



**VIRTUAL EXPERIENCE
OCTOBER 11-14**



How Working and Schooling from Home has now driven a change in how we view Home Connectivity and Networking

What we did during the Pandemic and how it could define new products and services

A Technical Paper prepared for SCTE by

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1. Introduction

During the last 18 months many things have changed for many people. One indelible change seems to be how important our home is for working, schooling, and staying connected. While we cannot fully predict what the real ramifications of virtual working from home, schooling from home are going to be – there are many predictions of significant changes in our workforce locations from new permanent at home work increases to flexible working being introduced more by employers. As well as the work from home changes there are likely to be other permanent changes in how we view and use connectivity and digital connection from our home.

- Our consumption and use of OTT and IP video services has increased and adoption of its use by even more ‘traditional telly’ focused consumers has increased
- The number of connected IoT devices we have has increased – because of more online consumer adoption. The current silicon shortages have been the result in this rapid change in consumer purchasing behavior of electronic devices for the home.
- The rapid acceleration of adoption of Telemedicine services including virtual doctor visits that is likely to change the way we engage with our medical resources.

Because of this step function and acceleration in behavior change driven by being at home for 12-18 months there is now also likely potential for new and improved Service Provider services that offer to cater to raised awareness and desire from Consumers to improve elements of their connected digital home. In particular

- Reliability of home network connection
- Latency of home network connection
- Improved performance of Wi-Fi
- Separation of work environment at home from residential environments

And potential opportunity for Service providers to bring the Enterprise, School or Doctors office to the home via new services, devices, and technologies.

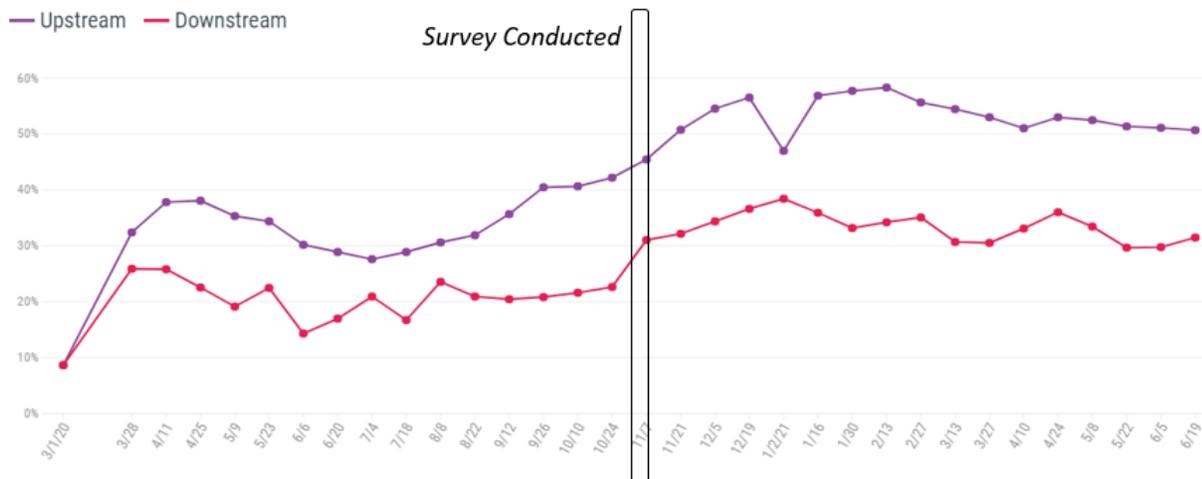
- WFH and Corporate services to the home
- Telemedicine and Aging in Place services
- Increased Privacy and Security
- Increased Reliability

This paper is the result of a poll of ~2,200 CommScope employees during the height of the pandemic last year in November 2020 when according to the NCTA Covid-19 dashboard – home downstream/upstream connectivity growth had not yet hit its peak (which seemed to happen during Christmas/Holiday Season end of December and early January 2021). The poll sought to understand the connectivity drivers and conditions of consumers during the pandemic and their robustness of connectivity and performance ratings. The paper will use some of this feedback to try and put the case forward that there are potentially new requirements for the Broadband delivered home. Based on the survey analysis it will then try and propose the potential for new pandemic home architecture and services potential and outline some of the new device and system elements that could play a new role for Cable Operators to continue to own the digital connectivity and services for their consumers.

National Peak Internet Growth During COVID-19

Observed Increase in Peak Consumer Usage Since Early March 2020

Overall change in pre-COVID internet usage since 3/1/20



Source: Data from NCTA member companies and others.

A Flourish chart

2. November 2020 Survey of Working and Schooling at home

Given the drastic change in all our lives, 2020 presented a unique opportunity to survey people on their new environments of lockdown and working, schooling and effectively trying to do everything from home and on-line. This change of

- Number of end points on Broadband networks concurrently active
- Number of concurrent active devices in the home
- Frequency and time of use of Broadband
- Increase in upstream traffic from Video and Audio conferences
- Number of IP connected devices in the home
- Rooms and new locations in home being used for high value and high capacity services like laptop driven Video conferencing

has been described as almost 2 years of growth of capacity and services in a 6 month period. It did however accelerate how people create their home connectivity platform, resolve their niggling issues that were tolerable when they only had entertainment services primarily at home, improve range of connectivity as new rooms were occupied with WFH and Schooling activities.

Consumers views on reliability, camera resolutions, microphone quality and latency were all sensitized more because of the higher performance of being able to work effectively and to not be that person upsetting everyone else on Video conferences. Because of these changes in our home environment the thesis put forward was that the existing set of Broadband, Video and IoT services may

- Not be good enough to cope with the demands for service the pandemic has highlighted

- Offer opportunity to improve services with new features that may either be sticky for consumer retention or drive new business opportunities
- Be driven by acceleration of new technologies like products developed using new 6GHz spectrum allocations, improvements in IoT like the new Matter solution.
- Be driven by price decreases in technologies like Cameras, Smart Assistants, Microphones, IoT devices which make them more accessible or potential for Operators to bundle into traditional broadband and Video services
- Be driven by acceleration of areas like Telemedicine which even as people resume some normality has reached a point in areas like Virtual Doctor visits where this has become more acceptable and the benefits of not having to wait in Doctors office for minor issues may move this faster to mass adoption
- Be driven by our adoption and acceptance of Video conferencing as a more normal and regular means of connecting with people generally and from the home
- Be driven by new niche areas that have been highlighted as capable of being addressed with technology solutions like Aging in Place – where during the pandemic innovative ways had to be created to keep elderly loved one’s safe and connected

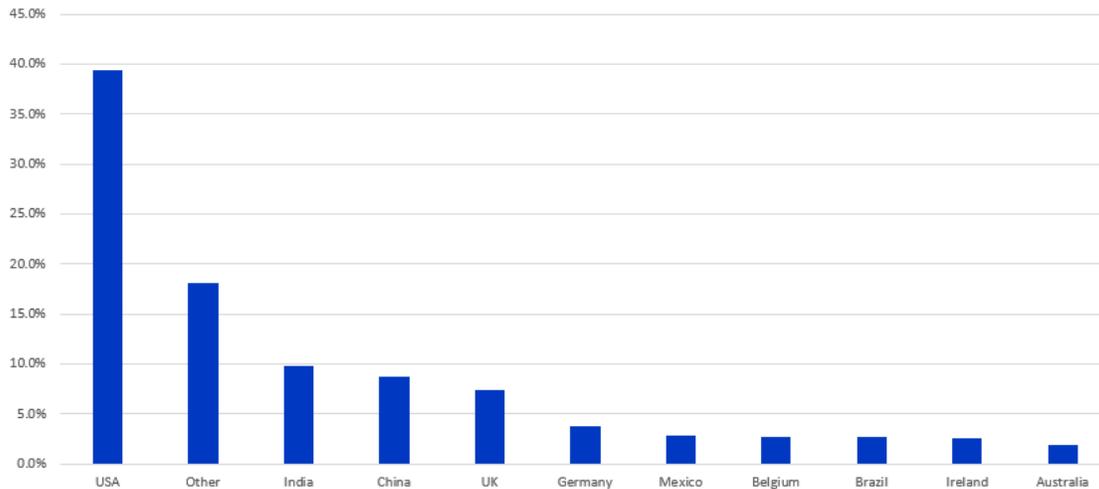
With the goal of trying to open up a discussion on new opportunities to capitalize on this technology acceleration and mind shift in consumers having changed habits pre-pandemic to more use of digital services this paper will first explore how over 2,000 consumers in different countries and with different

- Service Providers
- Home Sizes and constructions
- Home Family and occupancy differences
- Demographics

all coped and shared their insights to a series of questions that were asked to gage what they valued and what they will value going forward to ensure their homes are not just for after 5pm during the week for digital excellence.

Almost 40%/~1,000 of our respondents were from the US with the following spread of other non-domestic respondents in the table below. For the sake of this paper the answers to the questions are presented in a blended fashion as generally the differences created by the pandemic and the needs were similar in all countries.

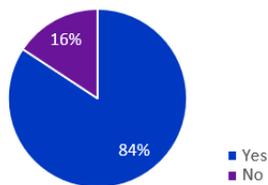
In which country are you currently located?



The sample of respondents had 84% working from home. 80% of these were working full time (5 days) from home. Of course, the key issue with the working from home experience is that many homes during the pandemic had multiple people trying to work and school from home. In our sample 64% of respondents had others working or schooling with them while 36% were on their own.

Working from home is the new normal

Are you currently working from home?

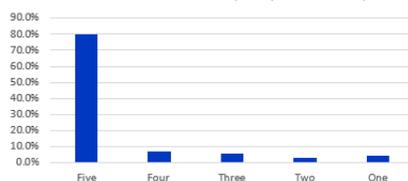


Full-time working from home has become the normal mode of working for most of the people surveyed.

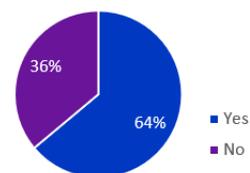
... and it is a shared experience

64% had at least one other person working or studying at home, requiring the sharing of space and Wi-Fi.

How many days on average do you work from home in a week? (5 days maximum)



At least one other person working or studying at home



Exploring the respondents working conditions in more detail, 23% of them had to share a working space in the home. Over 40% had 2 people in a room and 10% had 3 people trying to work and school in a

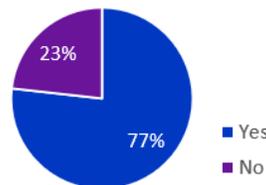
single room. While its is expected that many people will start moving back to their workplaces towards the end of 2021 many companies are now trying to find the best balance to

- Investment in Office real estate
- Creating collaboration face to face for innovation
- Maintaining flexibility for the employees to work more from home
- Allowing employees to work from home more permanently where it has made sense

To create and sell services to the needs of the height of the pandemic is the big question that is still hard to answer. However, there is a much more acute awareness of the reliability and performance of the home environment for connection to the internet and corporate office that is likely to remain, particularly for those employees who will remain working flexible conditions from home. As of the time writing this paper it does look like schooling will resume for the majority back in the classrooms at the start of the 2021/2022 school calendar. The worry about new developments in strains of the Covid-19 virus will keep consumers vigilant on their home connectivity performance but consumers will always balance their investment to their budget and additional performance/reliability features offered may not be invested in ahead of need.

23% had to share working space in the home

Is everyone working from home or schooling from home in a different room?



If no, what is the maximum number of people in a room while working / studying?

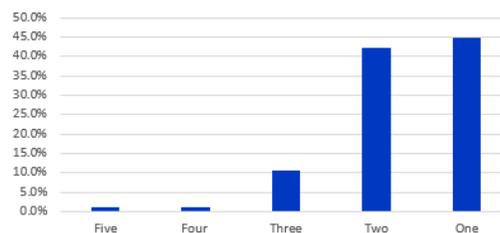


Figure 4 How many people had to share a room to work and school

Of those respondents working from home 42% of them had another person working with them and typically working 5 days per week. This has been a key stress point for both the psychological wellness of the workers from home as well as their connectivity performance.

Phycological wellness has been challenging for many households

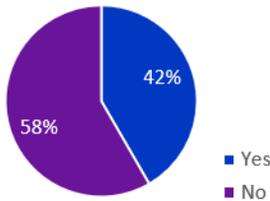
- Parents working from home and schooling and minding children

- Multiple people trying to work simultaneously in small homes
- Audio and background interference during working and schooling sessions
- Problematic connectivity on important schooling or work video or audio conferences
- Additional group meetings to stay connected

Connectivity performance and its issues was also higher and more exacerbated in homes with multiple people working and schooling at the same time. The stress of problematic calls and connectivity would generate household questions like

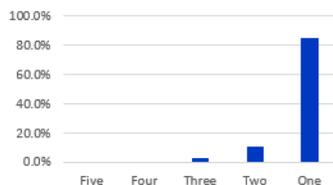
- Was someone watching streamed video content while others were trying to work – and it is causing problems
- Could someone in the house drop their sessions to see would it help others
- Could someone having problems get closer to the Wi-Fi router and work in that room for a while
- Could everyone stop what they were doing so Gateway or Access Point could be rebooted to see does it resolve the problem
- Trying to resolve an outage with your Service Provider in time for that important call
- Giving schooling children priority during exams even at the expense of issues with Work tasks and meetings

Do you have other household members working from home?



