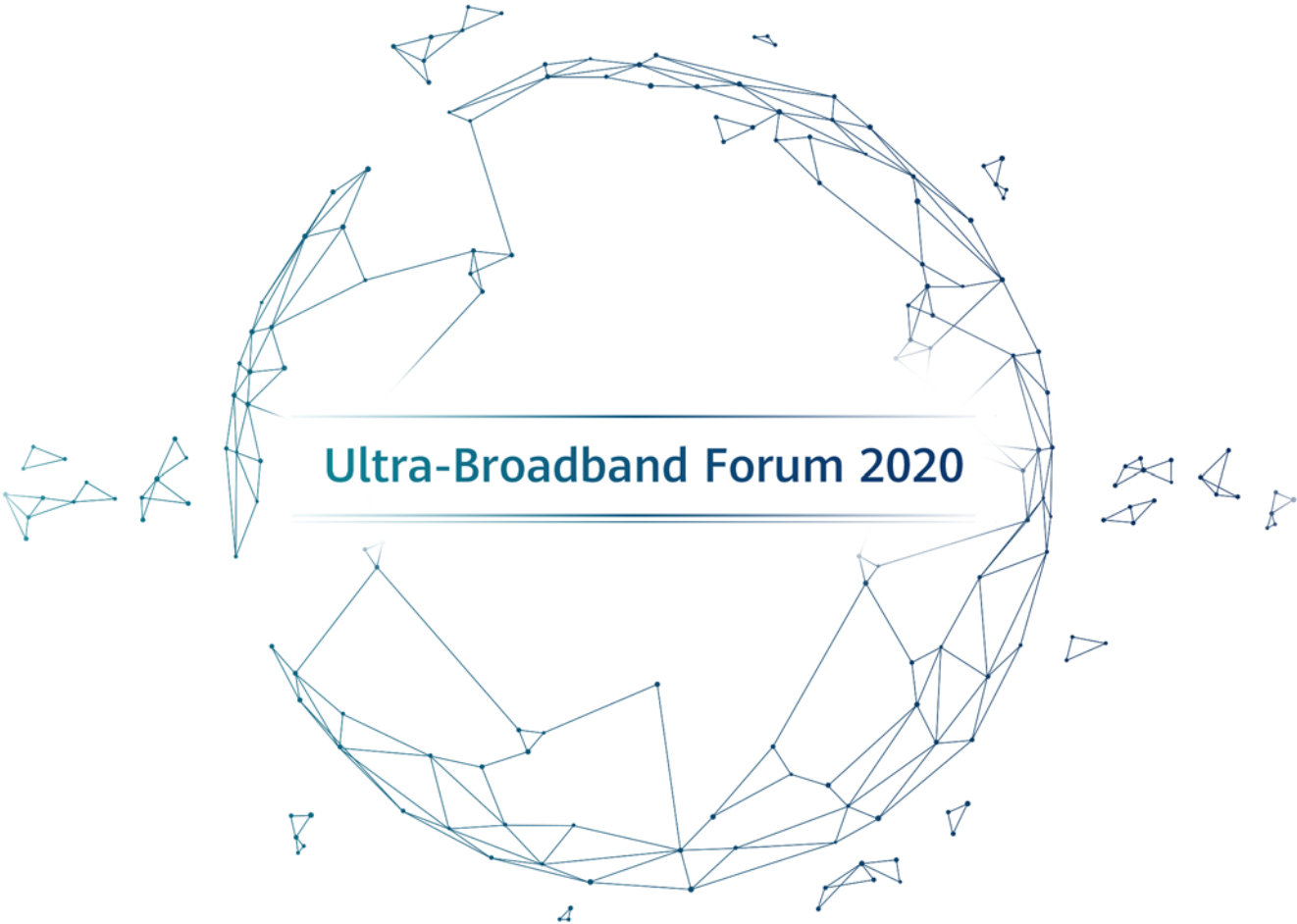


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Building a Fully Connected, Intelligent World

Intelligent Connectivity, New Value Together



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Enhance Ultra-Broadband Infrastructure Construction to Promote Inclusive Recovery and Prosperity

By Houlin Zhao,

ITU Secretary-General/Vice-Chair, UN Broadband Commission

Over the last decade, broadband has significantly facilitated communication all over the world, creating more possibilities in people's lives. More recently, it has played a crucial role in the fight against the COVID-19 pandemic. People stayed at home to shop, take classes, and work safely. For many this year, home has become a school, hospital, office, and even a cinema. Ultra-broadband has transformed the home into a production center.

In addition, as a critical national infrastructure, ultra-broadband networks accelerate the digital transformation of industries and improve productivity, which is key to building national competitiveness and sustainable development.

However, we must not forget that the digital divide still exists. Today, 3.6 billion people in the world are yet to be connected. The penetration rate of the Internet is only around 50% and its growth is slowing down. To increase ICT's contribution in achieving the Sustainable Development Goals (SDG), the ITU published a study titled *Connecting Humanity - Assessing investment needs of connecting humanity to the Internet by 2030*, with the vision to achieve universal, affordable broadband connectivity for the entire world by the end of this decade. To do that, we need to deploy 700,000-kilometer fiber trunks.

In addition to the insufficient infrastructure, broadband development also faces a series of other challenges:

a lack of effective guidance on industry policies; slow network roll-out; uneven development across regions; future-oriented new services requiring the enhancement of network profitability; lack of a clear evolution roadmap; and the need to involve new stakeholders to roll out the network infrastructure and attract investors.

With these challenges, global collaboration is required to quickly bridge the divide in broadband connection and achieve the goal of universal, affordable broadband connectivity for everyone by the end of this decade. I have proposed a "4I" strategy, namely infrastructure, investment, innovation and inclusiveness. Governments, operators, equipment vendors, investors, and industry verticals need to work together and the whole ICT industry must also work closely to overcome these challenges. Industries need to increase investments in ICT, and governments need to formulate policies for ICT investment. Cooperation and unity are crucial to recover from the impacts of COVID-19.

