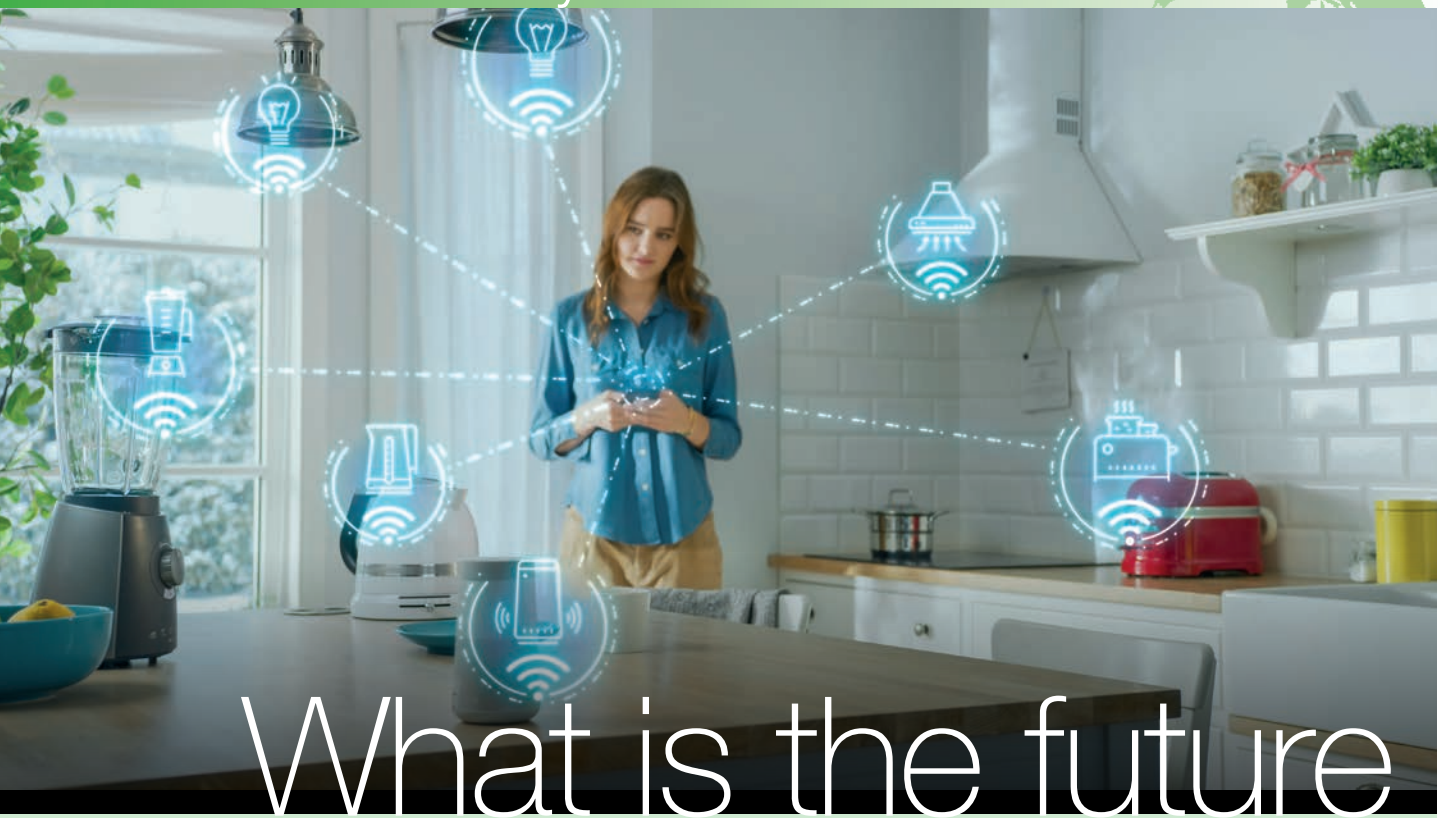


What is the future of broadband?

By Anthony Basham, President, SCTE

"The past is something we will always have, but the future is still to be written."

Broadband is converging. Whereas in the past the main concern was principally about looking at where a signal comes from and where it goes to, now the main concern is whether there is actually broadband or not.

Hybrid Fibre Coaxial Network (HFC), as one of the transport mediums for broadband has been subject to improvements in technology. My career in broadband started with LanCity in 1998. It was here that Broadband and TV merged for the first time as a way for consumers to obtain both TV and Broadband. Using 5-30MHz as the return was a new experience, and it was quite a learning curve for the industry to ensure hitting the head end with zero dBmV. Even the change to dBmV caused confusion for the dBuV experts; attenuation was calculated by hand with cable attenuation charts and attenuation in the passives.

