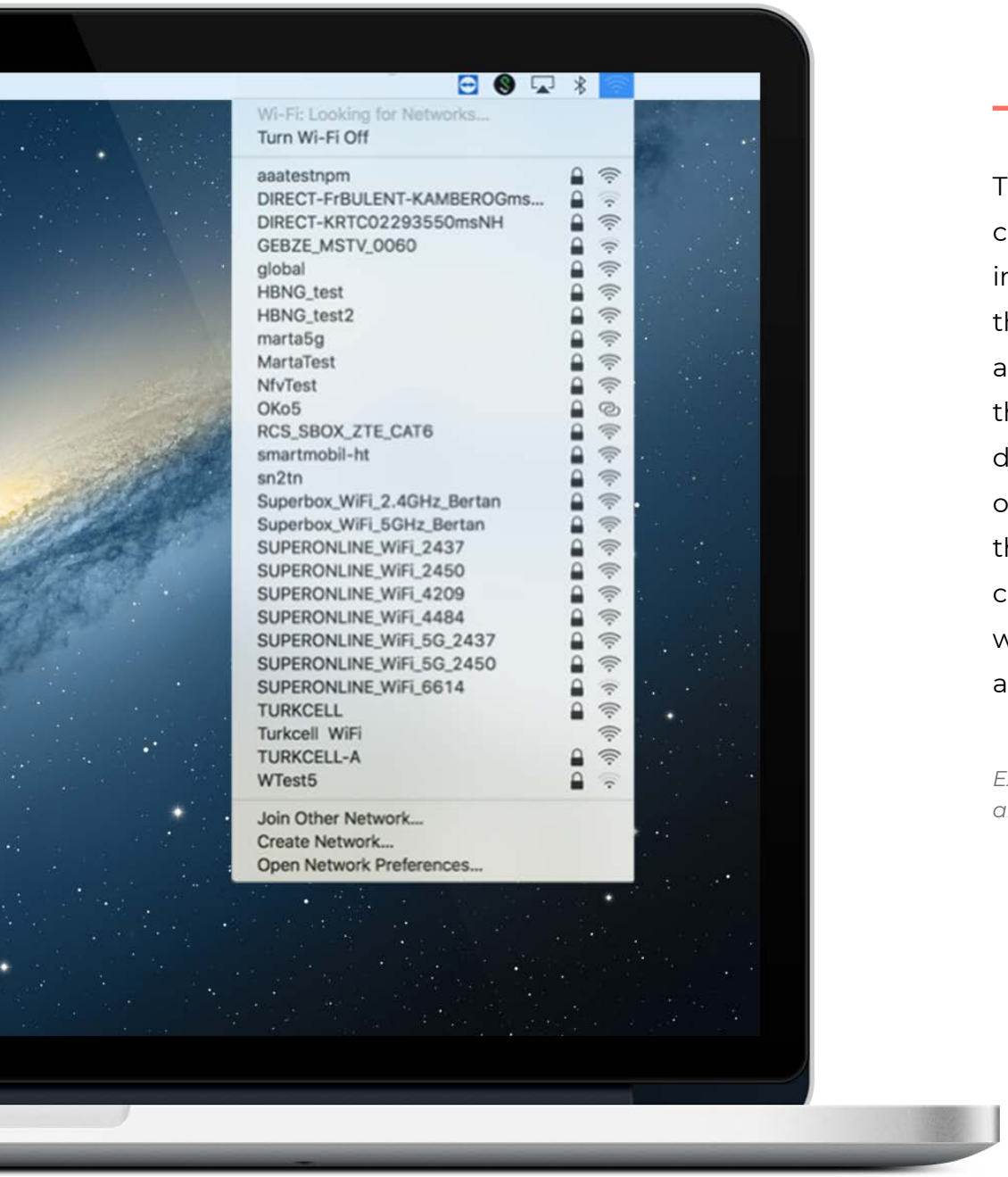
RTTs increase when there are queuing delays (e.g. due to temporary buffering at congested network routers and switches along the path) and mutual interference between different categories of internet traffic in concurrent use. Increased bandwidth and throughput does not directly translate to reduced RTTs in the domestic context and adding more capacity gives diminishing returns.