42% had one person working at least one day a week

How many Other Household Members are Working from Home?



How many days a week are they working from home?

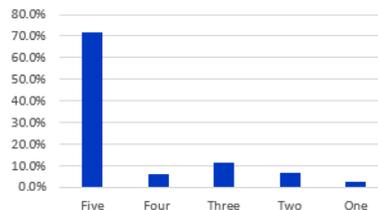


Figure 5 People working at home - did they have others working with them

Schooling from home was also important during the pandemic. In this survey 43% of the respondents had at least one child schooling at home with them. Over 50% of students were doing one day at home but most children were still attending school for the most part of the week. It is expected that most children or University students will go back to in school tuition in the coming 2021/2022 year. However, there is probably a marked rise in future homeschooling which in the US has typically been about 3% of children pre-pandemic but set to rise by potentially 5% based on effects of pandemic

<https://ifstudies.org/blog/homeschooling-is-up-thanks-to-covid-but-will-the-increase-last> ,
https://www.census.gov/library/stories/2021/03/homeschooling-on-the-rise-during-covid-19-pandemic.html?utm_campaign=20210322msacos1ccstors&utm_medium=email&utm_source=govdeliver
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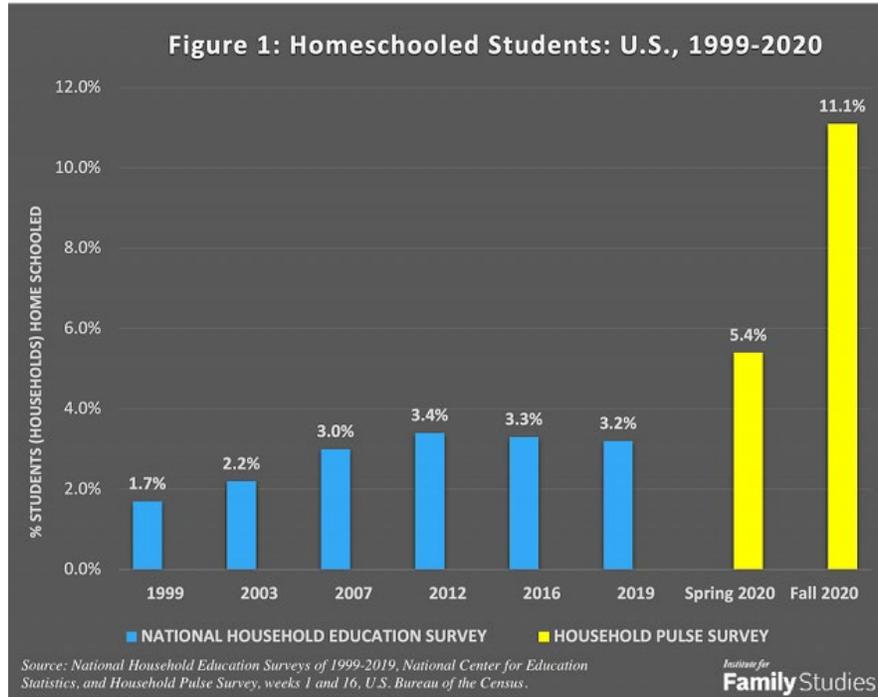


Figure 6 Homeschooled Students : US 1999-2020

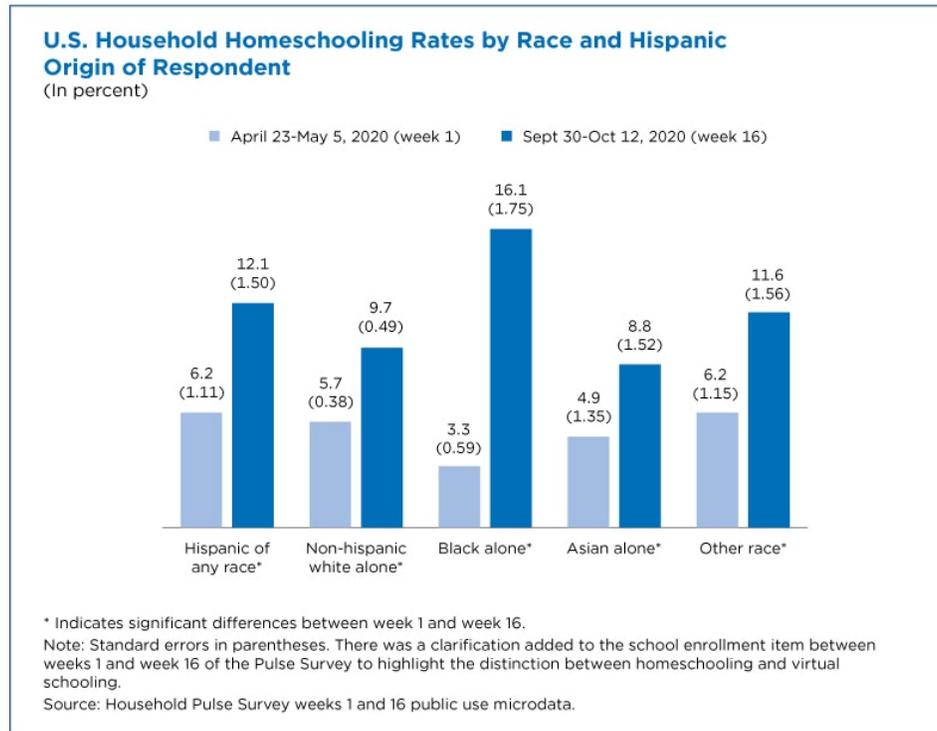
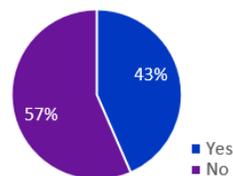


Figure 7 US Household Homeschooling rates

43% had children doing online schooling at home

Are there students in the home doing online schooling?



How many days a week are they learning from home?

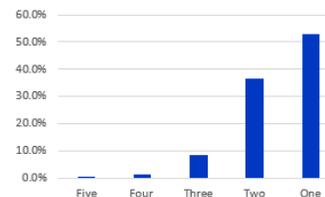


Figure 8 How many days were Children spending schooling at home

During this change in the home environment the importance of being able to work and school effectively raised in performance. There was pressure from several factors

- The ergonomics of a desk environment and replicating our office setup at home.
- Connectivity in particular Wi-Fi performance improvements
 - o Bedrooms and every room being used for concurrent family member use exposing issues with Wi-Fi performance at range
- Audio performance – multiple people working in single room and generally trying not to allow the normal noises of home life interrupt work and school times.

- Introduction of Video Conferencing as the new pervasive tool to try and fill the gap for in person meetings and its performance affect on the upstream bandwidth from the home. Video conferencing applications were not as efficient in adaptive bit rate technologies and typically wanted to grab 1.5Mbps to 2.5Mbps to stream video upstream.

Looking at the way the survey respondents spent their money on to improve their new home environment, we see that it covered a number of areas in particular

- 55% of respondents bought desks.
- 40% of respondents improved their home monitors to augment their laptop screens
- Almost 30% of respondents bought separate microphone solutions to improve their audio performance
- Almost 20% of respondents bought new webcams to improve their Video Conference performance
- Over 40% of respondents bought Wi-Fi AP or Wi-Fi mesh solutions

Additional purchases have been necessary

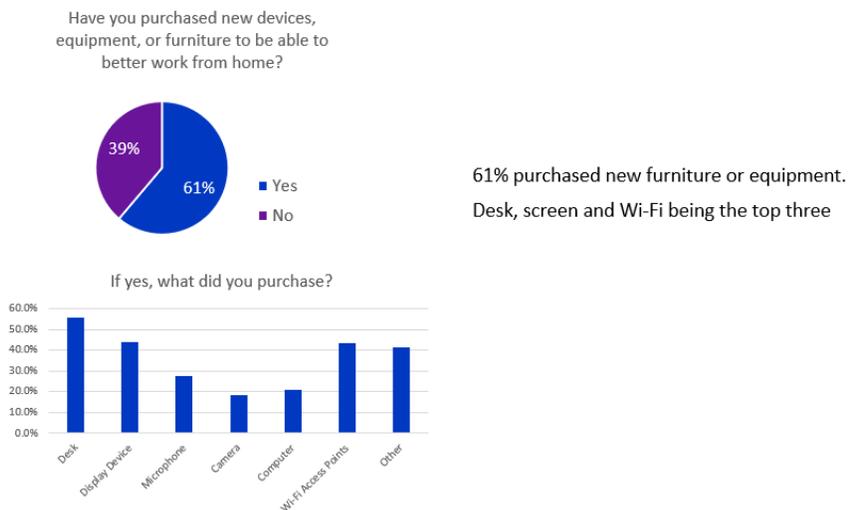


Figure 9 What items did WFH/SFH families purchase during the pandemic

With connectivity the main requirement of a stay at home solution the survey looked to see how respondent's connectivity performance catered to their work and school needs.

For Broadband speed generally 83% of respondents felt that they were on the right and acceptable broadband tier/speed for their requirements. The survey checked what access network the respondents were using with 30% of them on Cable, Fiber and FWA respectively. The ISP's the respondents were using was recorded and showed that 8 ISP's registered above 5% for our survey sample. Comcast, Charter, AT&T and Verizon served about 37% of our respondents. Internationally, China Telcom, Vodafone, Virgin Media, and Airtel also registered covering 5% of our respondents.

The survey also used the opportunity to see what percentage of homes had an MMP (Massive Multiplayer Gamer) in the house and 20% of respondents were gamer homes. As 10%+ of all downstream traffic now is gaming this is a growing segment of traffic that is important to understand for performance implications on home connectivity.

Satisfaction with broadband speeds

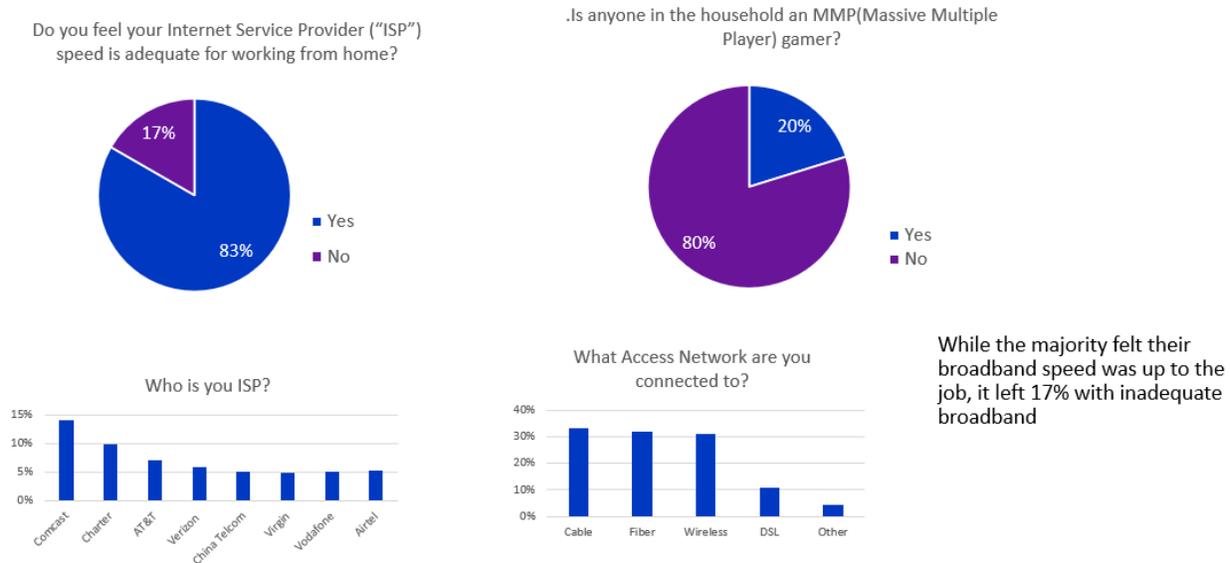


Figure 10 Consumer satisfaction with Broadband speed during pandemic

The survey further asked respondents to check their broadband speed both up and down and showed the following results.

Download speeds

- 25% of respondents were over 200Mbps
 - o 7% of these said it was inadequate
- 17.5% of respondents were 100-200Mbps
 - o 11% of these said it was inadequate
- 20% of respondents were 51-100Mbps
 - o 19% of these said it was inadequate
- 21% of respondents were 21-50Mbps
 - o 23% of these said it was inadequate
- And the remaining respondents 16.5% < 20Mbps
 - o 40% of these said this was inadequate

Upload speed performance and robustness was the most important metric during the pandemic. The survey respondents answered for their homes that

- 4% of respondents had > 200Mbps Upstream performance (100% of these on Fiber networks)
 - o 6% of these said this was inadequate
- 7% of respondents had > 101-200Mbps Upstream performance (100% of these on Fiber networks)
 - o 4% of these said this was inadequate
- 10% of respondents had > 51-100Mbps Upstream performance
 - o 10% of these said this was inadequate
- 30% of respondents had > 21-50Mbps Upstream performance
 - o 10% of these said this was inadequate

- 16% of respondents had < 20Mbps Upstream performance
 - o 70% of these said this was inadequate

Generally, it looks like respondents were happy with their broadband speed but room for improvement. It is the cost and hassle factors of upgrading or changing service provider for the return which will drive them to change. As the reader will see later in this paper the survey revisited this a few times as well as introduced reliability and latency questions to the overall view of Broadband performance.