The past is something we will always have, but the future is still to be written. We have all become quite spoiled over the last few years, and incredibly dependent on superfast broadband in the last 18 months; everyone would agree that our main concern now is buffering. Nobody wants to wait for anything to upload or download, stream or playback. Our patience is thin, our attention spans ruined. Ultimately, that means we all need enough bandwidth not to have to wait for anything.

The current DOCSIS 3.1 standard provides support for 10Gbps downstream and 2Gbps upstream. This is still a stepping stone on the Broadband HFC path; the DOCSIS 4.0 looks towards 1.8GHz as the high frequency for the upstream and 684MHz for the downstream. This is a significant change from DOCSIS 1.0.

	DOCSIS 1.0	DOCSIS 1.1	DOCSIS 2.0	DOCSIS 3.0	DOCSIS 3.1	DOCSIS 4.0
Downstream	40Mbps	40Mbps	40Mbps	1Gbps	10Gbps	10Gbps
Upstream	10Mbps	10Mbps	30Mbps	200Mbps	1-2Gbps	6Gbps
Issue date	1996	1999	2001	2006	2013	2019

DOCSIS has evolved a lot over the last 25 years and this means an extended lifespan for coaxial networks. The networks have also evolved to meet the possibilities that DOCSIS offered. The HFC network started as an analogue optical system which over time transitioned to a digital optical network. The used spectrum has expanded from 600MHz to the current 3GHz.

HFC is currently like a piece of clay on the potter's wheel. Depending on what happens with the clay in the potters hands and which tools are used, there are endless possibilities for the potter to work the clay into something useful, something to be used for a long time. We can consider the DOCSIS standard as the tools in this scenario; these will define where things are going, FDX and ESD are those possibilities and a number of hybrid solutions in between as well. This migration is another large migration for a network.

The clay itself and the wheel also have a bearing on this. If the clay is the network – then the wheel is the geography, demography and users. Coaxial networks are like clay and can be molded. They have also some of the natural flaws that Mother Nature throws into the clay. The network has an organic feel to it; this is not a one-solution-fits-all situation.

The biggest demand on the network is high traffic; COVID-19 certainly demonstrated that, as the broadband demand shot up in people's homes from an after-work pastime to heavy, 24-hour usage with multiple users per home. Bandwidth surged from 50-150% in weeks, with schools, offices, health and social usage adding virtual services. This resulted in more pressure on the networks, segmentation of existing nodes and bringing forward upgrade projects that had been scheduled several years ahead. This acceleration forced mid and high splits into the mix to ensure that upstream bandwidth continued to function.

Distributed Access Architecture (DAA) with both remote PHY and remote MACPHY are now emerging and adding more to the bandwidth, as segmentation alone is not enough to provide the required upstream capability in some areas. These areas are transitioning from standard nodes to DAA or R-PHY solutions in order to meet capacity demands. With this transition the head ends are also getting an overhaul as they move towards more virtual services. vCCAP (Virtual Converged Cable Access Platform) converges all of the networks together, requiring a central platform to support all of these is necessary.

Virtualisation moves the networks closer and also adds networks into the management and provisioning: HFC, FTT*, 4G/5G ultimately become one, with virtualisation controlling all of these and ensuring the experience for the subscriber remains ultra-fast broadband speeds and services, no matter which transport medium is used. Virtualisation moves the bar in a number of areas, as the rack space disappears.

Gone are the days of large headend, with the associated cooling problems, and more is moved into the cloud. Moving the headends closer to the users with the MACPHY solutions is one way the rack space reduces, and the virtualisation the other way. Headends space will decrease and the real estate that once was the headend will become a virtual headend.

HFC now becomes part of the bigger picture and adds value to the other transport mediums; it can also coexist, ensuring that broadband signals are available.

FTT*

This refers to the ubiquitous acronyms seen all over this industry now. Fibre to the *; the asterisk refers to Premises, Basement, Building, Home, Curb, or shed. Fibre deployment was advancing at a steady pace, COVID-19 has increased the deployments. More of us are working from home and the need for broadband that works has seen a huge increase in installations. Governments worldwide have provided substantial funding to aid this deployment by investing in networks and fibre to the home.

XGS-PON

Copper

HFC is one copper solution and the Telcos have the other the DSL network has seen the last of the big investments. The telephone centrals are slowly being repurposed. A lot of investments have migrated from DSL towards fibre with optical line terminals (OLT). Most of the DSL world is now actively promoting this transition towards fibre; North America, EMEA, and CALA have all moved from maintenance of DSL to the expansion of the fibre infrastructures.