Dead Zones

To achieve a good connection, Wi-Fi has to overcome barriers and obstacles, some of which—such as dead zones—cannot be eliminated by simply purchasing a new wireless router. While a dead zone can be a result of poor access placement, it is generally due to the structure or the size of the home, specifically, the walls or materials that block signals requiring multi-access points either in the form of extenders or repeaters which can be backhauled with a dedicated wireless link or with wireline.

Neighbor Interference

Wi-Fi networks interfere with each other. Older Wi-Fi standards are even worse in this respect, so old Wi-Fi hardware is not just hurting one's network—it is also interfering with neighbors. When multiple Wi-Fi networks are close to each other, especially in the MDU environments, ideally, they should be on different channels to reduce interference.

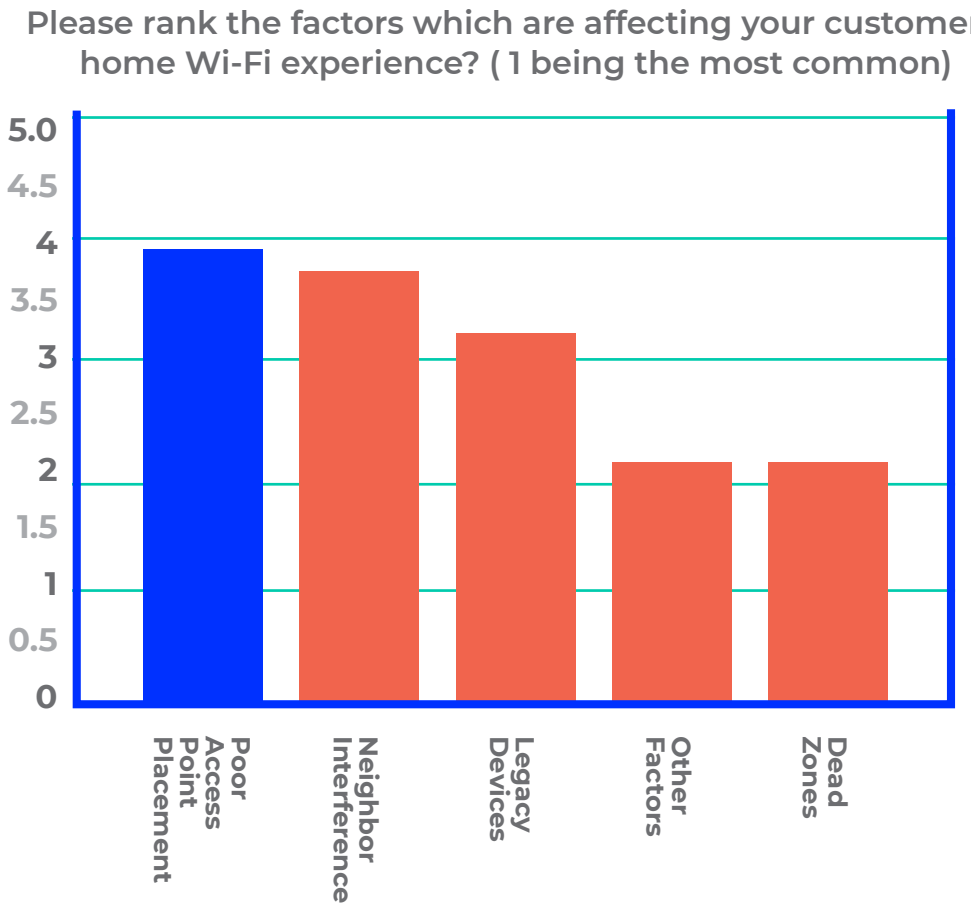


Therefore, modern routers often try to automatically choose the best Wi-Fi channel for the least interference in a distributed fashion. Older 802.11b/g/n networks use the 2.4 GHz range. While commonly used, these networks are not ideal for Wi-Fi channel interference. Given that there are fourteen different available wireless channels designated for use in this range, there is a considerable overlap between them. Specifically, channels 1, 6, and 11 are the most frequently used, so Wi-Fi networks on adjacent channels do not interfere with each other. In the event when there are more than three wireless networks in the area, they are just interfering with each other.