UBBF 2020 provided a great opportunity for us to communicate and collaborate to facilitate the development of the broadband infrastructure through technological and business innovation and make universal connectivity the cornerstone for the sustainable and inclusive global economic recovery and the intelligent era. Here, I call for a more universal and high-quality ICT broadband infrastructure to enable essential services, bring the society closer, bridge the digital divide, promote digital inclusion, and achieve the SGD 2030 goal.

Intelligent Connectivity, New Value Together

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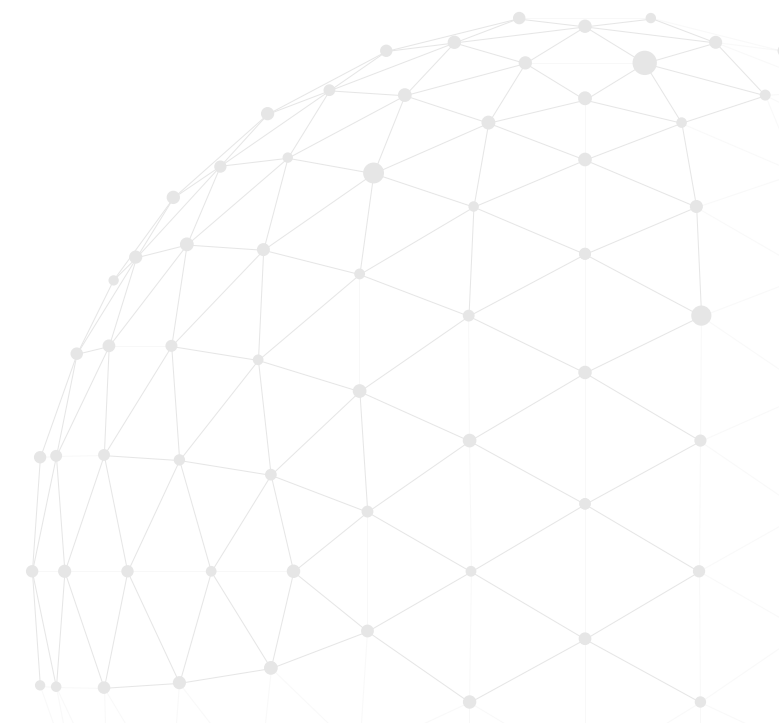
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INDUSTRY TREND

Moving Towards the Era of Intelligent Connectivity

The intelligent era is approaching, and individuals, homes, and enterprises require more from connectivity. The fifth generation of connectivity technologies bridges the virtual and physical worlds, enabling an intelligent world.

By David Wang, Executive Director of the Board, Huawei

In 2020, telecom operators around the world have played an important role during the pandemic and the value of networks has never been more evident.

Looking back, every upgrade in connectivity has driven social development. In agrarian societies, “post stations” connected remote cities. The Silk Road, a connection built on the post station system, promoted the exchange of goods and information between East and West. During the industrial era, telegraphs and telephones transformed long-distance communication. In the information era, mobile, fiber, and data communications have supported the explosive growth of the Internet and rapid development of the global economy.

Now, we’re entering the intelligent era. Individuals, homes, and enterprises require more from connectivity, which is increasingly embedded with new technologies such as cloud and AI.



“ In an era where people and homes are the focus, connectivity is the main goal – specifically, the connectivity of everything. As the integration of intelligence in our lives and enterprises accelerates, we need to connect more things, more intelligently. ”

The connectivity industry is experiencing 5 exciting changes —○

Change 1: From IoT and intelligent IoT to connected Intelligent Twins

In an era where people and homes are the focus, connectivity is the main goal – specifically, the connectivity of everything. As the integration of intelligence in our lives and enterprises accelerates, we need to connect more things, more intelligently. The goal of this phase is to connect everything intelligently. At HUAWEI CONNECT 2020, the entire industry reached a consensus that it requires industry-specific intelligent twins to make enterprises intelligent.

Change 2: from office to office + production

Home networks are expanding from simply providing information and entertainment services to supporting online education and telecommuting, enterprise networks are extending from offices to production environments. Third-party data shows that 18 million enterprises in China allow telecommuting and 420 million users are taking online classes. According to Huawei's report on digital transformation, the focus of digital transformation has shifted from digital office to digital production, transaction, and operation.

Change 3: from best effort to differentiated deterministic services

Connectivity requirements vary with industries and service scenarios. For example, smart city services require massive connections, while smart factory services require deterministic latency. Providing differentiated services is fundamental, and deterministic assurance is mandatory. Only after operators develop these two capabilities can they gain a foothold in vertical markets.

Change 4: from Mbps to Gbps via any medium

There are many connectivity technologies, including cellular, Wi-Fi, and fiber technologies, which will coexist for a long term since service scenarios are diverse. No single technology can do it all. The good news is, all of them now support gigabit connectivity.

Change 5: from manual O&M to hyper-automation

New technologies such as 5G, AI, and cloud enhance network capabilities, but also bring challenges to network O&M. Compared with 4G

networks, 5G networks increase the connection density by more than 100 times and the number of network configuration parameters by more than 10,000. As networks increase in complexity, manual O&M is no longer sufficient. Big data and AI must be integrated to simplify decision-making, implement hyper-automation, and free people from complexity.

The five changes above show that the value of connections depend not only on the number of connections, but also on the quality, bandwidth, latency, and network slicing of these connections.

For financial transactions, a reduction of 1 ms latency can increase revenue by US\$1 million. According to the test data of an OTT cloud data center, 0.1 percent network packet loss will cause a 50-percent loss in computing power. In the era of traditional connections, Metcalfe's law interprets the value of connections, which is directly proportional to the number of connections squared. For new connections, several variables need to be incorporated into Metcalfe's law, including bandwidth, latency, and slicing, to redefine the value of connections, to become the "new Metcalfe's law".

$$V = \sum_{\text{slice}=1}^N \left(\frac{k \times Bw \times N^2}{T} \right)$$

where

- K: value coefficient
- Bw: bandwidth
- T: latency and jitter
- N: number of connections
- slice (ranging from 1 to N): number of network slices

The new Metcalfe's law redefines the relationship between connectivity and productivity in the era of intelligent connectivity.