All of the above contributes to the expansion of fibre globally. It means the development of the next generation of networks and over time all of these networks will gradually converge into one solution for broadband fibre. These fibre networks are expanding to ensure that the increased demand for bandwidth is met; however the need for an agile network puts demands on openness, this has always been the restriction

on a network. Changes are now required within hours rather than weeks or months, where a new linecard was installed.

We have seen that the changing requirements of both services and the subscriber's calls for a more fluid infrastructure. It is clear that changes to the network need to be rapid and efficient, so that the network can move with the vendors, customers and applications required.

Telecoms companies have been rolling 4/5G services out and 5G is reliant on the widespread fibre network. 5G services rely on nano-masts that connect to the internet through a fibre connection. However, the main drawback on 5G is penetration of the signals, as unfortunately the higher the frequency the harder it is for the signal to penetrate buildings. Additionally, objects in the line of sight decrease the penetration. Offenders include trees, moving objects and vehicles, such as trains and buses. 5G services are very much like WiFi services in the home; both suffer with some dead spots from time to time.

One solution for all

XGS-PON has been the ultimate goal for a number of networks, be it FTT*, HFC or DSL. XGS-PON allows service providers to reach a capacity of 10Gbps and adapt the network as the infrastructure is no longer a constraint. The material is also no longer a logistical dilemma when upgrading, as the network has a more elastic design.

PON as a solution is not just one solution but has a number of solutions, these cannot all exist at the same time or just upgrade. PON in itself has a clear advantage with no active components between the transmitter and the home.

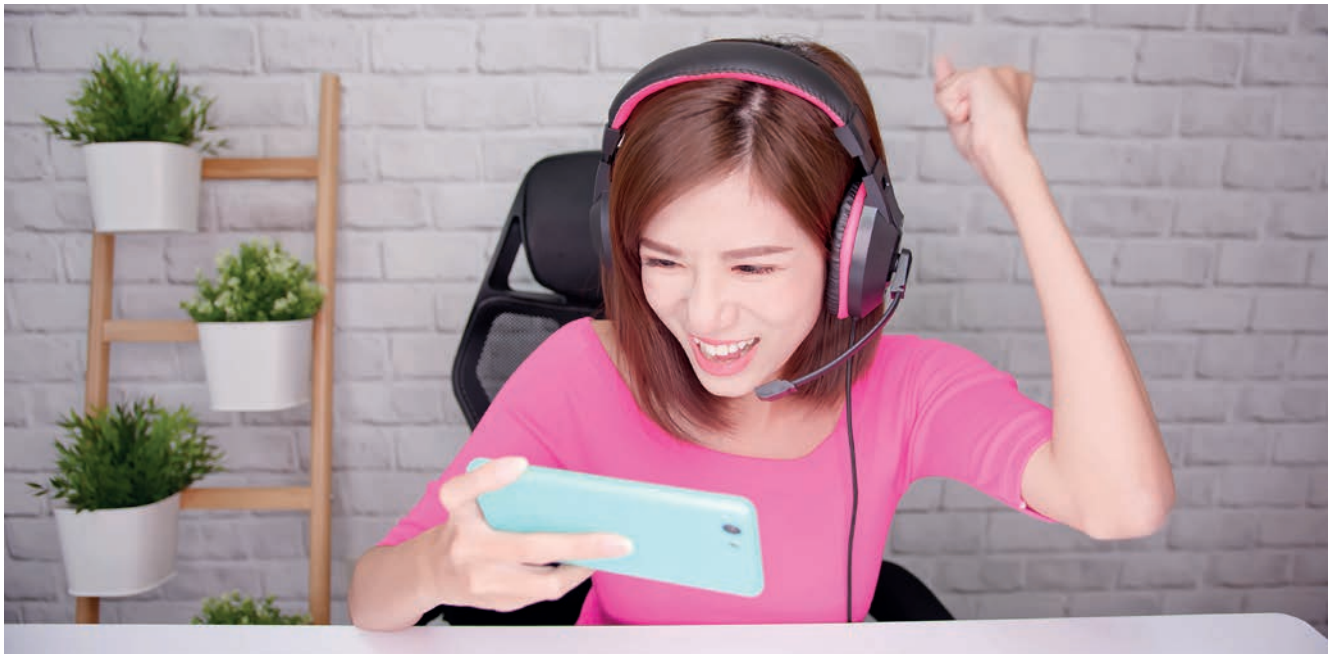
Driving the need for superfast broadband. The factors below are areas that are driving the need for superfast broadband. These are pushing the requirements many are still in their infancy, where some are the factors pushing the limits up currently.