Example of a typical house today which has 15-20 Wi-Fi devices and multiple neighbors with Wi-Fi

Modern Wi-Fi standards started to operate on 5 GHz instead of 2.4 GHz, due to congestion. 802.11ac operates only on 5 GHz. 802.11n routers can operate on either 2.4 GHz or 5 GHz, but not both; they are typically set up to operate on 2.4 GHz. Also, coming 802.11ax is designed to operate in all ISM bands between 1 and 6 GHz. Ambeent's solution is useful in collaboratively assigning the bands and channels with channel aggregation in mind in order to provide the maximum efficiency against mixed deployments with respect to coverage capability, capacity and device & application in use. This re-organization will not only utilize upcoming bands more efficient but also revive the cluttered yesterday's 2.4 GHz and tomorrow's 5 GHz bands.

Exhibit: Factors affecting home Wi-Fi experience



Source: Managed Home Wi-Fi Networks for the Smart Home 2020-2025

The Cost of Poor Wi-Fi Performance

The COVID-19 impact on home Wi-Fi usage has led to a decrease in QoE. Some operators are experiencing a 40% increase in the number of call center complaints because of low internet speed. Slow Wi-Fi speed is the number one reason triggering service calls, followed closely by unstable Wi-Fi. Resolving those main pain points obviously will result in a drop in service calls. The challenge for operators is to gain sufficient visibility into the home Wi-Fi network to understand what is causing those performance leaks—whether that be issues related to interference, sticky clients, overloaded gateway, etc.

Wi-Fi performance and, by extension, user experience, are frequently compromised by the adverse impact of numerous environmental factors such as congestion, noise, and interference. A typical user is frequently unable to differentiate between various types of problems associated with poor Wi-Fi performance, or other problems of the access network, or in the underlying applications.

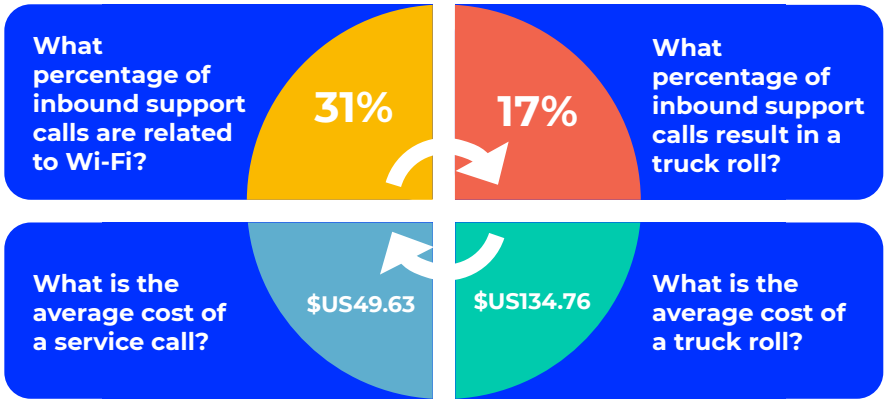
Currently, there are no effective tools available to operators to efficiently evaluate subscriber Wi-Fi QoE. Similarly, operators are unable to diagnose and solve Wi-Fi-related issues or to differentiate Wi-Fi-related degradations from other causes of poor customer experience. Some operators have developed their in-house tools to diagnose Wi-Fi networks, but these often need to be improved with third-party tools which have been fine-tuned over many deployments across a larger number of service provider's networks.