Broadband performance - speed

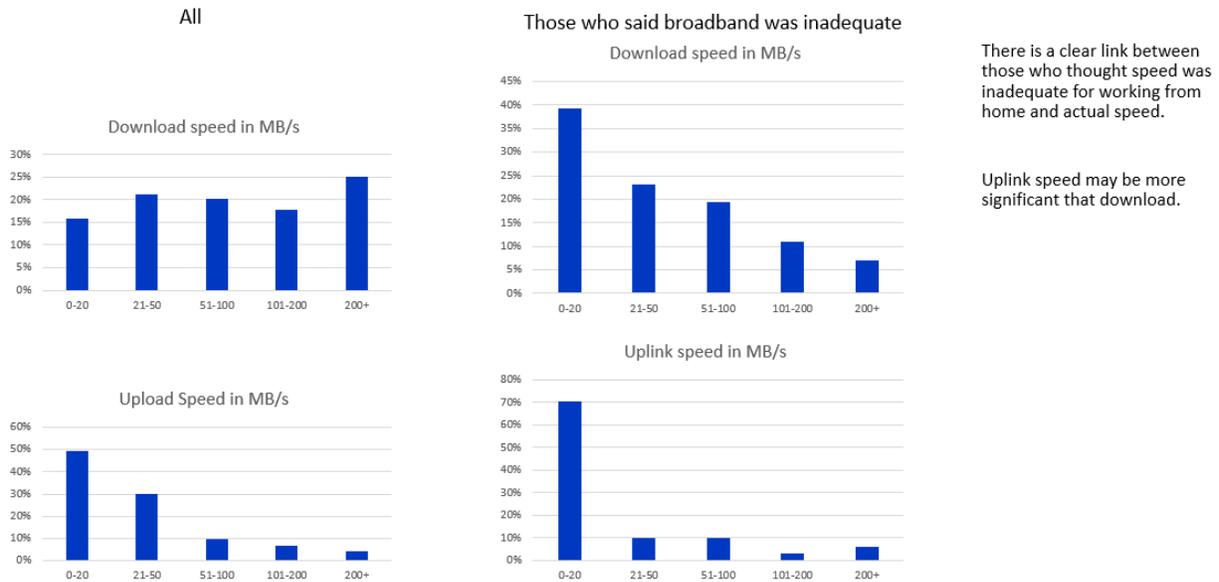


Figure 11 Consumers satisfaction with their Downstream and Upstream performance

As Latency is becoming more important as a performance metric for Audio and Video conferencing, Gaming, and more immersive video experiences like AR/VR – the survey also checked with respondents on their latency performance. Consumers are still not aware of what latency really is or what jitter is and still really view their Broadband quality as their overall speed. They are getting more cognizant of the difference between ISP WAN speed and their Wi-Fi speeds to devices, but latency is still something they don't fully understand. Homes that have gamers are more educated on the value of latency as there is a very specific correlation between latency (or probably more relevantly jitter) in the performance of gaming. With the pandemic consumers were introduced to more latency sensitive applications like Audio and Video Conferencing with echo and problematic video conferencing often related to issues with latency. The survey asked the respondents to use the Netflix fast.com web based speed test which ran loaded and unloaded latency tests (loaded have a traffic mix defined here <https://netflixtechblog.com/building-fast-com-4857fe0f8adb>). The difference between the 2 numbers is defined as buffer bloat and can certainly affect very latency sensitive applications.

A quick note on the importance of consistent jitter to a gamer versus latency. Gamers seems to be happy with any latency that is less than 55ms (55ping as it is referred to by gamers). What they really value then is having not more than 5ms of jitter within their latency value. This means that it is not good for a gamer

to have 50ms of latency with 10ms of jitter or reducing latency to 30ms but jitter inconsistent across packet arrivals.

The results were interesting with a diverse spread of latency

- 42.5% of respondents had unloaded latency < 20ms
 - o 50% of these felt their broadband was inadequate
- 28% of respondents had unloaded latency between 21ms-50ms
 - o 30% of these felt their broadband was inadequate
- 15% of respondents had unloaded latency between 51ms-100ms
 - o 9.5% of these felt their broadband was inadequate
- 6% of respondents had unloaded latency between 101ms-200ms
 - o 7% of these felt their broadband was inadequate
- 7.5% of respondents had unloaded latency > 200ms
 - o 4% of these felt their broadband was inadequate

For loaded latency result

- 28% of respondents had loaded latency < 20ms
 - o 28% of these felt their broadband was inadequate
- 18% of respondents had loaded latency between 21ms-50ms
 - o 23% of these felt their broadband was inadequate
- 23% of respondents had loaded latency between 51ms-100ms
 - o 20% of these felt their broadband was inadequate
- 12% of respondents had loaded latency between 101ms-200ms
 - o 14% of these felt their broadband was inadequate
- 17% of respondents had loaded latency > 200ms
 - o 12% of these felt their broadband was inadequate

These latency results and especially the correlation to broadband inadequacy is has some ambiguity as one would expect the higher latency issues to have increases in dissatisfaction. The comments on the respondent's survey seems to suggest that latency is not well understood by people generally. Those that are gamers or more technical understood latency well enough to in many cases still not be happy with 15ms latency results as they strove for higher performance. Those with > 100ms of latency seemed to also not really be interested in spending money on improving things.

There is also the reliability of the fast.com test and its repeatability and temporal performance levels based on how congested the networks were at time of test as well as what device the test was done.

Broadband performance - latency

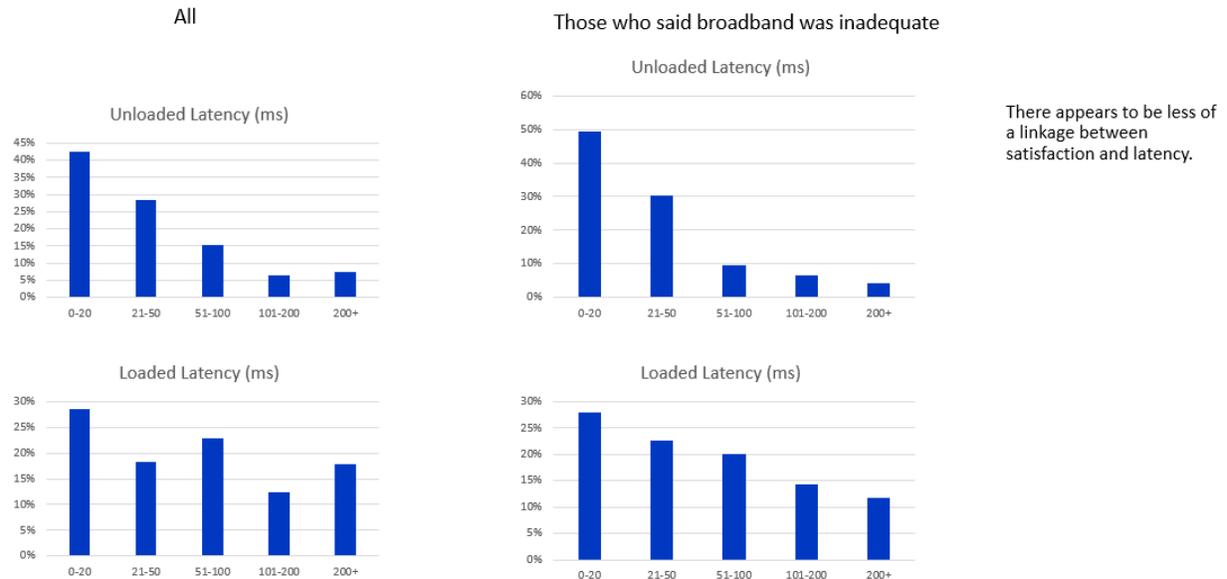


Figure 12 Latency performance of our respondents.

The respondents to rate their ISP and then this was correlated to each Network access type

- 85% of Cable ISP respondents were happy with performance
- 77% of DSL ISP respondents were happy with performance
- 90% of Fiber ISP respondents were happy with performance
- 76% of FWA ISP respondents were happy with performance

Network types

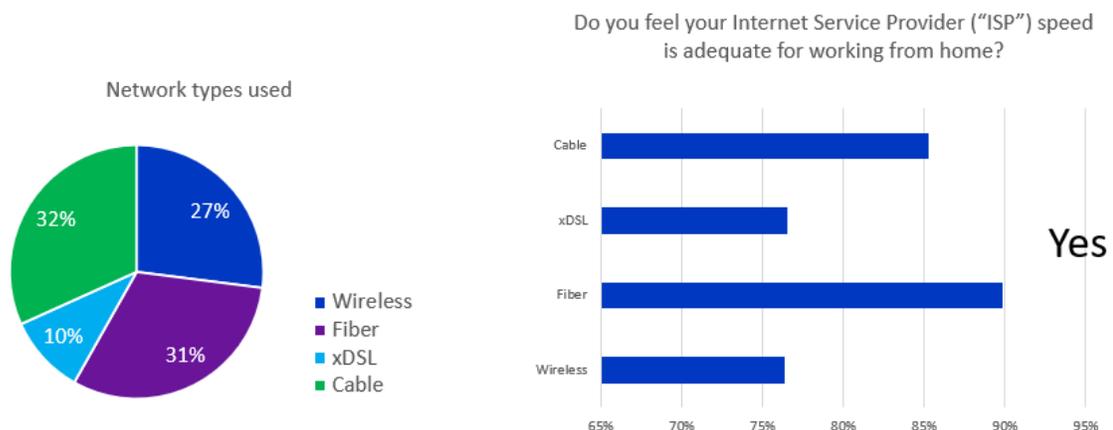


Figure 13 Respondent satisfaction with their ISP by Access Type

As Wi-Fi performance was so critical to everyone at home during 2020 the respondents were asked to explain their Wi-Fi solution and if they had added extenders.

It was interesting that

- 40% of respondents had an AP that was integrated into the SP's GW device
- 49% of respondents had bought their own retail Access Points
- 11% of respondents had an AP issued by their SP

Delving further into the Wi-Fi solution architecture of the respondents

- 31% of our respondents had a Wi-Fi extender/mesh solution with 69% relying in a single AP

Of the 31% of respondents with a Wi-Fi extender solution

- 50% of respondents had 1 extender
- 31% of respondents had 2 extenders
- 14% of respondents had 3 extenders
- 5% of respondents had > 3 extenders

This seemed to show clearly that respondents had to augment their Wi-Fi solution to cater with the increased demand of working and schooling from home at range. The survey may have some bias to more consumer owned devices versus using the supplied SP devices as it was based on employees from CommScope who do skew to more technically aware for a larger base of the sample. However, the majority of respondents were not engineers by job function.

Wi-Fi in the home

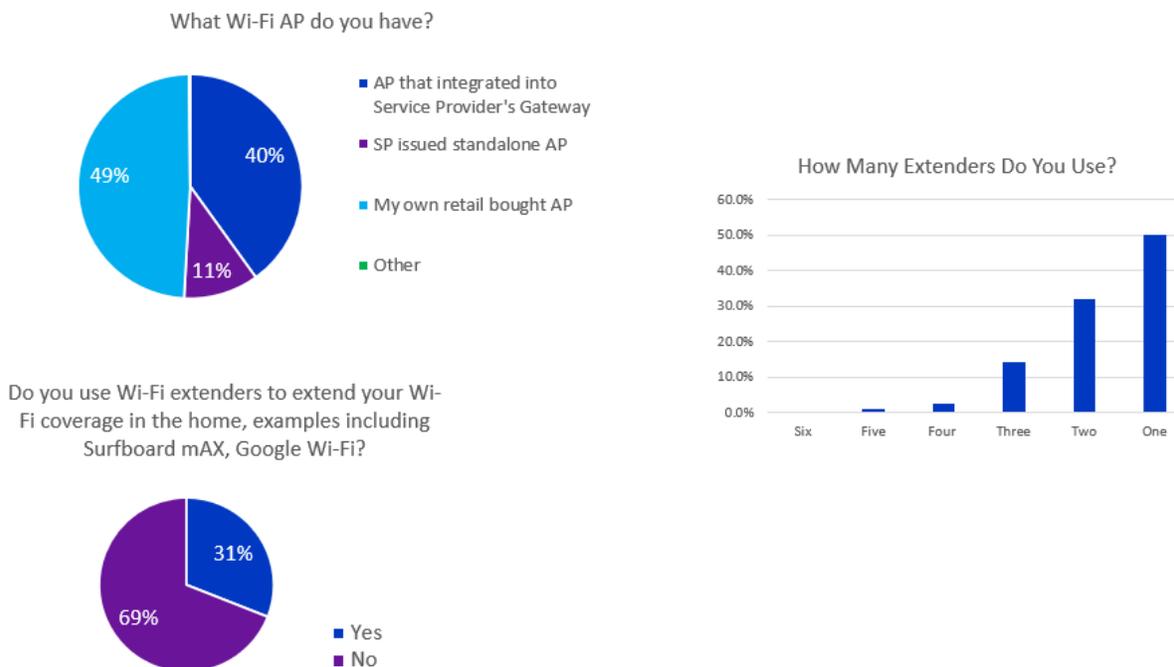


Figure 14 Wi-Fi device use and extenders in our survey

The survey respondents were asked what was their primary device for Working from home

- 95% of respondents said it was company issued laptop, tablet or phone
 - o The remaining 5% used Home PC/Laptop or Apple Product

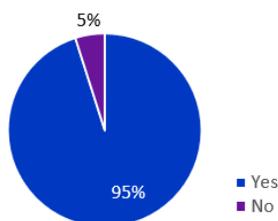
Of the additional devices that respondents used to work from home

- 66% of respondents used a second screen
- 42% of respondents used headset for audio/video conferencing
- 20% of respondents had a dedicated work printer
- 27% of respondents set up a separate webcam for video conferencing

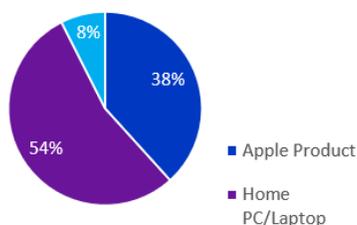
This was to be expected as many consumers during pandemic tried to ensure their home was as comfortable as possible to work and school. Because of security requirements and that almost all of the respondents have office jobs that have company supplied laptop or desktop device – the company issued laptop was the dominant WFH device for the respondents surveyed.