Constant Connectivity. As apps improve and connectedness becomes more attractive to the end user we are using our mobile phones more than ever. We are monitoring the electricity usage of our homes, when the washing machine has finished, who is ringing the doorbell and post-lockdown, we are streaming movies on our journey to work all on our phones, to say nothing of the limitless bounty on offer via Deliveroo and UberEats. Consumer expectation in 2021 is that broadband needs to work constantly and work well.

Megabits are not enough. Such constant usage also requires the need for not just megabits but gigabits. Pulling and pushing data are now the same; as mobile phone technology has improved and built-in cameras have rendered digital SLR cameras obsolete, we now create content on the go, taking photographs of our cats and videoing our roast dinners for uploading on Instagram, Facebook, YouTube and Twitter. A few years ago we mainly received data, but now we are also content creators.

Seamless connectivity. The mechanics involved in moving from a HFC network onto a wireless 4G network, using the WiFi on public transport, connecting to WiFi6 through a FTT* connection at work: these all require handoffs to the next. This is becoming more of a seamless handoff and with fewer dropouts and failures. The expectation is constant seamless connectivity, the broadband connection is experienced as

PON	EPON	10G EPON	10G EPON	GPON	XG-PON	XGS-PON	NG-PON2
Upstream (nm)	1310	1270	1270	1260-1360	1260-1280	1260-1280	1524-1544 1525-1540 1532-1540
Downstream (nm)	1490	1577	1577	1480-1500	1575-1580	1575-1580	1596-1603
Video (nm)	-	-	-	1530-1565	1530-1565	-	-
Splitting Ratio	1:32	1:128	1:128	1:128	1:256	1:256	1:256
Upload (Gbps)	1,25	10	1	1,25	2,5	10	40
Download (Gbps)	1,25	10	10	2,5	10	10	40
Maximum Physical Transmission Distance (km)	20	20	20	60	100	100	40



a necessity, and like the air we breathe should be a readily available constant supply of data.

Low latency. Time has always been a factor; even now the time difference between two stock markets is critical and can influence a win or a loss. Ensuring that the network performs at speed on all mediums is critical. The latency in an AR or VR requires a latency that does not cause any kind of delay. Delays give the experience problems: in freezing, pixelation. The network latency has provided problems from the first day and avid gamers will be the first to jump on this, as latency costs virtual lives.

What is in place for the future?

CableLabs are looking towards a higher frequency usage within the next 7 years. DOCSIS 4.0 is planned to be close to 3GHz in frequency by 2028 where Extended Spectrum is the solution (there are discussions of using above 3GHz and getting close to the 6GHz area). Moving to 3GHz within 7 years seems a hard task at present, knowing the constraints of the coax cables in the network, especially where coax cables are the biggest factor when utilising DOCSIS. Upgrades of coax cables are not taken lightly, when a fibre can be put in place and move the fibre closer. The attenuation of coax cables is the main factor affecting their future usage; the higher the frequency used, the higher the attenuation.

Dividing the network into upstream and downstream has always been the strategy before, with fixed diplexers to ensure the streams never mix. Every time the frequencies change the diplexers in all equipment needs to be upgraded to the new diplex frequency. Full duplex DOCSIS removes the diplexers from the equation and allows the frequencies to change, according to the network requirements.

Extended spectrum is again a tool to use on the clay, however there are a number of things that the potters wheel also needs; for example the whole network to be ready to transmit 3GHz. This includes the headend, the transmitters, the fibres, the receivers, fibre nodes, coaxial distribution, amplifiers, taps, splitters, the subscriber drop, the wall outlets, the in-home installation, the modems and STBS. All of these will need an upgrade to allow 3GHz to pass.

Hybrid networks is a name given to a mixed network, however a Converged Fibre Copper (CFC) network is more aptly named for the future, where copper and fibre converge at a specific point in the network. This is speculation of course, and open for debate. The need for more broadband is a requirement however, that much we know for certain. As always there are commercial, geopolitical and social tensions that will affect the direction of travel. Currently there are commercial pressures dictating that DOCSIS is a standard that will continue to evolve over the next many years, whereas fibre is seen as the only solution to a network. Politically the drive for a GIGABIT nation is more than evident, and the only solution seen currently is a move to fibre. Socially, the marketing campaigns around fibre have been so effective that the assumption must be now that fibre is the only solution that works. Nobody talks about getting broadband, they only talk about getting fibre.