Moving towards intelligent connectivity with AI

To address these five changes and increase productivity, connectivity needs to be upgraded. First, bandwidth is the bedrock of connectivity. In home and enterprise scenarios, the widespread use of ultra-HD video, VR/AR applications, AI cameras, and drones requires ubiquitous gigabit-level connections. Second, networks must provide a deterministic experience to ensure smooth telecommuting and online classes at home and secure and reliable production in enterprises. Third, as the scale and complexity of networks increase exponentially, big data and AI must be introduced to implement hyper-automation. Therefore, connectivity in the new era needs to offer ubiquitous gigabit connectivity, deterministic experiences, and hyper-automation. That is intelligent connectivity.

What does intelligent connectivity mean for operators? Huawei proposes two propositions for home broadband and enterprise services.

Proposition 1: powered by intelligent connectivity, realizing the value of home broadband experience with "1 + 3 + X"

"1 + 3 + X" enables smart connectivity to transfer home broadband from demographic dividends to experience dividends.

"1" refers to the "one" fiber that will provide gigabit-level broadband access, and "3" refers to the three measures over the fiber: full gigabit-level Wi-Fi coverage, optimized experience, and precise operation planning. This "1+3" initiative enables the development of more innovative broadband services such as office broadband, education

broadband, eSports broadband, live streamer broadband, and smart homes. This is the "X".

Proposition 2: powered by intelligent connectivity, inspiring new growth in enterprise business

- ❖ | **Deeper:** Intelligent connectivity extends LAN services to WAN services. Enterprise digital transformation must be based on high-quality and high-reliability enterprise campus networks. By leveraging the advantages of WAN networks and hyper-automation technologies, operators can extend their services to enterprise LAN networks to open up new market space.
- ❖ | **Better:** Intelligent connectivity refines the quality of interconnections between enterprise branches. As an increasing number of enterprise applications are deployed, branch interconnections need to meet diverse service requirements and ensure deterministic experience. Operators need to provide high-quality private lines by utilizing their advantages in network coverage and diverse connection capabilities.
- ❖ | **Wider:** Intelligent connectivity builds more extensive cloud connections. Enterprise cloudification is a huge opportunity. Operators can leverage their advantages in network coverage and integration to provide agile and secure cloud access for enterprise customers, and achieve strategic cloud-and-network synergy.

Huawei's all-scenario intelligent connectivity solutions

For home broadband scenarios, Huawei's intelligent distributed access solution upgrades home terminals, CO devices, and NMS systems. Fiber to the room (FTTR) builds an all-optical home network, providing gigabit-level Wi-Fi for each room. AI is integrated into home terminals to intelligently identify service types and ensure high-quality service experience. Second-level data sampling and intelligent analysis capabilities monitor user experience in real time and accurately identify users with a poor network experience.

For small- and medium-sized enterprise (SME) campuses, Huawei's intelligent campus network solution extends operator services to the campus, implement unified LAN and WAN management and control, Gbps-level all-wireless access, and intelligent O&M.

Based on the successful practices of the OTN premium private line in the financial, government, electric power, and OTT industries, Huawei has upgraded its intelligent premium private-line

solution. The latency is decreased with all-optical switching to build 1 ms latency. In addition, Liquid OTN technology is used to implement flexible bandwidth increments ranging from 2 Mbps to 100 Gbps to make premium private lines more affordable. Moreover, by binding the channel resources of wavelengths or sub-wavelengths, wavelength-level private networks are provided for enterprise customers.

To support cloud migration in different industries, Huawei has launched the intelligent cloud network solution. Based on the intelligent IP network, this solution builds a high-quality private network to provide multi-cloud services for enterprises. For the cloud backbone, multiple clouds are pre-connected to access multiple clouds through one private line. For cloud access, network slicing is used to provide differentiated SLAs for different industries. Finally, for cloud private lines, the wide coverage of the mobile transport network is leveraged so that 90 percent enterprises in urban areas can connect to the cloud within one day.



Huawei's key strategic moves

To support and promote the development of the intelligent connectivity industry, Huawei is implementing three key measures. First, we continuously invest in basic research and system engineering capabilities to develop leading products and solutions. Second, we're working with the entire industry to overcome the challenges of deglobalization and maintain a unified global standard for the connectivity industry. Third, Huawei is working with ecosystem partners to continuously improve solutions based on industry scenarios, the IPv6 expert committee to promote network capability openness, and alliances such as NGOF and ONA to jointly develop scenario-based F5G solutions.

Society is at a critical stage of evolving from an information society to an intelligence society. People will increasingly utilize intelligence to provide the immersive interactive experience of the virtual and physical worlds, strengthen collaboration, and break limits. The fifth generation of connectivity technologies, such as 5G, F5G, IPv6+, and Wi-Fi 6, provide ubiquitous gigabit connectivity, deterministic experience, and hyper-automation, bridging the virtual and physical worlds and enabling the intelligent world.

In the future, the sixth generation of connectivity technologies will continue to develop in multiple aspects such as space, time, and scale. They will provide 100-fold bandwidth improvement, lower latency, and wider coverage to evolve an intelligent society into a futuristic society. Huawei will explore the sixth generation of connectivity technologies such as 6G, F6G, next-generation IP, Wi-Fi 7, and Wi-Fi 8, continuously make breakthroughs to achieve optimal network performance, and provide the best connections for the world.



Any assumptions about the future of connectivity may be underestimates. The best way to predict the future is to create the future. Let's advance towards the intelligence connectivity era together.

What drives fibre development in EU

At the FTTH Council Europe, we believe that Full Fibre networks are the future-proof, climate-friendly infrastructure which enable innovative digital technologies and services.

By Vincent Garnier, Director General of the FTTH Council Europe

My 16 year old son recently asked me what I was doing of my days as Director General of the FTTH Council Europe. I told him, joking, that I was mostly talking to my computer. Just like me with my classes on Teams! He replied. And I guess, most of us are in the same situation. Sometimes video conference works fine, sometime not so well.