The company laptop is complemented with additional devices

Do you primarily use a company issued laptop, tablet, or phone to work?



If no, what do you use?



66% use a separate screen

Microphones for video conferencing and a dedicated tablet for work are also popular

What other devices do you use for working from home ?

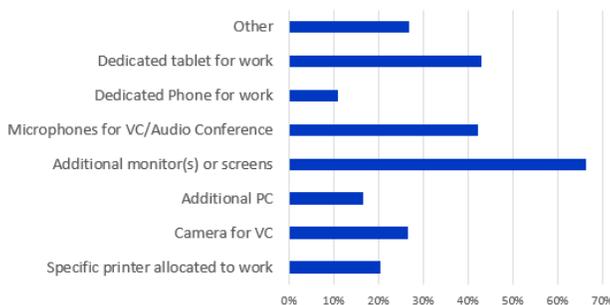


Figure 15 The devices people used at home to Work from Home

The survey asked the respondents if they used VPN to access work resources.

- 97% of respondents were using VPN for work related traffic. (There are some CommScope services that require VPN)

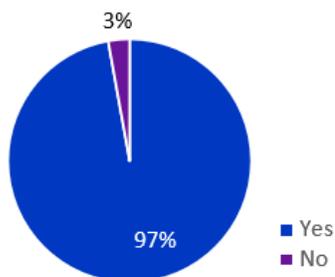
One of the issues at the outset of the global WFH change was the lack of VPN resources scaling and the overhead in speed/performance of VPN. In the survey we checked with the respondents the reliability as well as performance of the VPN

- 30% of the respondents answered they kept the VPN on all the time
 - o 15% of respondents said they never turned it off
- 24% of the respondents frequently turned it off

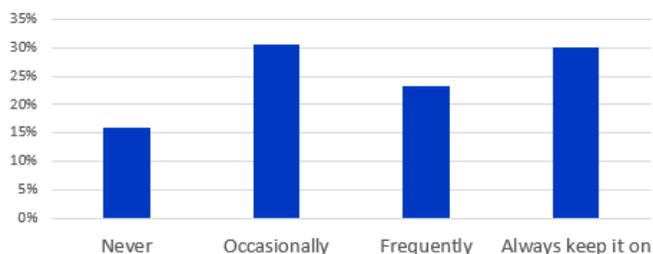
- 30% of the respondents said they occasionally turned off the VPN

Use of the corporate VPN and mobile

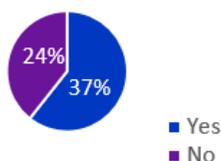
Do you use the VPN to access CommScope Resources



How often do you turn off corporate VPN on your company devices, or do you keep it on all the time?



If no, do you use web-based resources/mail?



How often do you use LTE or 4G for work?
Typically on your smart phone/tablet for voice, or sometimes using phone as hotspot.



Figure 16 Use of corporate VPN and Mobile device

The survey asked the respondents the direct question of their view of their connectivity issues while working from home

- 31% of respondents said they had connectivity issues
- 28% of respondents identified issues related to using VPN services

The respondents identified the source of the connectivity issues they had

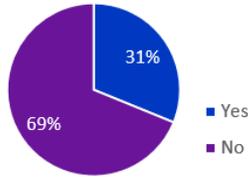
- 59% of respondents said their connectivity issues were the fault of the SP or speeds
- 48% of respondents said the issues were related to Wi-Fi performance
- 50% of respondents said issues were related to VPN performance and overheads
- 28% of respondents said issues were related to Video Conferencing application

Additionally the survey checked with the respondents how often they chose to call IT for support when they had issues

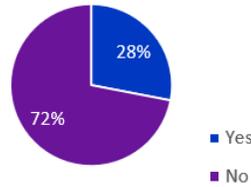
- 56% of respondents never called for help
- 42% of respondents called IT 1-4 times during first 7 months of working from home

Connectivity issues

Have you had many connectivity issues while Working from Home?

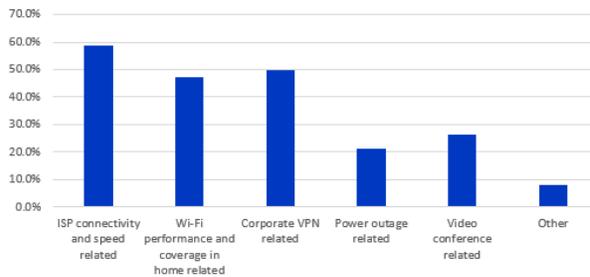


Do you have VPN problems that affect your work?



31% experienced some form of connectivity issue, which was the reason for the great majority of calls to the helpdesk.

If yes, select issues that apply to you



How many times have you called CommScope IT to help you from home?

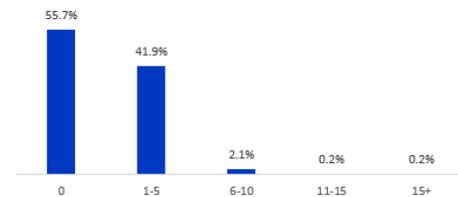


Figure 17 Frequency of Connectivity issues WFH

Being specific again on Low Latency the survey explicitly asked the respondents how they valued low latency

- 42% of respondents valued low latency working from home and for services like gaming

Low-latency

Do you value lower latency in your working from home experience, ex snappiness in services like gaming?

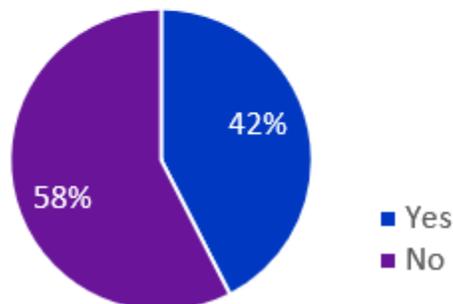
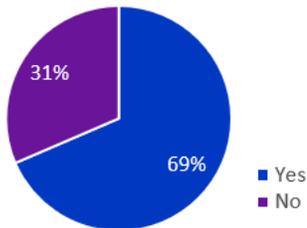


Figure 18 How do we value Latency working from home

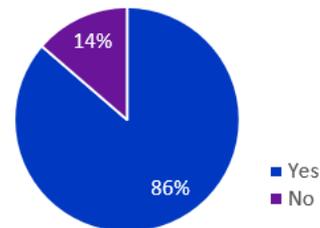
Going a bit deeper on the Audio and Video Conferencing side of Working from Home the survey asked several questions

- 69% of respondents used a headset when doing Audio or Video conferencing
 - o 40% were wireless; 60% were wired headphones
- 86% of respondents primarily used the camera in their laptop or PC for Video conferencing

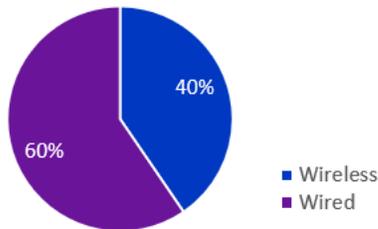
Do you use a headset when doing Audio or Video conferencing?



Is your VC camera primarily the one in the Laptop or PC?



If yes, do you use a wireless blue tooth headset like Apple AirPods or a wired one?



If no, what do you use?

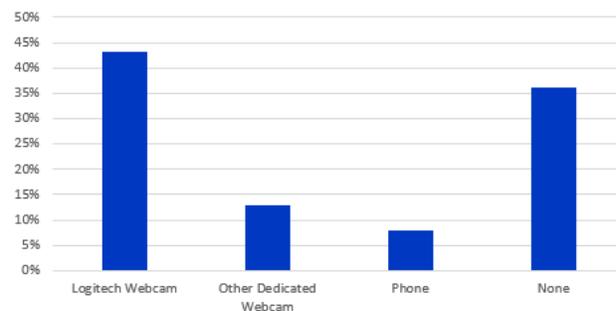


Figure 19 Audio and Video Conferencing for WFH

With the potential of using existing home screens like TV's to help with Working from home the survey asked respondents if they would value using the TV for work video conferencing – only 34% of people felt this was something they would use.

Video conferencing on the TV?

Would you use a TV in your house for video conferencing if the right Camera and Microphones were added?

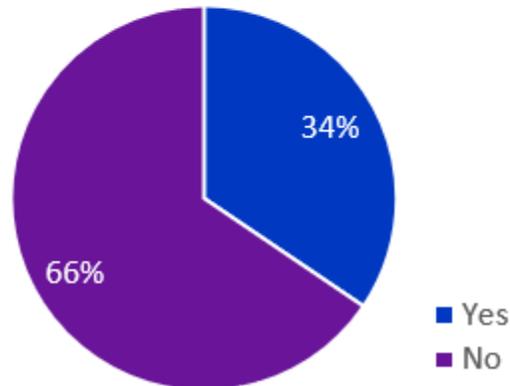


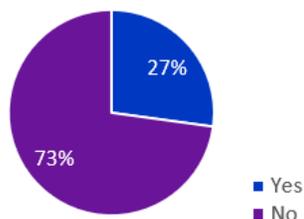
Figure 20 Would you use Video Conferencing on the TV ?

Trying to understand the impact of others Working and Schooling from home on each other the survey got the following responses

- 27% of respondents felt that other home members doing Video Conferencing or Video streaming was affecting their own connectivity
- 44% of respondents said that they had experienced Video Conferencing dropouts that had made doing their job more difficult

Impact of other network users in the home

Is your WFH experience impacted by others in your home also using services like Video Streaming or Video Conferencing when you are working?



27% are impacted by others using the network while working and video conferencing drop-outs are common.

Have you experienced video conferencing drop outs, which made it more difficult for you to do your job ?

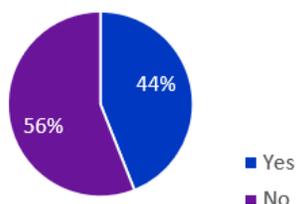
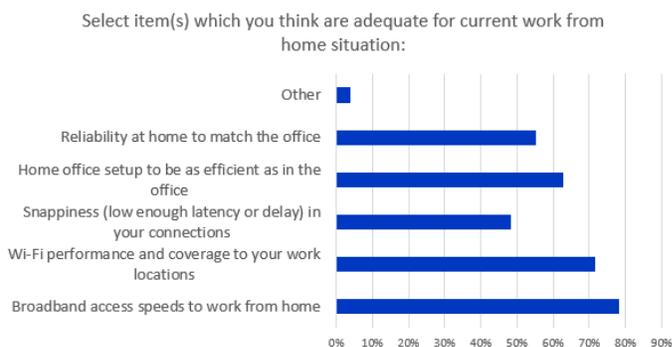


Figure 21 Impact of other home members on your Work connectivity

Going deeper and asking directly if respondents felt that their home working environment was adequate the survey got the following responses

- 45% of respondents felt they needed more reliability
- 37% of respondents felt they needed a better home office setup
- 52% of respondents felt they could benefit from lower latency broadband
- 28% of respondents felt they had Wi-Fi coverage and performance issues
- 22% of respondents felt they had inadequate broadband speeds

Is the home working environment adequate?