Likewise, subscribers are typically unable to resolve their Wi-Fi issues on their own and have to contact their service providers. For service providers, this lack of customer inability to solve Wi-Fi problems results in high operating costs stemming from ineffective or lengthy support calls, costly "truck rolls" for on-site service, and CPE (Customer Premise Equipment) replacement. Accordingly, due to the aforementioned lack of effective tools to diagnose and solve Wi-Fi-related issues, operators' attempts are frequently ineffective. This leads to many return calls and visits, generating higher levels of customer dissatisfaction which is only amplified in the context of COVID-19 where both the use and expectations have increased.

Results from Survey

As the figures from our survey show, one-third of inbound support calls are Wi-Fi-related, and 17% of them result in expensive truck rolls. Numbers vary greatly by region and by operator, but service calls can become expensive and add up to carriers' OPEX.

Exhibit: Key Figures of Wi-Fi-Related Support



MARAVEDIS
Wireless Infrastructure Analysts

Source: Managed Home Wi-Fi Networks for the Smart Home 2020-2025

One way to address the rise in Wi-Fi-related help desk calls is by offering a managed Wi-Fi service. This service involves the service provider providing the home gateway and managing all aspects of the subscriber's network to provide the best possible Wi-Fi experience. While there are also arguments against using routers sold by retailers, the burden is again on service providers to explain why consumers should opt for their managed hardware. Among the problems with retail solutions is that they are proprietary and request to switch off the Wi-Fi of the operator's CPE (Customer Premise Equipment). In addition, the ability for the operator to resolve hardware issues, if they arise, is decreasing.

Moreover, the security of retail APs is highly questionable, and a potential security breach will have negative impacts for operators, rather than for the hardware vendors themselves.