What the COVID-19 pandemic as revealed is the critical importance of telecom networks to keep people and businesses connected. And this is only one aspect of what digital technologies can do to help us adapt to the challenges the world is facing.

The European Union embraces this vision and has set objectives to make Europe fit for the digital age while helping to achieve its target of a climate-neutral continent by 2050.



Fibre, the only future proof and sustainable technology

At the FTTH Council Europe, we believe that Full Fibre networks are the future-proof, climate-friendly infrastructure which enable innovative digital technologies and services. We have been monitoring the progresses of fibre deployment

across Europe and from recent updates we will see the key drivers behind the development of Full Fibre access networks in Europe as well as the roadblocks still in front of us. We should do something today, to make sure we can meet and

exceed the targets set by policy makers and pave the way for a better future for our children.

The benefits of fibre are now well established: Higher upload and download speed, virtually unlimited capacity, extremely low latency and low operating costs. The fibre infrastructure you build today have all chances to meet the needs of your children in 20 years.

What is less known, and becomes now critical, is the fact that fibre is also the technology which has the lowest energy consumption, by far, compared to alternative solutions. Copper or coax networks, require more energy when frequencies and data rates increase, while fibre, as a passive system, keeps a very low power consumption level regardless of the bandwidth it offers. All data converge to demonstrate that fibre has a much lower carbon footprint than other technologies

and that this advantage will dramatically increase with the growth of data rates. Fibre is the only technology supporting both EU ambitions of a Digital and Green society. The FTTH Council, together with other trade associations will soon communicate about this subject and reference several studies.



Status of FTTH roll out in Europe

Partly due to the good quality of legacy networks in Europe, the development of FTTH has been slower than in other region like Asia. But we are catching up. Our latest market panorama, based on 2019 data, shows that, since 2012 the number of homes connected to Full Fibre networks has tripled to reach 50% coverage ,and the number of subscribers has been multiplied by more than 4 to reach 20% of households. This average subscriber penetration rate is the combination of very contrasted situations by country. While Sweden, Spain or the Baltic states are above 50%, we still see large countries like Germany, Britain,

Italy or Poland below the 5% threshold. We still have a long way to go.

In December we will publish our market forecasts, which have been adjusted to take into account the impact of the coronavirus pandemic. These data will show an acceleration of the FTTH development, especially in Western Europe. According to our survey, the COVID 19 crisis has significantly amplified this evolution and our forecasts integrate an uplift of up to 14% due to the expected long lasting consequences of the crisis.

“ Full Fibre networks are increasingly seen as utilities and become a very attractive long term investment. We are happy to see more and more private funding supporting the development of fibre. ”

Key drivers behind FTTH development

Not only roll out plans are accelerating, but the take-up rate is expected to progress significantly. How can we explain this evolution? What are the key drivers of Fibre to the Home in Europe?

The volume of data on the internet keeps growing at impressive rate and leads to a demand for more bandwidth. We expect 5G networks, especially those using millimetre waves, to become an important driver for fibre deployment as 5G multiple small cells will need to be backhauled with fibre.

As telecom networks are built to last decades, you need a long term vision, an anticipation of the societal needs of tomorrow, and this is the job of policy makers. The latest plans presented by the European Commission show its ambition to progress towards a more digital and green continent. The European Union has historically played an important role to foster competition in the interest of citizens. With the European Electronic Communications Code which is to be implemented in country legislation by the end of this year, the EU favours clearly investments and take up in Very High Capacity Networks, which are defined as having technical performance of fibre.

At country level, we now see much more ambitious

Full Fibre development plans. Spain, France, the UK and just recently Poland are good examples.

Public investments are important, especially for rural areas, but the majority of the money comes from private investors. The growth of Fibre in Europe owes a lot to alternative operators who have been pioneers and have proven that their business case can fly. Thanks to these entrepreneurs, incumbents have been obliged to react and develop their own FTTH plans. Full Fibre networks are increasingly seen as utilities and become a very attractive long term investment. We are happy to see more and more private funding supporting the development of fibre.

Wholesale only operators are particularly interesting for investors who like the simplicity and transparency of their business model. This is to be put in perspective with a trends among incumbents to split the management of their broadband infrastructure from their activity of service. Cooperation between incumbents and alternative Operators, network sharing and network mutualization are increasingly frequent. This reduces overbuilt, make FTTH coverage more cost effective and accelerate the availability of fibre for citizen.

Addressing the challenges ahead

If we continue and amplify the current trend, EU average Full Fibre subscribers' penetration could jump from 20 % to 50% by 2025. This requires however to address several challenges.

A report shows that European roll out are an average 2 years behind schedule. In many cases this is due to difficulties to obtain permits and complete administrative processes. If National and local authorities could facilitate things even more, this would greatly help operators. At a European level several pieces of the regulatory framework are still to be adapted and to align with the new Code. At the FTTH Council Europe, we are contributing actively to these revision works. We also believe that public funds should be focused on areas where there is no business case for private initiatives, this concerns to a large extent rural, low density areas where Government Investments are important. However, these state aids must only support future proof infrastructure, and we believe only Full Fibre networks can be qualified as such.

Digital public policies should also embrace the Green Deal as broadband networks are an essential enabler of a more sustainable

society. We would like to see the level of energy consumption of broadband technologies considered as an important decision criteria.

Increasing the take up rate remains a very important challenge. It has progressed to reach now 40%, but it needs to be much higher if we want to fully transition to fibre infrastructures. To do so, end user must be convinced by the compelling experience brought by Full Fibre networks. We need much more services leveraging the gigabit symmetrical speed so people see the full benefits of fibre.

At the edge of the fibre network, performance of home connectivity is crucial. It should not be the bottle neck of the network and impact negatively customer experience.

Last point. Customer should also be able to make the difference between genuine Full Fibre connectivity and the other technologies combining fibre with copper and coax. We encourage governments to fight against misleading advertising where the brand fibre is associated with broadband services which are based on hybrid technologies.