While the majority feel the environment is adequate, there is significant gaps to address to match an office environment:

- 45% need more reliability
- 37% need a better home office set-up
- 52% could benefit from lower latency
- 28% have Wi-Fi coverage and performance issues
- and 22% suffer from inadequate broadband speeds

Figure 22 How adequate is your Working from Home environment

Now that we have learned the key issues and things that our respondents' value in their Work from Home lives the survey wanted to check their interest and value in improving the issues and adding new value services

The survey asked them to rank High, Medium and Low several items

- Use of additional screens at home
 - o 57% of respondents ranked it high; 29% of respondents ranked it medium and 17% low
- Security on connection to the office
 - o 46% of respondents ranked it high; 34% of respondents ranked it medium and 20% low
- Power Backup solution
 - o 25% of respondents ranked it high; 36% of respondents ranked it medium and 39% low
- Separate Wi-Fi SSIDs for company work vs personal work
 - o 24% of respondents ranked it high; 36% of respondents ranked it medium and 40% low
- Higher Reliability from ISP with backup WAN connection
 - o 51% of respondents ranked it high; 33% of respondents ranked it medium and 16% low
- Better Hands-Free microphone solution
 - o 42% of respondents ranked it high; 33% of respondents ranked it medium and 25% low
- Separate Corporate Network and Service to residence
 - o 25% of respondents ranked it high; 38% of respondents ranked it medium and 37% low
- Better Cameras for Video Conferencing
 - o 21% of respondents ranked it high; 36% of respondents ranked it medium and 43% low

This was somewhat different than some of the similar other responses asked in the survey but if we are looking for responses that show over 50% pull from the respondents from the cumulative High+Medium results, there seems to be some merit in number of areas below – in particular high reliability , security. Other teaser questions like the need for corporate SSID and network separation also seem to have some merit but may need to be driven more from the company side vs a pull from the consumer to really make them emerge as potential services a Cable Operator can sell back to corporations.

Enhanced solutions ranked – High Medium and Low

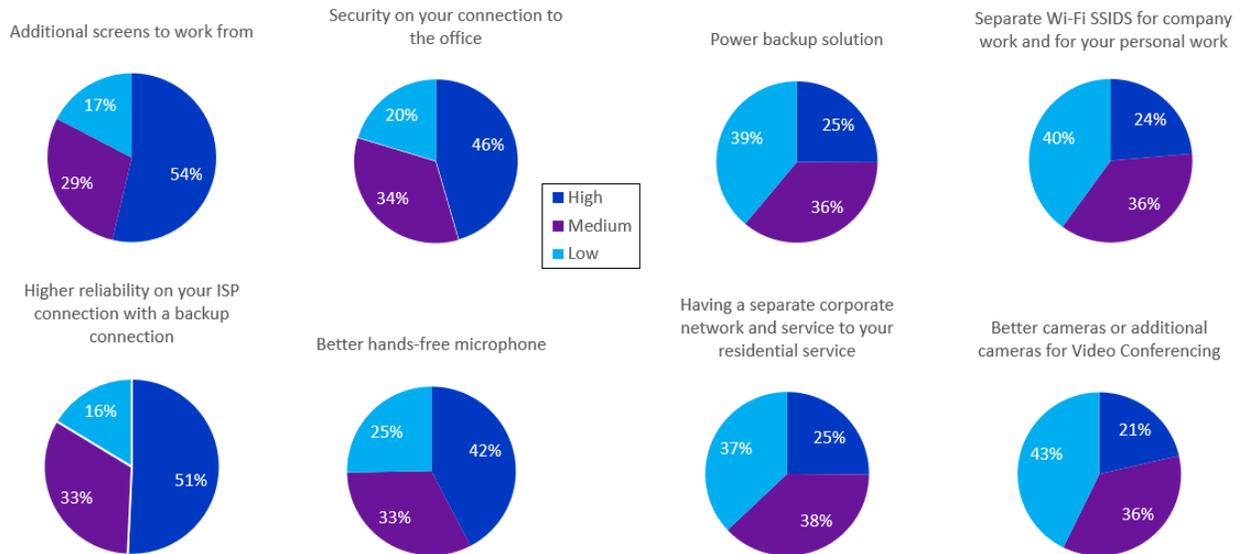


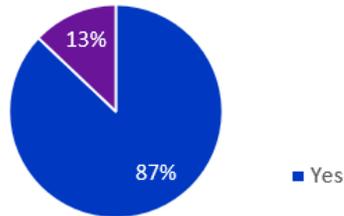
Figure 23 What additional Services and Features would WFH respondents value

Moving to the more social side of working from home the survey asked respondents how they would value more separation of Work and Home time through technology features

- 87% of respondents stayed in the same room while working
- 40% of respondents would like a technology or connectivity solution that separated Work time from Personal time
 - o As you will see below when the question is posed as a summary set of questions with the specific use case of turning off corporate resources at certain times there was a higher interest level

Separating work and personal time

Do you tend to stay in the same room when you work?



40% would value a solution that separates work and personal time.

Would you value a working from home solution that tries to separate work time from off-work time?

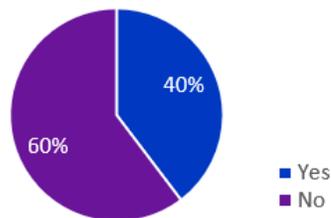


Figure 24 Value to our respondents of solutions to separate work and home life

Trying to analyze further some ideas that may benefit working from home the survey asked the respondents to give their view on some work life balance ideas

- 48% of respondents thought a timer that shut off WFH activities at defined time would be a worthwhile idea
- 73% of respondents thought that there were value in tools that analyzed your working habits to help you stand up from your chair, get some exercise and take breaks from balancing working and screen time
- 51% of respondents thought a dedicated work Wi-Fi, VPN solution may be something they valued
- 6% of respondents interestingly felt they wanted their company to pay for broadband service to the home. This question when followed up with respondents was interpreted as the company would pay for and own all broadband services to the home. There was some fear of privacy that came with this interpretation. When explained that it could be a completely separate service that was independent from residential broadband there was a much higher acceptance of company sponsored broadband and connectivity in the home.
- 68% of respondents felt that they valued physical separation of Work from home location with dedicated devices to home working.

Ideas for improving work-life balance

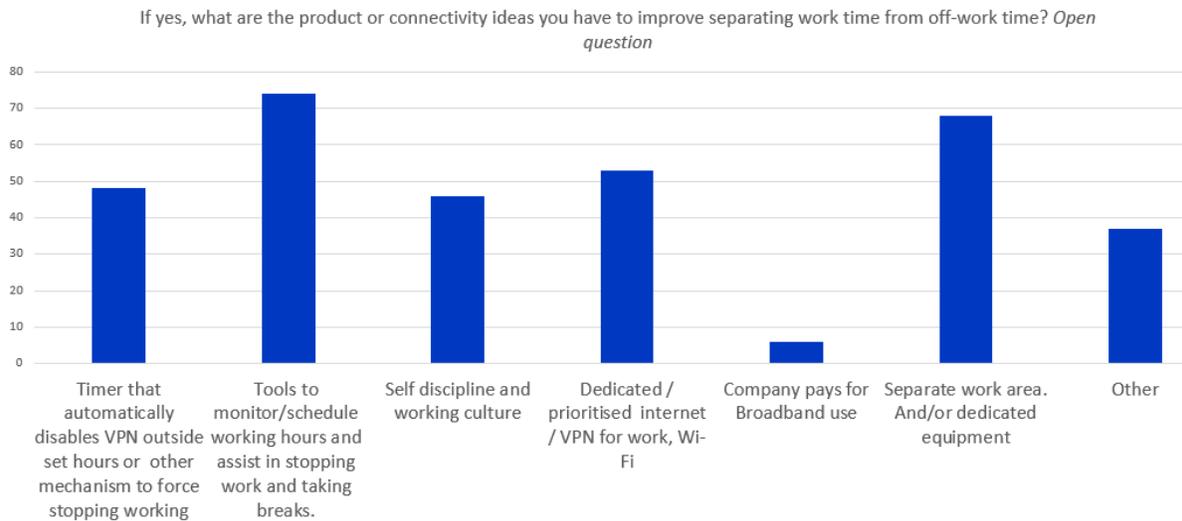


Figure 25 How do you value tools and features for work from home and life balance

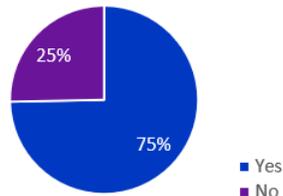
As we now try and ascertain if there is a product, service, or market for a better working from home solution we delve a little deeper with the survey to ask some additional questions.

The survey directly asked the following

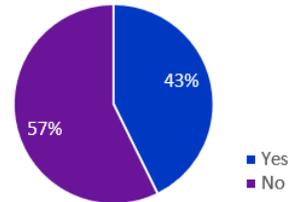
- Would you be interested if your SP offered a better WFH solution with higher downstream and upstream speed, better home Wi-Fi and more reliability – 75% of respondents said Yes. (For this initial analysis we did not push on how much the respondents would pay for this)
 - o To further clarify some of the elements we asked
 - o Are you likely to upgrade Wi-Fi because of issues – 43% of respondents said Yes
 - o Are you likely to upgrade your WAN connection – 39% of respondents said Yes

There is a market for a better working from home solution

Would you be interested if your ISP provider offered you a better WFH solution with higher downlink and uplink speed, more reliability, and a better Wi-Fi home connection?



Are you likely to upgrade your Wi-Fi solution because of the issues encountered working from home?



Are you likely to upgrade your ISP connection because of the issues encountered working from home?

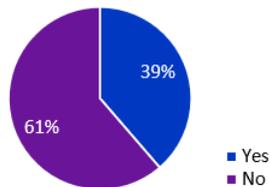


Figure 26 Would Homeowners want to upgrade their connectivity because of WFH

This survey result has some clear responses and leaves a number that are still ambiguous when trying to figure out the value of

- Reliability and backup – the results seem to show clear potential value here
- Security – the results seem to show clear potential but also highlight (with privacy) the importance for clear separation of any WFH sponsored services that they do not bleed into residential use.
- Separation of work and home life – the respondents were a little ambiguous in a couple of shaped questions but there seems merit in exploring this area. There are a number of separation areas from data, time and even Wi-Fi channels and frequencies. Additionally, even separate devices are also potentially something the respondents would value.
- Performance – its clear that consumers and the respondents in this survey vary on their understanding of the performance issues affecting their video conferencing and ability to work from home. Some just rely on their top line speed and maybe aware of their upstream speeds, others very cognizant and aware of Wi-Fi performance in the last 30ft and others who are also aware of latency derived issues.

So, let's move to the next section and explore the potential for the current stock issue of Cable Operator devices to change to reflect some of the new drivers for the home beyond supporting entertainment primarily.

3. Is there a better Home solution now for supporting Working and Schooling from home

Let us now explore the potential opportunity for the new home architectures that cater for

- Residential and Corporate services to a home
- Reliability of Service
- Extension of Corporate Office to the home
- Security and anti-theft of corporate information
- Separation of residential, schooling and working from home services
- Separation of work life and residential life from home

But before we do that lets baseline the simple service offered by Cable Operators today where there are predominantly

- 4 devices – Gateway (or EMTA and AP) , Extenders/Wi-Fi Mesh , STB and for a growing number of Cable Operators a Smart Phone MVNO play.

From a service perspective though there are the following assumptions and residential class of services that are offered

- For the majority of Cable Operators – a single Coax cable to the home with no backup solution for Coax side service failure.
- An ever-decreasing number of Gateways that provide battery backup of the VoIP service
- No solution for battery backup service for data services
- Typically, only 2 SSID in the home – the primary residential service and guest Id. Additional SSIDs can be Community Hotspot and for a few Cable Operators a Smart Home Wi-Fi network. Current networks on 2.4GHz and 5GHz frequencies.
- VoIP services using EMTA function in Gateway as part of DOCSIS network – which has been diminishing in use – in favor of smart phone calls at home and increasing use of FaceTime, WhatsApp and other popular video conferencing applications.

Predominant device and services offered today



- Cable Operators provide primarily 3 devices today for Broaband
- Have been adding additional MVNO Mobile services – Hotspot capable
- Have been buying shared spectrum – CBRS – potential for some FWA

Figure 27 Current Cable Operator devices and services

Is there an opportunity to develop the following logical solution to create separate networks to the home and split the residential and corporate/schooling services for different SLA and policy management or possibly just increase all residential SLA to be able to support the same levels as Enterprise. There are several factors in consumer want and adoption of a solution like this

- Who pays for this uplift to Enterprise or Corporate level reliability and SLA's
- Privacy and separation of home and work life
- Can an Operator provide an SMB/Business like SLA and solution en-masse to consumers with or without subsidization of corporations?
- Will there be enough employees stay at home for work to have enough of a market and need for this solution
- Does the Cable Operator have the economics to be able to provide wireless backup solutions to wired services and without control of the wireless network in MVNO solutions can it work
- Will a consumer value having corporate IT control some of the elements of a home network or see it as invading their home privacy?
- Does the DOCSIS GW technology or indeed even standalone Access Points have low enough power draws to support meaningful holdup times for home data services off of backup wireless solutions. Indeed, can a HFC solution also work long enough for data in the event of a power failure in the home but HFC network still capable of passing data.
- Is it less complex when a consumer wants a WFH solution with higher reliability and performance SLA's to just offer a separate set of devices to separate the residential service/devices?