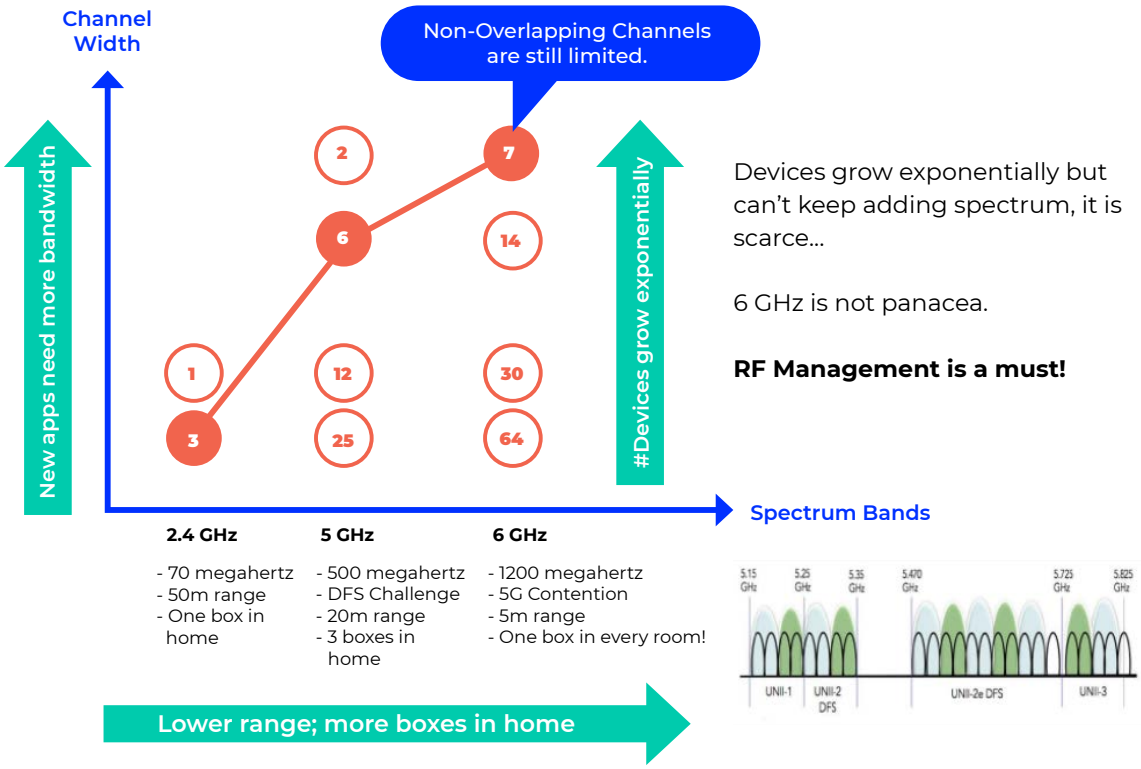
Wi-Fi 6E won't Solve all Problems

Given the vision that next generation wireless will be providing the connectivity for the digital society, which will mean supporting a huge variety of applications, it is clear that one radio technology will not be able to deliver that vision alone. Coexistence between different radios, spectrum bands, and deployment models will be essential to deliver the full potential of wireless connectivity in

the “5G era.” Wi-Fi will be part of 5G, and 5G will increasingly be leveraging deployments in unlicensed bands, in both public and private networks. Wi-Fi 6 has true 5G capabilities, including support for multi-gigabit speeds, massive device density, and very low latency. Not only does it boost performance, but it is readily deployable for a huge array of use cases.

We know the current Wi-Fi spectrum is congested, and the industry has been claiming the need for additional spectrum for unlicensed use.

Congested Spectrum



Devices grow exponentially but can’t keep adding spectrum, it is scarce...

6 GHz is not panacea.

RF Management is a must!

Source: Ambeent

At the beginning of the year, the Wi-Fi Alliance announced new branding of Wi-Fi 6E in reference to the spectrum extension to the existing Wi-Fi 6 standard capable of supporting all-new 6 GHz frequencies (5.925-7.125 GHz). On April 23rd, 2020, the Federal Communications Commission made the opening of 1200 megahertz official for use by unlicensed devices in the 6 GHz band (5.925-7.125 GHz). The rules are designed to allow unlicensed devices, such as Wi-Fi, to operate in the 6 GHz band without interfering with the operation of the licensed services which will continue to use this spectrum.

Routers will have wider channels to work with to accommodate more devices at higher throughput rates. Wireless Broadband Alliance research[2] shows the use cases that survey respondents believe will deliver the most benefit with the combination of Wi-Fi 6 and 6 GHz spectrum (Wi-Fi 6E). Seventy-two percent (72%) said the biggest consideration is that 6 GHz spectrum won't have traffic interference from legacy Wi-Fi devices. More than 65% of respondents want to use 6 GHz spectrum to enable applications that require high bandwidth and low latency, such as augmented and virtual reality (AR/VR) and gaming on Wi-Fi 6 devices.

Some Elements of Managed Wi-Fi

There are different approaches and elements to solving the home Wi-Fi performance and coverage issues. Each vendor has its own approach and "secret sauce" comprised of algorithms sold in modules to perform the essential functions needed to solve the problem.

Smart Spectrum Management

We already indicated that the number of devices in the home is exploding, thus creating more competition to access this limited unlicensed spectrum in the 2.4 GHz, 5 GHz, and upcoming 6 GHz bands. That demand will be further aggravated by the emergence of 5G technology using the 6 GHz band and will increase the need to perform dynamic channel management with solutions like Ambeent.

While data traffic and demand using the unlicensed spectrum is growing, the present wireless network architecture on Wi-Fi spectrum suffers from uncoordinated spectrum utilization in a growing number of Wi-Fi access points and technologies. Insufficient coordination among a large number of APs that use overlapping channels leads to interference among them resulting in reduced efficiency and lower data rates. Inefficiency also results in re-transmissions, which not only reduces throughput, but also wastes energy.