Virtual Reality

VR is a simulated experience that can be used for entertainment, education and business. VR requires a form of immersion through a headset or a projected environment. As this uses a visual environment there is a high data requirement with queueing of visuals depending of the direction the user is facing. Interaction and reality allows the user to experience a reality.

Online Gaming

Gaming has always required broadband, moving into more immersive gaming and higher graphics; this has not stopped. Allowing multiplayer cooperation requires all of the user interfaces to be synchronized. Online gaming has been synomous with lag, with players complaining that the latency is too high and ping times poor. Online gaming has been using better and better graphics, pushing more data through the net.

Remote Work

COVID-19 has changed the way we work. With lockdown enforcing upon us a work-from-home environment, the amount of data sent for business purposes has increased. Ensuring connectivity in business requires a significant amount of data to be transferred. Many companies are not allowing data to be stored locally but work through virtual access, where the data remains in the confines of the company but the images are transferred to the user. The statistics tell us around 25% of the total workforce working from home (Global Workplace Analytics). Data has been kept on a company network until working from home, and now has been moved into a broadband network.

Education

As with working remotely, remote education was enforced worldwide in 2020, with all students sent home. However remote education has improved, enabling remote and rural areas to ensure education needs.

Augmented reality

Enhancing reality by using the environment you are in and adding a visual layer on top drives a new level of reality. Overlaying cable plans onto the trenching workers displays is one example that allows trenching to see what is under the ground. AR is not just for gaming and entertainment. In construction, cable plans have to be clear and ready so when they start digging up roads the workers don't hit any cables. The use of AR in this instance overlays the cable plan to the screen so the JCB operator can avoid the cables.

Direct connection

User interfaces are getting smaller and soon they will be too small for us to see anything. What will be the display of the future? Glasses, contact lenses, neural connections, head-up displays, holograms and holographic environments – the prospects are limited only by our imagination and increasingly by sustainability targets.

4/8/16/32K streaming

4K has a total of 3,840 by 2,160 or 8,294,400 pixels and 8K doubles these numbers to 7,680 by 4,320 or 33,177,600 pixels. 16K is 15,360 by 8,640 or 132,710,400 pixels and 32K 30,720 by 17,280 or 530,841,600 pixels. The expectation is a requirement of 50Mbps to ensure that 8K can function. With viewing changing towards streaming a family of four (two adults two children), the current UK average download speed is 50,4Mbps (Ofcom, March 2021), this would allow only one person viewing an 8K stream.

IoT

Internet of Things (IoT) is a physical object with sensors, processing ability, software or other technology embedded. These connect and exchange data with other devices and systems over the internet or another communication system. With the expectation of 22 billion IoT devices by 2025, the amount of data these devices use is set to increase; Cisco estimated that 500 zettabytes (zettabyte = 1 000 000 000 000 000 000 000 byte) of data per year would be used in 2019 just by IoT devices.

What is in store for the near future of developments?

LEO

Low Earth Orbit satellites, disposable satellites placed in the low earth orbit, (160 to 2000km above the earth) will allow for better web performance and wider coverage than the current satellites. Instead of having a base station or mast placed on the earth, the idea centres around moving this into orbit. This allows for network of satellites covering the globe allowing data connectivity. SpaceX is one of the ventures that has currently 1791 satellites launched, with 1429 of these operational (as of the 30th of September 2021). Allowing access to a connection in orbit removes a large part of the network requirement and places this in terrestrial base stations and satellites, with a user terminal to get broadband into the home.

Internet balloons

20km above the earth in the stratosphere balloons are deployed and software controlled to ensure they move into position using the winds to keep them in a stationary deployment. Each balloon can maintain an internet connection to an antenna on the ground. Solar powered balloons transmit using LTE technology which allows a rural and remote area connection.

LiFi

Light fidelity is a bidirectional high speed wireless communication technology using visable light or infra-red and near ultraviolet from light emitting diodes. With speeds faster than WiFi at 224Gbps, this technology is deployed in electromagnetic sensitive areas such as hospitals, nuclear plants, aircraft, basically anywhere where radio frequency waves are not viable. However, this is a line-of-sight technology and the downside is its short range, so there are limitations.

The future is unknown; there is a lot in place already to aid the push for more data and that is the one thing we are certain about. More data is a necessity; the global population is growing and broadband is a utility that every global citizen should have access to. This push is raising the demand for more. The route to achieving such a goal is complicated by the existing network topology, the investment required and the commercial tensions that lie therein. Whichever route is being taken the SCTE will continue to follow this and provide insight to the industry.