- Giving Corporations the Security, Performance and Reliability that they offer their employees in the Office
- Providing differential QoS and Separation for Residential and Corporate Svcs
- In HFC plant – even a separate eMTA

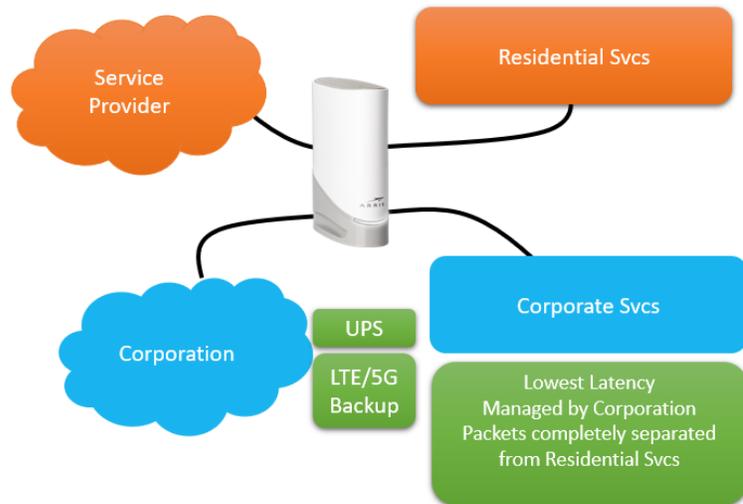


Figure 28 New Potential split Residential and Corporate services model

Expanding on this Gateway/Broadband/Wi-Fi architecture more could the following be a set of potential requirements and features for the better Gateway

Corporate SLA on Home device – is this the better WFH/SOHO device ?

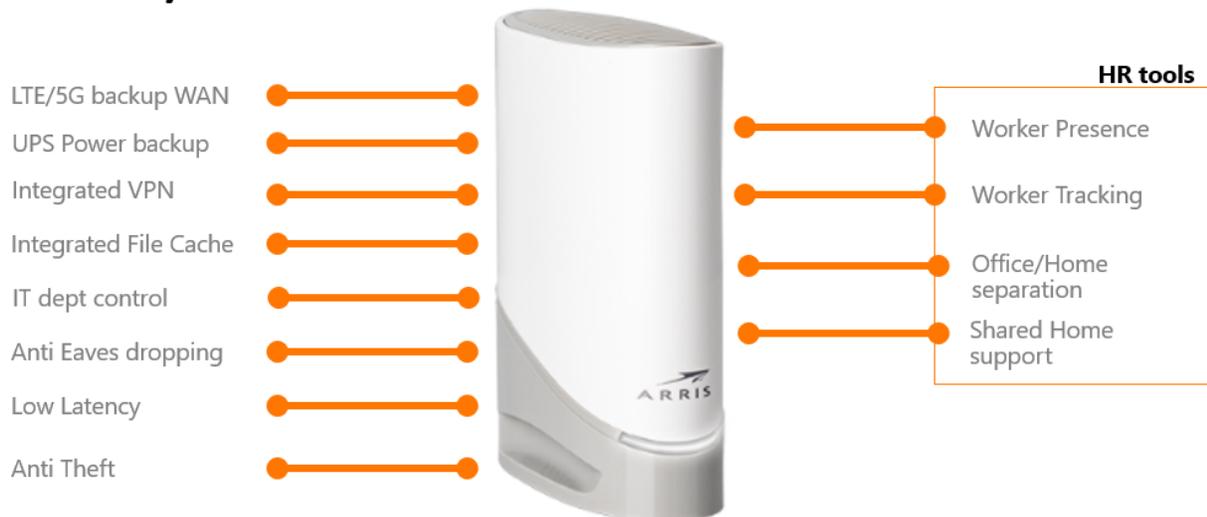


Figure 29 Potential additional features for the better WFH/SOHO Gateway

Some of the features we are defining are not new and have been always in the mix for inclusion in residential services but with the pandemic now really highlighting the stress points of reliable services and devices will these features like LTE backup and UPS/Battery backup now have a place for Operators to sell an improved service to consumers. These services cannot be free to the consumer as they have

additional capital and operational costs to provide them, so consumers must see value to their home requirements to increase their monthly payment to their service provider.

We could also look at the SMB and Enterprise market and apply some of the technology directions there to the home. For example with SD-WAN services and architectures squarely focused on Enterprise and SMB – would the solution above be better defined as an SD-WAN play and provide a Universal CPE (uCPE) component to the connectivity gateway (integrated or separate compute/storage device) and use SD-WAN software solutions for orchestration and management of WFH services independent of the residential services. Who would provide the uCPE device and is there a collaboration with Corporation and Operator to provide the SD-WAN services? Corporations for example providing their own authorized VPNs but Operator providing other value add services.

Let's go through the services mentioned above to see their relevance to the consumer and if each one itself makes a difference or the combination of all these services is the 'killer application' for the consumer.

3.1. LTE/5G Backup WAN

Probably one of the most often discussed residential features over the years has been the potential of WAN backup to DOCSIS or xPON with LTE or now emerging 5G networks. This has been something that Telco/MNO's have offered more in the past given their ownership of LTE spectrum. Generally, because of the high availability of the wireline network it has not really been deployed at large scale. This paper does not contain any reference information on the number of outages or average yearly outage level on the HFC elements of the network. Residential services had not tended to be enterprise critical but now with increased WFH residential use WAN backup has now also become a potential service that consumers may now pay for the additional capex and cellular packet costs to have a convenient and ready to go backup service.

The increase in higher speed LTE services and more importantly the additional 5G capacity being developed for mobile and FWA applications makes a high function WAN backup feasible.

Some Cable Operators also offer their own MNO services and more and more Operators are moving to offer MVNO cellular services. In North America some Cable Operators have also purchased CBRS band 3.5GHz spectrum so have the potential to use that spectrum for WAN backup if they develop the network and CPE infrastructure to support

As well as a backup solution the addition of an LTE/5G module with a DOCSIS or Fiber WAN port also offers the potential for

- Carrier/Hybrid Aggregation – potentially combining at the cellular spectrum levels across different channels or potentially across wireless spectrum and wired service. This solution has been employed in some cases to augment low bandwidth xDSL networks with LTE and is less likely to be of high value to aggregate high bitrate DOCSIS 3.1 or xPON networks.
- Policy/Service based routing – the potential to be able to send packets over either of the WAN links based on achievement of SLA levels (latency) or congestion issues in either network.

The key issue in this solution particularly at the time of writing this paper is the overall cost of the addition of the wireless backup solution

- LTE UE modules of higher category performance and 5G UE modules are almost the same cost as a Wired Gateway so can the cost of supporting 2 high speed Access networks be covered in the service charge to consumer.
- MVNO costs for data make it less desirable to have wireless backup as the goal of the Operator is to minimize data traffic over LTE/5G or pass the cost of backup services to the consumer.
 - o In an MVNO relationship packet priority for MVNO packets may also be constrained to create longer latency in congested areas of cell use.
- The speeds and latencies offered by the wireless backup solution also must be of sufficient enough speed and low enough latency to provide a WFH solution. This may be a lot lower than the Wired service but sufficiently high enough to support WFH service. A reliable 25Mbps/25Mbps could potentially support the majority of WFH workers for quality Video conferencing and low latency enough connectivity for the workers in the home. To make the lowest bitrate possible, software policies can be added to the WFH SLA to prioritize all WFH packets over any other residential devices to at least minimize latency for WFH traffic.
- Probably, most importantly consumer view on the reliability of Wired Broadband vs the investment in a backup solution for Wireless. Additionally, their views on power outage vs wired broadband outages and the downtime exclusively for wired outages. Its also a tougher sell from a wired Service Provider to provide a Wireless backup to their inability to maintain reliability on their wired network. However, consumers are becoming more aware of the environmental issues of fallen trees and storms affecting infrastructure outside the control of the operator so there is some sensitivities now in consumers to want to pay for this additional reliability. As we saw from our survey 51% of people felt it was a High value feature to them with a further 33% saying it was of medium value. Only 16% of respondents felt it was low in their home broadband requirements.

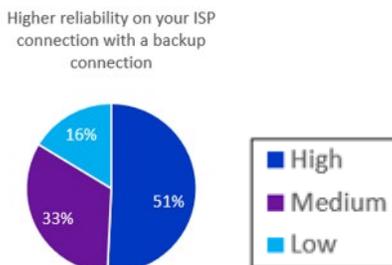


Figure 30 Respondents view on needing a backup higher reliable WAN service

So, for a multi wan backup solution there does seem to be a more heightened view by residential subscribers that it is a worthwhile option to have for their homes to keep them reliable for working and in the rare time outages occur.

3.2. UPS/Battery Backup

It's always an interesting question whether the HFC plant is inherently more reliable than the power grid. Certainly, in parts of the country with overhead power lines and HFC cables and with lots of trees, there tends to be correlated power and HFC outages when a tree takes down both power lines and HFC cables. The US Energy Information Agency reported <https://www.eia.gov/todayinenergy/detail.php?id=45796> in November 2020 on the 2019 grid metrics. The average US power interruption was 4.7 hours or (284 minutes) per year (about 99.95% availability or 3 and a half 9's).

Including major events, the average interruption of 4.7 hours (284 minutes) in the United States during 2019 was nearly half the average interruptions [experienced in 2017](#), a year with more hurricanes, wildfires, and severe storms. Excluding major events, the average duration of interruptions customers experienced was 1.5 hours (92 minutes), relatively consistent with previous years.

U.S. power customers experienced an average of nearly five hours of interruptions in 2019

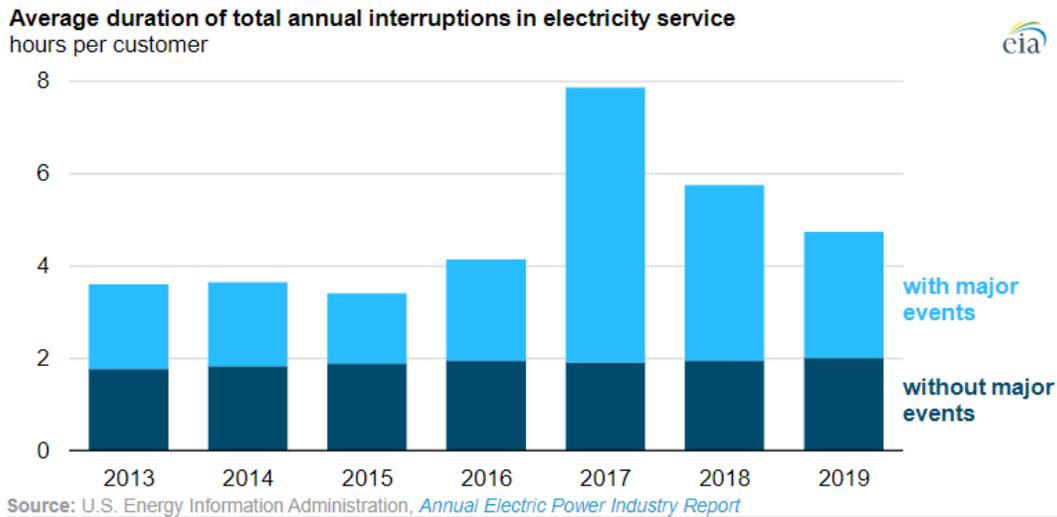


Figure 31 Average Duration of total annual Electricity interruptions in the US

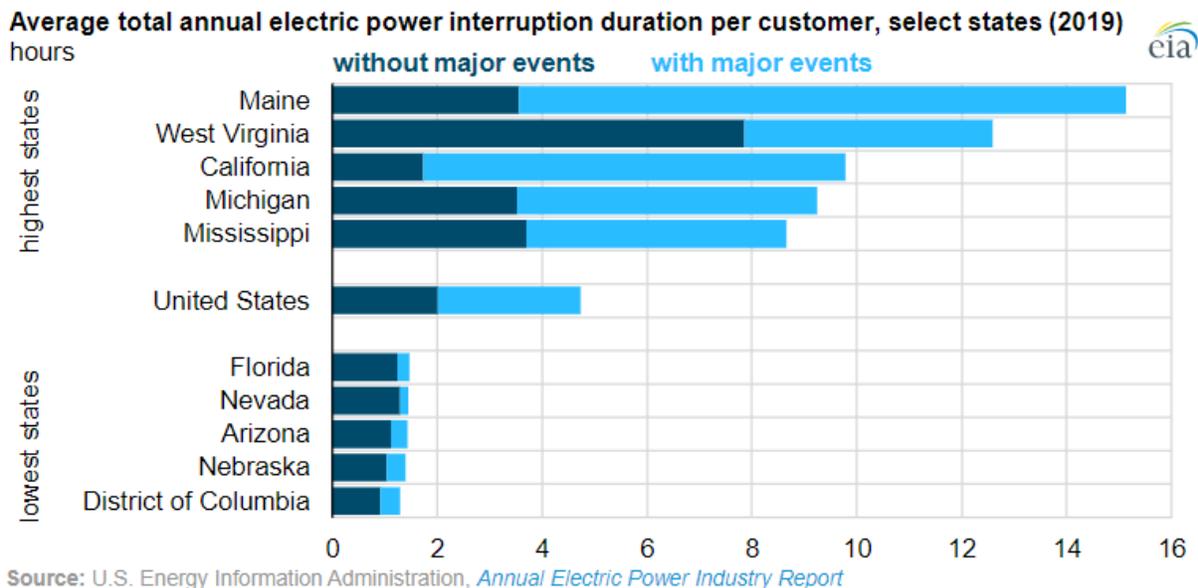


Figure 32 US Power interruption average duration per consumer - select States

So, how often does the power drop in the home really cause the consumer and the SP to want to invest in backup solutions. Certainly requirements for E911 calls still remain but smart phones and power backed up local base stations tend to be the main fall back for consumers now for critical communications and we

have seen a big drop in the use of battery back up in eTMA for VoIP calls on DOCSIS/Cable as consumers and Operators see less of a reliance on the main landline phone for critical or even comfort level services in a power outage.