In conclusion, Europe has made good progresses in its Journey towards Full Fibre connectivity, the momentum is there but we should stay focused, because every detail counts. Ultimately, the choices we are facing are simple. Decisions are not about the next quarterly results, not about next year, they are about the next generation. The investments of today will impact the infrastructure available for the next 30 years.

Next time my son ask me what I am doing of my days as Director General of the FTTH Council, I will not joke. I will tell him that I am working to make his world a better place.

IPv6+: Boosting the Value of IP Network Infrastructure

When you're on IPv4, you're in economy class. If you're on IPv6, you're in business class. With the new functions enabled by IPv6+, you upgrade to first class.

By Latif Ladid, Founder and President, IPv6 Forum

Due to the public health crisis that's spanned 2020, we're becoming accustomed to new application scenarios such as video conferencing, collaborative office, wireless projection, and robot-based services. New infrastructure deployments involving 5G, artificial intelligence, cloud computing, and industrial Internet are also on the rise.

These changes are posing higher requirements on IP networks.

- **Massive connections:** On November 26, 2019, the world's 4.3 billion IPv4 addresses were officially exhausted. However, the booming growth of 5G, cloud, and IoT means that the number of global IoT connections will hit a predicted 27 billion by 2025. In general, the number of communication connections will continue to grow explosively, taking us into the era of massive connections.
- **High-quality of connections:** 5G is the starting point for people to shift their focus from personal entertainment to a fully connected society. Emerging services, such as VR education, smart healthcare, smart grids, enterprise cloudification, and autonomous vehicles, require low latency, large bandwidth, high mobility, and high-quality connections.
- **Swift provisioning for connections:** With the increasing adoption of cloud, many types of businesses will migrate from local platforms to cloud. The service opening period ranges from 6 to 12 months to hourly, and so we need to provide a quick deployment method.



“

IPv6+ is IPv6 Enhanced Innovation for the 5G and cloud era. It's characterized by protocol innovations such as SRv6 and BIER6, combined with capabilities such as network analytics and intelligent tuning.

”

With a massively huge address space of 340 trillion trillion, IPv6 solves the IP address shortage forever. In addition, IPv6 extension headers functionality greatly improve the scalability and flexibility of packets. The industry's collected wisdom is already seeing IPv6 as the future. IETF IAB stated that, "IETF will stop requiring IPv4 compatibility in new or extended protocols. Future IETF protocol work will then optimize for and depend on IPv6".

IPv6 is a basic ingredient to address current evolution trends and solve the problem of insufficient IP addresses. But that's not all: emerging services require massive, high-quality, and fast connections. These new services pose higher requirements on network automation, intelligence, and user experience. To tackle those requirements, IPv6 needs to combine with other technologies to generate groundbreaking "IPv6+" based networks.

IPv6+ is IPv6 Enhanced Innovation for the 5G and cloud era. It's characterized by protocol innovations such as SRv6 and BIER6, combined with capabilities such as network analytics and intelligent tuning. These functions can meet the requirements of path planning, quick service

provisioning, SLA assurance, automatic O&M, quality visualization, and application awareness.

IPv6+ powers innovations in business models, which in turn increases revenues and efficiency. For example, in the financial services industry, if a customer uses the traditional MPLS scheme, every node needs to be configured, just like a bus that stops at every bus stop. Upgrading to IPv6+SRv6 can achieve automated service provisioning between, for example, bank branches and HQ in one-hop. Like a taxi, it focuses on the destination. No transfer is required, which reduces service provisioning time by 90%.

In the healthcare industry, IPv6+slicing technology can isolate multiple planes on a physical network to carry different types of services and provide dedicated channels for different scenarios like ambulances, CT scans, and office tasks, driving up service experience. Operators can transform from selling bandwidth to selling differentiated services, changing their business models and increasing revenues in the process. Through dedicated healthcare channels, patients, for example, can receive medical diagnosis and urgent treatment 15 minutes faster. Medical resources can be better shared to improve medical standards.

In a totally different class

When you're on IPv4, you're in economy class. If you're using NAT, then you're in the luggage hold. If you're on IPv6, you're in business class. But when you're on IPv6+, like SRv6, you've upgraded to first class.

IPv6+ has gained traction in the research of international standard organizations. ETSI has released whitepaper recently covering IPv6 Enhanced Innovation. The IPv6 Forum, Huawei, TLF, CT, KPN, POST, and others are working together to set up new ISG in ETSI. The new ISG will focus on IPv6 enhanced innovations in the context of things like use cases, reference

architecture, and deployment best practices.

IPv6+, combined with innovations in business scenarios, is deepening and developing IPv6 into a key basic technology of IP networks for the 5G and cloud era. The accelerated deployment of IPv6 also provides a broad space for IPv6+ technology, networks, and service innovation.

IPv6+ will undoubtedly boost the value of IP network infrastructure. The future of IP networks requires the efforts of the ecosystem chain and you're welcome to join us!



Corroborating the Need for Advancing ICT Infrastructure in the SAMENA Region

The world's remaining 47% population is still unconnected Migration to IPv6 and IPv6+ will prove to be absolutely essential for removing connectivity constraints and bandwidth bottlenecks.

By Bocar A. BA, CEO of SAMENA Telecommunications Council

Digital transformation enabled by mobility, cloud and broadband technologies is taking place in almost every industry, reinforcing the need for us to re-think ICT infrastructure development. SAMENA Telecommunications Council is tri-regional (South Asia/ Middle East/ North Africa) not-for-profit industry association spanning more than 25 countries. In our growing, hyper-connected world, about to experience fifth-generation communications technologies, the Telecoms Industry holds an ever more important position as the key enabler of innovation and convenience. The Industry's enabling role has become very visible in multiple dimensions of the society's progress toward digital development and digital inclusion; an imperative that has now been extensively defined by regional governments through their ICT visions.



The digital ecosystem is complex and, with the fourth industrial revolution in play, it is constantly evolving at a fast pace. Seen from a 50,000 foot layer, these are the forces that are driving digital transformation within and all around the Telecom/ICT landscape.