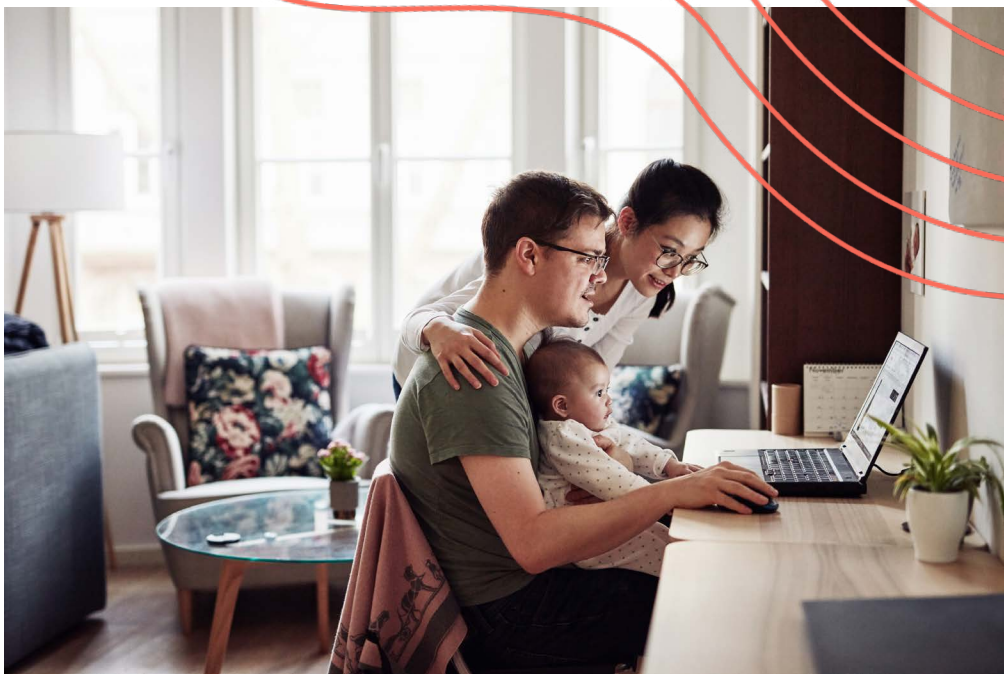
Shift from a decentralized to a centralized management system on the unlicensed spectrum is critical to obtain the maximum possible degree of efficiency and to increase overall wireless Quality of Service (QoS). What is needed is a smart and dynamic allocation of the channels based on a number of parameters, leverage continuous data collection and intelligent AI based processing engines for optimization.

Interference Management

Steering can be done for bands, channels, and clients (devices). For example, dual band operation with band steering detects clients capable of 5 GHz operation and steers them to that frequency, which leaves the more crowded 2.4 GHz band available for legacy clients. This helps to improve end user experience by reducing channel utilization, especially in high-density environments. Dual band operation with band steering is configured on a per-SSID basis.

Radio Resource Management

Radio Resource Management (RRM) involves strategies and algorithms for controlling parameters such as: transmit power, user allocation, beamforming, data rates, handover criteria, modulation scheme, error coding scheme, and so on. The aim is to efficiently use the limited radio-frequency spectrum resources and radio network infrastructure. RRM may include radar detection and re-entry (DFS). Again, each vendor comes up with its own version of RRM, and may or may not support radar detection and re-entry.



Towards Multi-Access Points (MAPs)