The correlation of both a power and internet outage are also another interesting data point. As of writing this paper – we did not have correlation information of power vs internet outage. Certainly for major events like Hurricanes, flooding there is often a 1:1 correlation between both power and HFC infrastructure outages (Trees bringing down cables) that also diminish the value that a Power outage solution can bring to somebodies home.

All that said – given the right marketing and cost points WFH consumers who are in areas with higher rates of power outage may opt for a UPS system. Marketing departments in Operators could test the market for UPS to support up to 65W for a single GW device (not including Mesh Wi-Fi) from 600VA/330W at under an hour of hold up time and about \$60 to 3000VA/850W solutions closer to \$1,000 exceeding the total average power outage time in the US and far exceeding the typical spike fallout or non-major event outage. This UPS would be targeted to support the Wi-Fi GW only with scope for USB charging of phone devices and potential to keep a WFH laptop trickle charging as well.

Of course, homes that generally feel that they experience multiple outages also opt for home generators and typically place their refrigerators and lighting circuits on the generator but with more sensitivities around the importance of Wi-Fi connections in the home also tend to add the Residential Gateway to the Generator.

3.3. Integrated VPN

Many corporations still use VPN for their WFH security requirements. More and more corporations do provide non-VPN support for Applications like Office365 and some companies require specific USB keys like Yubikey to authenticate the use of laptops and devices outside the corporate network. Generally, there is continual work to improve the performance and security of VPN's – supporting context aware connections, zero trust networks and what is defined as Software Defined Perimeters (SDP) to improve security.

When a corporate VPN is used – it is typically run as a software application or extension on the Laptop, Tablet or Phone and in most cases is not application aware. Certainly, corporate VPN's may route all traffic from the corporate device through their VPN servers. In some cases, the VPN client can offer split VPN capability where corporate domain applications or servers/data are sent over VPN and other IP addresses are sent directly through the Gateway to their internet destinations. The Corporation itself will be the ultimate driver of this feature and will determine its viability from their IT policies

- Does the corporation want ALL traffic from a WFH device to go over the VPN for its security and employee application use policies?
- Putting a specific corporate VPN application into an ISP provided Gateway is something not supported currently. With the advent of new containerized Services Delivery Protocols, the feasibility of allowing a corporation to add their own VPN client to the GW runtime.
- Does the corporation favor a single VPN client in the GW supporting multiple WFH devices and having clear channel connections to the client only encrypted by Wi-Fi?
- For regular mobility use of VPN the end device like the laptop must support VPN client anyway so is a WFH solution worth it.

This last point is potentially the most interesting one from the WFH employee's perspective. Often while at home the employee may use their WFH device for non-work applications and typically drop their VPN

for these applications. Potentially, listening to music or watching videos during their lunch break or after hours. Bringing up and down the VPN client manually from the laptop device is an employee inconvenience that could be better accommodated with a GW based context/application aware split VPN. It depends totally on the IT policies on laptop and WFH device use and what is monitored from the company's perspective. Sometimes IT policies for workers while in the office will apply tools like WebSense to prohibit access to certain websites even general use of YouTube or Filesharing tools like Dropbox. If the device itself is not the restricted element but the work hours usage is – then some IT policies can reflect this with the ability to use laptop for personal uses when not on VPN or outside working hours. Ultimately if an IT department has a policy that a corporate issued device can only be used for company activity and all internet access is subject to the company's policies then split VPN tunnel at the GW itself may not be a useful feature.

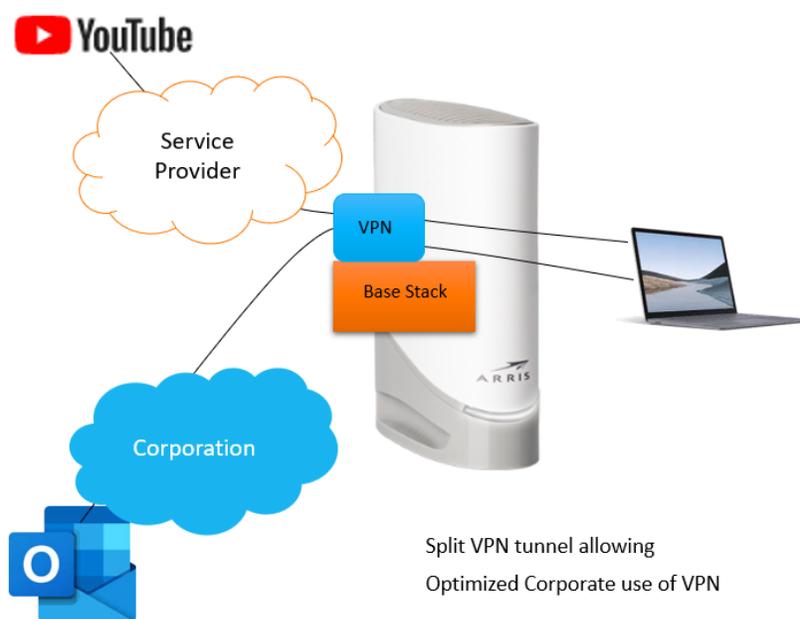


Figure 33 Integrated VPN and Split VPN solution

One additional comment on VPN from a Laptop vs VPN from a Gateway is the ability to provide quality of service to individual services like Corporate Video conferencing vs treating all VPN traffic as higher priority. When every service from a corporate laptop is encrypted in a VPN tunnel then differentiated service policies cannot be applied. While there are additional security implications with WPA3 encrypted traffic to a VPN in a Gateway – it does allow the GW to apply split VPN solutions easier and treat different services with different QoS policies better. A VPN client on the laptop applying split tunnels can also be used.

3.4. Integrated or Home File Cache

With much of the increase in upstream traffic in a WFH environment now starting to be file syncing to solutions like Microsoft onedrive – is there the potential to move that onedrive location to a local file cache in the home and then replicate it also in the corporate or Microsoft cloud? Depending on sync and user policies this could also help with Operator upstream bandwidth crunches where the syncing could be dependent on available bandwidth on the network vs currently more realtime and during office hours. It is

unlikely today that file syncing or local home storage solutions would be integrated in the Gateway (SSD technology making it at least easier from a size perspective) but could be something that is done in a Universal CPE device that offers local WFH processing and storage functions for SD-WAN like services to the residence

3.5. Corporate IT department control

Looking at the potential for the GW to be an extension of the corporate office and maintained as a virtual office end point by the IT department, what are the basic elements of a solution that may extend the office to the home.

Work at home like the office – extension of office

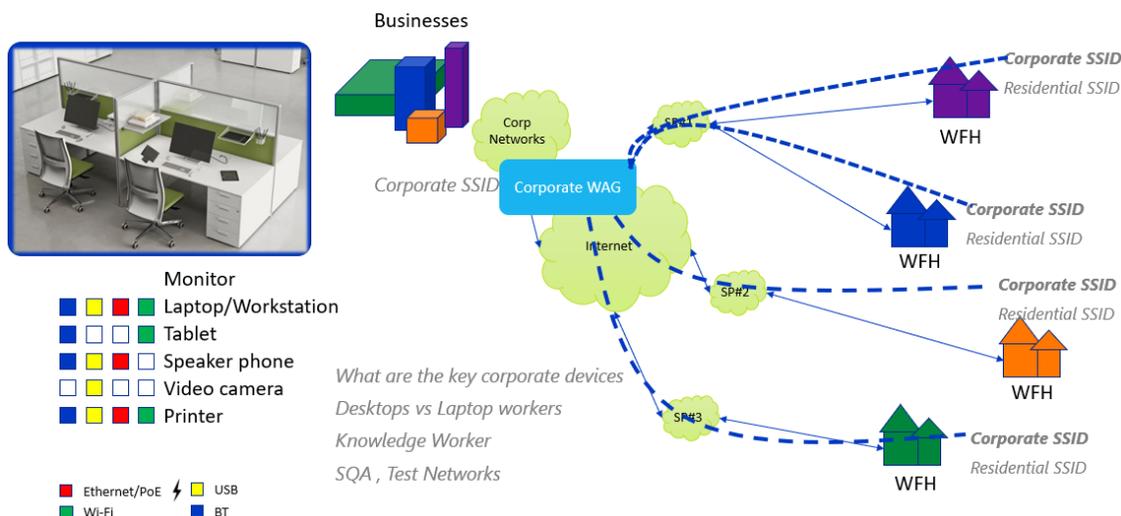


Figure 34 Extending Corporate IP Scope and SSID to the WFH GW

Consider the above approach of providing a dedicated Corporate SSID extending the typical office setup. Using both WPA3 encryption for the Wi-Fi SSID and VPN for all corporate bound traffic and services there is scope to have these residential GW's offer this service by downloading a specific containerized s/w solution on a per company basis. Allowing an Operator to charge to host this service and SSID for the separation of residential and WFH services. Creating containerized edge solution that can allow Corporations to apply their own security policies and ability to reset the service to the SSID when required. There could also be some options where the Operator provides telemetry information normally picked up by its own TR-181 pull and sends a subset of this to the IT department in the case of issues with the Broadband or Wi-Fi services in the home. Simple elements like – the broadband service speeds, wired broadband service is down and 5G/LTE backup is on and its usage statistics, Wi-Fi performance and any anomalies, VPN status, Security Status, CPU status, Memory status etc. An application and telemetry demarcation that (i) allows the Operator to pass the issues for any WFH service to the IT department to resolve (with special access to reset the Wi-Fi or even the Broadband Router device) and (ii) sells a service to Corporations that ties in with Employee presence and use on the Corporate connection could have a double benefit to the Operator.

Something more to consider as its realization is much easier to implement now as Gateways move towards containerized services models and away from monolithic images. Being able to add these services as well as protect the Operator/Consumer in residential mode from the Containerized memory

space and runtime and services that are exposed – enables these applications more to be able to be realized.

COMMSCOPE

Corporate IT support of GW functions

- Ability to provision and manage new services attached to corporate SSID
- Ability to troubleshoot issues with VPN or other corporate services
- Metrics on Corporate services usage and WFH employee use of the GW
- Ability to set up device attach ACL and shutdown services
- Anomaly use detection

IT Service Support of Gateway

- Basic control of any hosted corporate svcs
- Debug capability
- Services addition

3.6. Anti-Eaves Dropping Solutions

With working from home now exposing corporate information outside the company office at huge scale and now having lots of endpoints distributed like leaves on a tree over a huge geography – the ability to steal corporate assets seems to have increased. Consider the following scenarios

- Shared GW and Wi-Fi networks by people working for different companies in the same house or apartment. More frequent and easier access to both Wi-Fi data from specific devices and even open laptops in the apartment. Will corporations pay to improve security in these more often and more frequent situations.
- Increased number of hours that someone is connecting to their corporate network. Everyone usually does work at home, but this can be intermittent vs WFH had day long corporate devices connected to corporate network.
- Higher probability of someone trying to get access to company information targeting a worker at home to steal passwords or create an intrusion to the corporate network. Still requires sitting outside someone’s home or being in a neighboring apartment where Wi-Fi connection of the target is available.

One of the reasons why corporations favor running VPNs on the Laptop directly is that all passwords and traffic is VPN encrypted additional to the Wi-Fi encryption on the link to the corporate device. To provide VPN from the GW vs from the Laptop does leave a potential security hole between for example a corporate laptop and the GW it connects over Wi-Fi. Typically, this link will now be WPA3 encrypted but can be exposed with Man in the middle attacks and typically what is know as Evil Twin Access Points that masquerade as the users own Access Point and SSID. Solutions such as a **wireless intrusion prevention system** that monitors the radio spectrum within a wireless network’s airspace for unauthorized or unexpected activity and frequencies could also be deployed and be part of a new improved WFH security solution.

Shared homes with different company employees in the same market are also now exposed more for theft of IPR/Assets with the increased frequency of WFH and the opportunity to target employees and corporations by sharing homes and apartments. Solutions that

- Separate traffic, networks, SSID's, encryption schemes as much as possible between co-habitants in a SFU or MDU are potentially desirable. Again, typically corporations require on VPN from the corporate issued laptops to provide security for their IPR. Would SSID separation and WPA3 encryption separation also be desirable?
- Minimize exposure to passwords employing two-factor authentication to a second issued corporate device like a smartphone/SIM is another solution that should be employed more for WFH as the location of the WFH employee and device could be easily spoofed.
- Provide Operator created schemes that are like 2FA using other associated home devices to help a corporation ensure their employee is located in a specific WFH location while working? For example, using other devices such as extenders and Wi-Fi STB to be present in Wi-Fi scans to correlate to an employee being in their home while working and using the specific corporate issued VPN or other connection.
- Track and manage large downloads – potentially requiring 2FA schemes to continue and or limiting the number of bytes that can be accessed in a day for WFH. While the corporation can track the capacity through the VPN client and concentrator the operator can potentially also provide some correlation numbers on this endpoint as well. This also highlights potential applications too of work and home separation (discussed later) to be able to provide billing information for WFH traffic vs residential traffic. This is particularly important given that many service providers operate traffic caps where overages cost the consumer. With WFH increasing both Downstream and Upstream traffic usage, there could very well be an offered solution from a Cable Operator to offer corporations a separate bill for any corporate traffic, identifying it from per instance VPN bandwidth and/or destination addresses, application use etc.