- 5G is occupying a central space in discussions, aspirations, concerns, and new possibilities.
- IoT ecosystem is getting developed, and COVID has played its role in it.
- Sustainable Development Goals (the SDGs) have become among the most familiar of terms (and images) as well as ICT policy catalysts all around the world.
- Internet traffic is seeing an exponential rise, contributed in part by the use of Social Media platforms.



And it all comes down to a realization that we need to future-proof our connectivity, for which we need Fiber. As the demand for the Internet of Things increases and the amount of HD content including videos and a large amount of data generated and transmitted rises, it is becoming more and more evident that the need for bandwidth and speed will increase too.

Many countries in the region now have well-defined national ICT visions and plans are being implemented to infuse ICTs across the board into each dimension of the national economy. These visions are already proving that countries that take ICT policy measures soon than later, secure for themselves and their citizens a better future. Some notable regional national visions are the UAE Vision 2021, the Saudi Vision 2030, Bahrain 2030, and Kuwait Vision 2035, among others.

Implications and Necessities of Digital Transformation

It's crucial to recognize and acknowledge the implications and necessities of digital transformation. Let's look at and agree on the ground realities and challenges.

- The world's population is close to 7.7 billion people, and the remaining 47% population is still unconnected. "Connecting the unconnected" is a challenge.

“Fiber will make Ultra-fast broadband and 5G, IoT and advanced smart technologies possible, and will be necessary for achieving the Digital Inclusion and Global Digital Connectivity imperatives.”

- COVID-19 has accelerated hyper-connectedness such as human and machine online presence, causing huge data pressures on wireline infrastructure. The economic contraction currently being seen due to COVID demands ICTs to play a greater role in the recovery process and in ensuring sustainability of the socio-economic order.
- Depletion of the pool of unallocated IPv4 addresses is on the rise. Almost forty years after the IP version 4 protocol came into practice, our systems, goals, global agenda, and ways of working all have transformed.
- Global aims for sustainable development are complex and require accelerated pace of fulfillment over the next 10 years.

Therefore, questions we need to ask ourselves, what could be the ICT-driven ways to deal with these ground realities and challenges? How to fill the gaps in ICT infrastructure?

Considerations for Digital Inclusion and Sustainable Digital Economy

As a priority, we need to accelerate investment in ICT infrastructure and advance higher-speed, reliable wireline infrastructure based on Fiber. Data integrity, reliable long-distance transmission, and higher bandwidths are the hallmarks of fiber networks. Optical fiber has played a vital role in making possible the remarkable growth in global communications that has taken place in the last 25 years. For the coming decades, Fiber will again be instrumental in delivering innovation in many sectors that now increasingly rely on ICTs and collaborate with telecom operators, supporting new technologies. Fiber will make Ultra-fast broadband and 5G, IoT and advanced smart technologies possible, and will be necessary for achieving the Digital Inclusion and Global Digital Connectivity imperatives.

We need to embark on a collaborated journey to IPv6 adoption to address hyper-connectedness related requirements, and stimulate further acceleration with IPv6 enhanced innovations (also known as IPv6+). As IPv4 exhaustion becomes more and more imminent, network operators across the globe are taking a

closer look at transitioning to IPv6. IPv6 has a capacity of 2^{128} addresses and thus will help materialize our dream of having billions of devices connected. The forecasts that point to billions of devices being connected, in fact, really points to the necessity of having IPv6 in place. IPv6 permits broader access, supports business growth, and opens the door to new services.

Given that significant positive impact on the implementation of 5G and digital transformation in the region will be driven by advanced Physical networks and next-gen IP Protocols, several considerations are to be mindful:



For the Public Sector.

Digital transformation must be understood clearly. Along with incentivizing Fiber deployment, governments should play their role in driving adoption of IPv6. Policymakers and regulators should incentivize investments and help future-proof both Physical Infrastructure and Cloud Infrastructure investments.

For the Private Sector.

Build consensus on approaches to develop ICT infrastructure in non-economical zones and to implement IPv6 as smoothly as possible. Driven with the collaboration of government entities and TRAs, fiber deployment can be accelerated, and transition towards IPv6 can be catalyzed. New funding models may be necessary to fund Fiber deployment and IPv6 transition.



For moving to the next phase and stimulate innovations, IPv6 and IPv6+, with its promise of automated and committed next-gen networking, will prove to be absolutely essential in removing connectivity and bandwidth bottlenecks, while allowing for further stimulation of digital innovation across industries and how those industries elevate the end-user experience.

BUSINESS PRACTICE

The world is entering an age of intelligent connectivity. In response to this, Huawei and carriers strive to bring intelligent connectivity with deterministic experience, ubiquitous gigabit speed, and hyper-automation, so that full connectivity is available to homes and enterprises.

By Ryan Ding, Executive Director and
President of the Carrier BG, Huawei



Intelligent Experiences Unlock New Value



Today, ultra-broadband connectivity is part of the strategies of many countries and regions, such as the EU's Gigabit Society 2025, South Korea's 10GiGA plan, and Malaysia's National Fiberisation and Connectivity Plan. According to our survey, there are over 24 million gigabit broadband users worldwide. Carriers are racing to release their gigabit broadband services. For example, in France, Japan, and Singapore, 10G home broadband packages have been released, while in Thailand and Saudi Arabia, Wi-Fi full-coverage packages are now available. The world is entering an age of intelligent connectivity.

Home+: Better experiences and more diversified services



As online connectivity becomes increasingly important in our lives, homes are developing into multi-purpose platforms. Now more and more people are working, studying, and doing business from home. Many international conferences and decisions are currently being held and made online.

To facilitate such online events, networks must be stable and secure, with a guaranteed level of user experience. In the first half of 2020, 800 million students worldwide had studied online, with universities running online classrooms. In the UK, professors from Cambridge gave online lectures. In South Africa, Rhodes University streamed its graduation ceremony online. Connectivity is unlocking new possibilities in education and many other sectors.

Live streaming platforms are giving consumers a true-to-life shopping experience. During the pandemic, many small business owners in Africa have sold products through live streaming. Their businesses have not been affected and they are even able to sell their products to more regions. All of these are made possible thanks to stable and smooth live streaming.