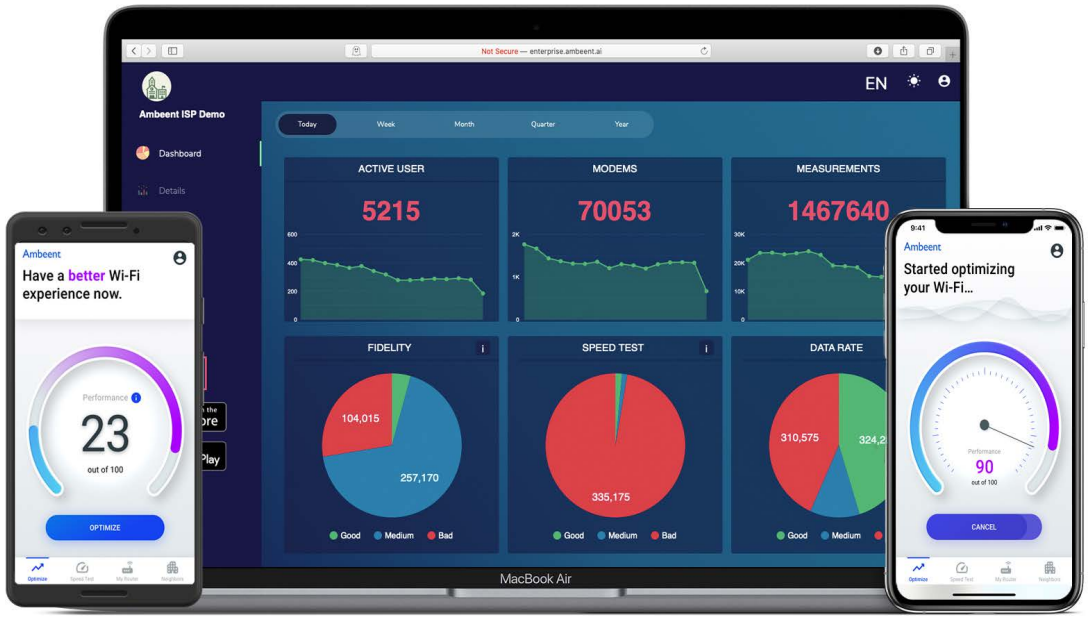
Multi-Access Point (with or without mesh) networks seek to solve problems with coverage, largely within the home. Wireless mesh network devices (Mesh STAs) form links with one another, over which mesh paths can be established using an ad hoc mobile routing protocol. A key aspect of this architecture is the presence of multi-hop wireless links and routing of packets through other nodes towards the destination nodes.

In the traditional approach to mesh, hops introduce latency and reduce throughput. Several vendors seek to provide their own methodology to solve the issue of the coverage/capacity trade-off, for example with a dedicated wireless channel for backhaul to avoid reducing throughput.

At the same time, mesh network gateways with a core gateway and either nodes or repeaters that go with it become increasingly available. The underlying principle is simple: a centralized gateway architecture with a multi-node mesh solution providing coverage throughout the home, with nodes placed, for instance, on an upstairs floor, the main floor, and maybe the garage or a basement, creating a resilient network. Therefore, if one node goes down, another one is available in the mesh.

An Innovative Approach to Managing Home Wi-Fi

Ambeent.ai introduces a mobile-controlled Wi-Fi Console[3] that monitors and provides collaborative optimization to reduce the neighbor interference problem. Ambeent's technology is the only Inter-Home Wi-Fi Performance Solution in the market that is between homes.



Ambeent's solution is device-based, collecting various inputs from the user nodes, for example a mobile phone, to carry out optimization decisions. It is AI powered, as it dynamically leverages the data collection to perform advanced multi-dimensional optimization. Its novel technology is universal, addressing the lack of coordination and diversity of technologies of router makers and service providers. Ambeent's device-centric approach tailors the network supply to meet diverse conditions and demands of users—enabling smart channel allocation that is user-location and application-aware. The result is substantial performance gain in throughput and QoE. The future iterations of interference management will further include the use of machine learning and the need to manage multi-radio access technologies, including cellular, as spectrum sharing and aggregation become the norm.

Collaborative

Because this innovative approach enables the first user to enjoy the benefits of smart allocation of channels, it is incentivized to spread the word to its neighbors and friends and generate a viral spread of the solution without having to resort to the operator's permission or involvement. This is a very low-cost entry which is self-driven by positive results.

As explained in the above section on the deployment scenario, the shift from a decentralized to a centralized management system on the unlicensed spectrum is critical to obtaining the maximum possible degree of efficiency and to increase overall QoS. It works with the combination of application on the device which configures the router and signals that it must send the user to another channel. All of the data is sent to the cloud to feed a central repository and machine-learning algorithms.
Another aspect of increased collaboration is seen in dynamic spectrum approaches—such as Television White Space (TVWS) regulation and more recently, Citizens Broadband Radio Service (CBRS) in the US which have emerged as an alternative approach to spectrum assignment. It strategically occupies a middle ground between traditional spectrum licensing and license-exempt spectrum. Through a database approach to validating dynamic spectrum devices, dynamic spectrum management offers the regulator some control over the use of the spectrum; however, it does not confer exclusivity in the way that licensed spectrum does. In this context, Ambeent solution can be deployed to avoid spectrum waste in the context of converged technologies that involve spectrum sharing (such as CBRS and 5G).