If WFH is set to be a high percentage consistent activity these eavesdropping security issues will only increase so there may very well be value to expand some of these ideas to provide the most secure WFH Wi-Fi or Ethernet connection with some of these ideas below – offered by Cable Operator to corporations as a potential chargeable service.

3.7. Low Latency Service

Latency is very topical now as people have experienced video conferencing issues, audio breakup while working from home as well as the rise of online gaming and general gaming during the pandemic. Is there an opportunity to apply low latency features like Low Latency DOCSIS and Low Latency Wi-Fi into the WFH application space? Is the following thesis potentially valid enough to create these new services and architectures?

- WFH traffic during working hours should be prioritized higher than residential traffic?
- Certain WFH applications like the audio from Video conferencing should be prioritized ahead of other traffic when those flows are detected. This can be impossible to do when Video Conferencing applications are always put into the VPN tunnel and hard to identify their service or destination address to apply QoS and priority policies.
- Being able to apply DSCP and TOS marking to WFH services with or without affecting residential priorities.

There is potentially other latency issues that occur in MDU environments with congestion on Wi-Fi networks in the 5GHz and 2.4GHz. Jitter and latency in congested Wi-Fi environments can affect Video conferencing and potentially in the future other work from home low latency sensitive solutions like

running visualization application on cloud servers but rendered in home devices – for example mechanical engineers running immersive video-based visualization tools and using hand gesture to move around objects in real time.

Enter the new 6GHz spectrum that has just been released in US and is rapidly being approved across the globe. Is 6GHz spectrum destined to be used as a WFH private network to optimize performance, separate service, improve security and create an extension of the office. One simple representation of a Wi-Fi 6E WFH application is illustrated below. Using additional corporate sponsored or supplied devices that connect to the Cable Operator Gateway using a private corporate supplied 2 box Wi-Fi 6E network could create the best blend of home Wi-Fi performance for WFH, total separation of residential and WFH traffic using not only VPN and IP separation but now channel and frequency and device separation. There could be also potential improvements for Wi-Fi RF eavesdropping as well using a solution where 25mW in room VLP is used to connect corporate devices to the first 6GHz AP and then VPN tunneled from their through 6GHz backhaul double protected with WPA3. VLP 6GHz propagation is highly unlikely to be sensed outside SFU and even in the majority of MDU environments so could provide a range limited but effective WFH Wi-Fi spectrum to use for both lowest latency and security.

From a latency perspective using Wi-Fi 6E and 6GHz spectrum provides access to Wi-Fi 6 scheduling of device transmission, clear spectrum for the most part, 160MHz (and 320MHz channels with Wi-Fi 7) all contributing to be able to provide deterministic latency and high probabilities of retaining a 1ms latency per AP hop. This would provide a WFH solution independent of congestion, contention, and latency to be able to power all WFH applications.

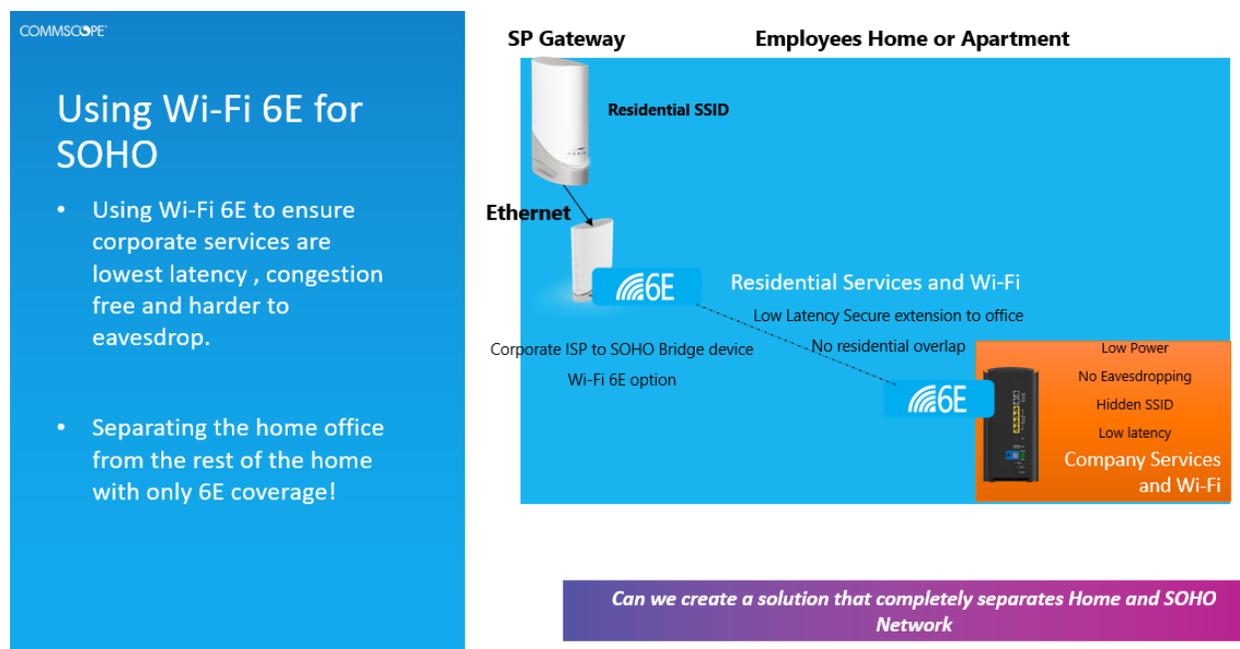


Figure 35 Is 6GHz the opportunity to create a private WFH low latency network

3.8. Anti-Theft of Service/Device solutions

Assuming that there are corporate software solutions added to Cable Operator Gateway or Corporate supplied home solutions like those defined above for a 6GHz VLP based in home office WFH solution –

then is it desirable by corporations or their employees alike to also have a solution that supports anti-theft of the device. Having the device only work in WFH environment for the specific corporation and in specific locations and with specific people and even specific applications.

Providing a series of checks to allow operation of the device could be done by several means

- Two or more factor authentication – using Cable Operator other Wi-Fi based devices that are defined to identify location and person requesting use of the WFH gateway
 - o One or more STB need to be present
 - o Bluetooth beacons need to be present from designated devices like Smartphones and STB
- Specific association of a corporate supplied device with a specific Cable Operator GW or Extender to allow WFH operations
- Nonoperation and boot of a GW if removed from its regular client environment. Regular client environment could be defined as simple as some mandatory presence of the devices in a persistent ARP table. (Note MAC randomization makes these simple associations more difficult and other schemes may have to be used).

There seems to be some merit in adding a feature like this to review with corporations if this level of anti-theft of service and device makes them feel more comfortable allowing employees to work from home.

3.9. HR Tools : Worker Presence & Tracking

A more sensitive or controversial set of features that may be relevant to employers and corporations as they move to completely virtual work solutions – is the application of presence and tracking technology for their workers. This all has to be done within HR guidelines as well as GDPR, CCPA, CCPR privacy regulations. Employers have been concerned that employees working from home, may not retain the same time and work diligence at home than in the office and can take opportunity to skip out from work to do home activity or other local activities during the day. There are simple technology ways to validate worker presence (presence not totally being indicative of the person working to any quantitative level) and a potential Realtime clocking in solution. Potential ways to do this are

- Traffic activity from the specific WFH device or on specific WFH VPN, SSID etc
- Connection of the WFH laptop or corporate issued phone on the Wi-Fi AP and correlating its frequency and potential type of traffic

Additionally, there could very well be some policies applied that an employee must have Bluetooth on in a corporate issued phone and this BLE beacon presence potentially also combined with Wi-Fi presence on the Operator or Corporate supplied GW/AP/IoT hub defines worker presence. This can obviously be spoofed by leaving home without the corporate issued phone but a somewhat restrictive solution to define trust that you are at home and working.

Other more intrusive but potentially allowable schemes are

- Using camera on issued laptop (Exam taking schemes now require the use of camera on the device exam is being taken on. Employers could also mandate something like this for their employees to work virtually).
- Radar and Wi-Fi motion solutions. Trying to signature a specific employee vs another home member is the key algorithmic requirement to make this solution offering viable.
- Remote clock in and clock out solutions – that are also aided by correlating to traffic and network usage

- Keyboard clicks, mouse usage are more invasive presence detection solutions but may not be qualitative of work or who is using computer or mouse.
- Turning on location services on corporate issued devices and company having agreements with employee to track their location during working hours or as a condition of being supplied corporate phone or even working from home.

And of course, a combination of all of the above may be able to reliably track the presence of an employee.

Of course, this may not be an appropriate or acceptable way to create a trust culture with employees and it may be better to trust the time-honored tradition of managers being responsible for the qualitative performance of their subordinates – so does presence or the metric pursuit of presence make any difference if any employee constantly excels at their tasks and role.

One security related use of presence that would be good to improve a WFH environment where multiple employees of companies in similar sectors are sharing an apartment. Having a local only presence solution between a smartphone and a GW/AP where the AP/GW or the WFH virtualized services running the GW are paused/blocked/not accessible unless the GW detects via BLE presence of the corporate phone and/or Wi-Fi attachment of same. A similar approach could be applied directly to the laptop or other corporate devices where they are logged out in the absence of another 2FA solution like BLE presence of smartphone.

A very sensitive and controversial area but there could be some happy medium of presence detection that is both beneficial to employee and employer.

3.10. HR Tools : Office/Home Separation

One of the more employee centric and mental health elements of working from home is the issue of separating Work and Life, This includes work and life from time and location perspective. Working in the place you also live can have issues on many levels. One of the simpler ones is to try and ensure that employees have the same natural triggers and events to start and end their day as well as take breaks for health purposes. For sure in a virtual world online meetings and meetings in general have now become scheduled rather than impromptu with a check of someone in their office. This has caused many people in WFH environment to say that they walk downstairs directly to their computer and surface late in the evening without the regular rhythm of commute to work, beating the traffic home and the odd call by to see can you do lunch.

Also, in certain countries there are very specific rules for time worked per week and the times that you can work. A virtual work environment makes it harder to enforce and check on this and there could be in the future WFH employees who have stress and mental issues that they blame on this WFH virtual working environment.

So, is there a technology way to separate Office and Home?

Separation can be defined in several ways

- For those fortunate enough to have a home office – it does provide some logical and physical separation of work and lifetime. When you enter the office – you are in the company domain even in your own home. When you step outside you are back into your residential environment. As we discussed above something like 6GHz VLP for example could actually separate Wi-Fi

connectivity from work and home and effectively only allow work devices to connect in a specific room of the house and not follow you to the kitchen.

- For time separation, policies can be applied to corporate issued devices or even in the case of a Cable Operator GW providing a WFH SSID for example – it be shut down at specific times to conform to companies working policies. The employee themselves may have to unlock things to complete certain critical tasks they deem necessary, but the company has complied with its or country working directives.

And of course, presence and tracking mechanisms coupled with solutions that have to comply to specific hours worked may be complete solution.

This may be something that could be applied to contractors in particular who understand their requirement to offer value typically billable on hourly basis.

Another potentially controversial topic but again in this new world of increasing virtual work and contracts based on virtual work stipulations giving HR tools to understand working patterns or even to shut down employees or throttle their work based on work directives that companies have to show compliance.

4. Conclusion

As we all wait to see what the permanent effect of the 2020/2021 pandemic is on the number of employees who work fulltime from the office, full time from their home or a flexible mix of both it does seem that there is opportunity to develop a better home connectivity and services solution that caters to the WFH elements and its new effect on the typical residential connectivity solutions. This paper tried to create a discussion on the development of this new mousetrap and see does it have merit for the employer, employee, the employee family or all of the above. Is there a business plan that can show who would pay for these improved services for productivity, security, anti-theft of IPR and even remote worker wellbeing? It does seem that most of the funding for these new services would have to come from corporations paying the Operator to allow these services to be dropped into their devices as containerized home services or easy onboarding of corporate supplied devices into a primary residential service provider solution. With the emergence of containerized service delivery and the arrival now of 6GHz spectrum this does also provide at least new technology elements that can offer path to be able to create some of the solution ideas discussed above. Is the better path to follow the SMB SD-WAN architecture and move this to manage a single WFH employee? Does it scale down to support that and does the new WFH solution also need a new rethink on the Universal CPE solution and role for split residential and WFH services. The authors conclusion from both the almost 2,500 WFH pandemic time employees and the wire brush of some of the ideas above is that there is an opportunity to extend the current residential only connectivity, security, and services model to add WFH as a service with feature additions like those above BUT this is dependent on the indelible change in the ratio of hours spent working in an office moving to the home environment. As of today in August of 2021 , the prediction is that an hours work ratio in 2019 pre pandemic of Office:Home ratio something like 90:10 is now going to be something like 70:30 or 60:40 is probably a big enough shift to make the better WFH GW and Solution mousetrap.