From 128 Kbit/s bandwidth and gigabit broadband, to intelligent connectivity, connecting homes is a never-ending journey.

Providing an intelligent experience for diverse home services is where our value lies. We have come up with a formula:



Home digital value = Broadband Speed + Home Network + Diversified Services.

- First, carriers need to deploy **FTTH and ensure fast broadband connectivity**. This way, a single investment can lead to returns for 30 years. With fiber infrastructure in place, users will enjoy faster speeds, from 100 Mbit/s and 1,000 Mbit/s all the way up to 10 Gbit/s in the future.
- Second, carriers need to build **networks that can cover an entire household**. They should not simply connect homes, but every user in every home. Minor home network upgrades will result in major user experience improvements.
- Third, carriers need to provide **guaranteed levels of user experience for diverse services**. This will grow the entire smart home ecosystem and further unlock digital value.

Next I will elaborate on each of these three aspects.

By the end of 2019, 1 billion households were still unconnected and 500 million households only had access to low-speed Internet. Being able to quickly provide broadband access at home is a major obstacle we must overcome.

In the Philippines, Globe used Huawei's AirPON solution to build FTTH. They used AI-powered building scanning technology to accurately identify where high-value users are located. In addition, lighter, easier-to-deploy products increased construction speed by 90%. The TTM was cut from 180 days to 7 days. In Peru, Claro and Huawei conducted joint innovation and came up with a digital ODN solution. This made plug-and-play of optical fibers a reality, eliminating the need for fiber splicing. This solution has made

fiber deployment much faster.

Second, Home networks are key for carriers to improve user experience. Many carriers have launched related services.

In the UK, BT has launched its Complete Wi-Fi value-added service. Users can install the AP themselves and test the Wi-Fi. If necessary, BT will provide door-to-door services. If committed data rates are not realized, BT will return 100 pounds to their users. In Anhui Province, China Telecom offered services like custom networking, self-service management, monthly quality reports, auto network optimization, and online expert services, through its network O&M platform, to end users. By upgrading its basic services to professional services, the carrier has seen a rapid growth in sales.

“

Unlocking the digital value of homes depends on intelligent connectivity and guaranteed experience levels.

As homes become multi-purpose platforms, we will work with carriers to explore and incubate new services and offer end users an intelligent experience at home.”

”

Of course, home network development does not stop with Wi-Fi coverage. We are working with carriers to promote the Fiber-to-the-Room (FTTR) solution. Once fiber is available at every room, we will see an explosion in intelligent services.

To further improve home experiences, the ability to intelligently identify priority services is increasingly important. We can provide differentiated services with guaranteed experience levels across multiple scenarios.

For example, VIPKid needed to guarantee a high-quality online learning experience when the number of users quickly rose during the pandemic. So they worked with China Unicom and used

Huawei's eAI technology to increase the network speeds specifically for VIPKid services. In Thailand, 3BB used Huawei's eAI technology to identify popular games and provide gaming broadband packages to end users, attracting a large number of gamers. The carrier has since seen an increase of 10,000 new users every month.

Unlocking the digital value of homes depends on intelligent connectivity and guaranteed experience levels. As homes become multi-purpose platforms, we will work with carriers to explore and incubate new services and offer end users an intelligent experience at home. This will help carriers unlock new value while monetizing their differentiated services.



Enterprise+: Maximizing digital value with better experiences

For enterprises, digitization is about connecting the flows of capital, human resources, assets, and information.

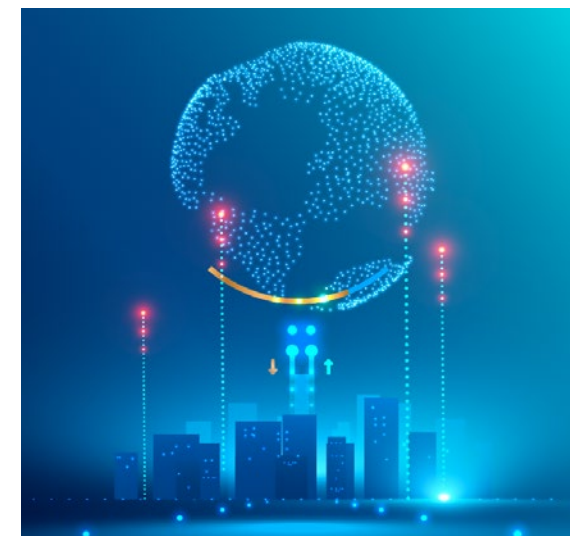
Connectivity is the lifeblood of digital enterprises. Mr. Zhang Qingxian, a professor at the First Affiliated Hospital of Zhengzhou University, China, has seen the value of the remote consultation system. He said that a doctor can provide remote consultations for 81 cases each day. The earlier that cloud and private lines become available, the more patients that can be treated.

At the Hong Kong Stock Exchange, the average daily turnover has exceeded 100 billion Hong Kong dollars, with their network handling 300 transactions every millisecond. When a private line with guaranteed ultra-low latency is in place, the stock exchange can quickly handle more transactions, giving it a head start in the volatile

financial market.

In the automotive industry, a key approach to ensuring driving safety is to use the cloud to simulate collisions in all scenarios. At FAW Group, the model used for the collision simulation of a single car generates hundreds of gigabytes, if not terabytes, of data. A high-bandwidth private line is needed to instantly upload the model data to the cloud. Bandwidth demand during off-peak hours is about one hundredth of that during peak hours. Therefore, bandwidth flexibility is crucial.

Many issues are affecting connection experiences at enterprises. Provisioning of services takes a long time. Pricing options are limited. SLAs are invisible. We have come up with a formula that can be used to address these issues and help enterprises create greater digital value.



Enterprise digital value = Coverage x Architecture x Fusion, which is outlined below.

- **First is coverage.** This is about achieving seamless coverage through comprehensive service area planning and intelligent network construction.
- **Second is architecture.** This is about adopting a flexible, intelligent architecture to deliver deterministic SLAs.
- **Third is fusion.** This is about integrating the cloud and networks to achieve one-hop access to the cloud and deliver user-defined experiences.