User-Centric and Location Aware

Ambeent collects various inputs from the user nodes, for example a mobile phone. Incorporating data from mobile users provides compliance to GDPR/CCPA and makes the amount of information in our optimal solutions larger than those that use less information. For instance, operators collect only a limited number of inputs from Wi-Fi Access Points in order to carry out optimization decisions.

Ambeent's AI sits both at the edge on the device, as well as in the cloud where a large number of devices are feeding the machine learning algorithm.

The device-centric approach also means we tailor the network supply to meet diverse conditions and demands of users. By having the device scan the immediate channel conditions instead of relying on a centralized gateway, the system is much more precise and dynamic. If, for example, the user is using channel 6, and walks to the kitchen where their neighbor also uses channel 6, the algorithm will tell the device to move to another channel such as 11. Ambeent's AI sits both at the edge on the device, as well as in the cloud where a large number of devices are feeding the machine learning algorithm.

Artificial intelligence will allow the key characteristics of problems in the Wi-Fi network to be picked out from the big data that is the mass of traffic data, fix known problems directly, analyze trends in performance, and predict future requirements to avoid problems altogether in the future. AI enables computing devices to learn as they receive new data with no need to be reprogrammed. This would allow the Wi-Fi network management system to constantly add to its knowledge base, extend its repertoire of known problems and solutions, and raise standards of user experience even higher—in essence, self-learning.

Application-Aware Optimization

The solution is lying the groundwork of enabling application-aware allocation to take into account throughput requirements of each user or device in the home. When neighbors exceed the number of overlapping channels, the need to allocate channels according to session types is inevitable. Indeed, a 4K TV streaming video or a collaboration app will have different throughput and latency needs than web browsing or email activity. Therefore, applications requiring high throughput will require a priority access to clean channels, which will result in a better QoE overall. In the context of COVID-19, application aware solutions are even more relevant given the traffic surge and the increased requirements on the home network.

Conclusions

In this paper, we looked at how the Covid-19 pandemic has caused an unprecedented surge in home internet usage due to shelter-at-home orders and school closures. We argue that because Wi-Fi is playing a center role in the home QoE, operators and any Wi-Fi owners will need every tool in the box to optimize their network performance all the way to the device.

We discussed the various factors affecting Wi-Fi performance, including neighbor interference, as poor Wi-Fi performance also results in higher costs for the operator in the form of higher service calls and truck rolls. We presented and made the case for an innovative approach to tackle these relative Wi-Fi inefficiencies. This solution offered by Ambeent is to enable smart channel allocation that is location- and application-aware and lends itself to a collaborative approach. The result is substantial performance gain in throughput and QoE, and a corresponding reduction in support and operational costs.

The future iterations of interference management will further include the use of machine learning and the need to manage multi-radio access technologies, including cellular, as spectrum sharing and aggregation become the norm.

About Ambeent

Ambeent offers an AI-powered collaborative spectrum broker to enhance Internet services' QoE. It offers a cloud-based platform that brings order and dynamism to chaotic unlicensed spectrum among
Wi-Fi and 5G technologies with applications in public and private networks. Ambeent's technology is used by service providers, Wi-Fi enterprise owners, and OTT application providers as a spectrum as a service. Ambeent was founded as a result of the research groundwork done at the University of California, Berkeley, and has earned many awards, including from the European Innovation Council Accelerator program, MWC, and Wi-Fi NOW in 2019. Ambeent's innovation is the first of its kind, absolutely imperative in both the delivery of reliable and high-performance Internet and in laying the groundwork for future heterogeneous networks.

Thank You

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