“ To ensure agile access for enterprise users, carriers must plan their infrastructure networks and make resources rapidly available. ”

The value of connections is maximized when we multiply C, A, and F together. But if we miss any one of these dimensions, the overall value of the network suffers.

First, let's look at the coverage dimension. To ensure agile access for enterprise users, carriers must plan their infrastructure networks and make resources rapidly available.

China Telecom Shanghai has realized wide coverage with its all-optical city plan. The carrier

deploys one private line for each SME, providing five types of services. This further reduces SMEs' ICT deployment and maintenance costs. The carrier can then deliver more compelling services and generate higher revenue.

The second dimension is architecture. Carriers need an elastic and intelligent architecture that is congestion-free, always-on, scalable, and simplified. This type of architecture is the precondition for providing deterministic experiences.



A Western European carrier built a country-wide private line specifically for the local media industry and employed a transparent transmission solution that dynamically adjusts bandwidth. China Telecom Shanghai rapidly upgraded its services by optimizing optical cable routes, and reduced the network latency at the local stock exchange from 4.6 milliseconds to 0.63 milliseconds. BRI is one of the largest banks in Indonesia. It requires highly reliable interconnection between data centers in order to guarantee its business development and security. The Indonesian carrier Indosat has rolled out a private line for the bank, improving network reliability from 99.9% to 99.999%. This improvement translates to a 50% increase in service prices. China Telecom Ningxia enables network sharing through slicing, and provides dedicated services for different tenants. It has deployed private lines in multiple industries, including 3,000 medical institutions and 2,000 educational institutions.

Carriers must optimize their network architecture to make it more agile and adaptive to the needs of enterprise customers. This will leave carriers in a better position to monetize their networks.

As AI technologies mature, enterprises' demand for computing power is growing rapidly. How can we increase network bandwidth to make the most of computing power and accelerate digitization across industries? We believe network capabilities should gradually become the foundation. Carriers will provide cloud and network integration, as well as one hop to the cloud with guaranteed SLAs and differentiated cloud and network services.

Business developments and tech advancements cannot happen independently of one another. To constantly grow, an industry needs both the technologies and the business applications that monetize the technologies.

Huawei is ready to work with carriers. Together, we will innovate on intelligent connectivity that will offer hyper-automation, ubiquitous gigabit, and deterministic experiences. We will apply the two monetization formulas to generate greater value from homes and enterprises and deliver intelligent experiences based on ubiquitous connectivity. We will enable digital transformation based on the two drivers, and tap into industries worth trillions of dollars.

The industry continuously changes, and people always want something new.

We believe that demand can always be created and experiences will never stop evolving. Intelligence shapes experience. Connectivity creates the future.

Sharing Cloud-Based Networks for High-Quality Digital Transformation

We are now stepping into a new digital world where next-generation information technologies are becoming the new standard. This digital society is driven by cloud, network, and data services that are open, interconnected, and shared, facilitating cost-effective and high-quality infrastructure construction.

By Guanglu Shao, Board Member, China Telecommunications Corporation

The pandemic will have long-lasting effects on China's economy, particularly on the retail, transportation, and commercial real estate sectors. We have seen explosive growth in online shopping, education, work, and video conferencing. It's evident that industries spearheading digitalization and cloudification are growing, whereas traditional industries have been left in the shadows.

Currently, 5G mobile phones and home bandwidth can reach peak speeds of 1 Gbps, while cloud connections can reach 100 Gbps. The Internet of Everything has already achieved low latency and high bandwidth. These capabilities are based on a series of network infrastructures including 4G/5G networks, AI, big data, cloud computing, IoT, and data transmission.

The digital economy has shown similar signs of growth in other countries – a trend that will see traditional infrastructures such as roads and railways give way to 5G, IoT, AI, big data, and cloud computing. Society needs digital transformation more than ever.



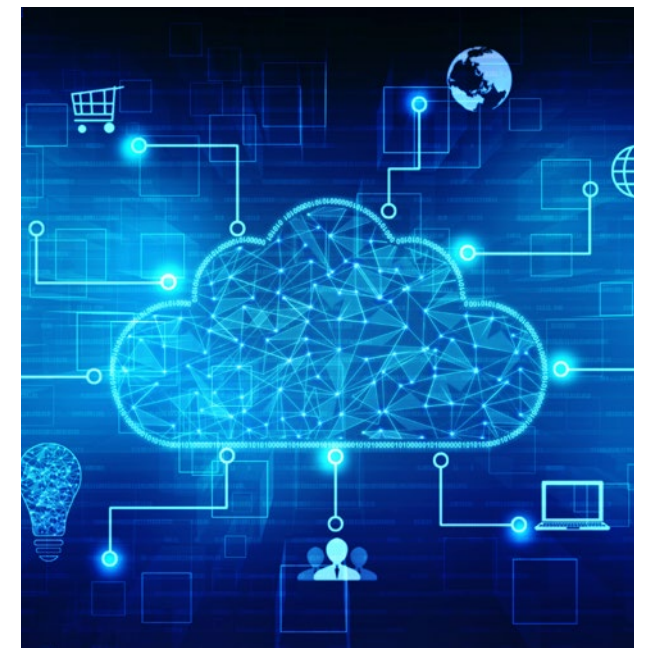
A number of industries have recognized that cloudification will be implemented sooner or later, and sooner is better than later.



Regardless of the differences between industries, enterprises can only achieve transformation with the support of networking, cloudification, digitalization, intelligence, and e-commerce-style service subscriptions. Telecom operators have inherent advantages in networking and digitalization. Therefore, they should focus on cloudification, intelligence, and e-commerce-style service subscription. The following looks at how China Telecom is exploring cloudification and intelligence.

Cloudification: the sooner, the better

This year, China Telecom implemented the cloud transformation project, covering IT, CT, business, and office systems. According to China Telecom's plan, new IT systems must be completely cloudified, and existing IT systems must be cloudified within three years. During this process, China Telecom will set up four platforms to enable the migration of the IT systems to the eCloud. The self-service application and minute-level provisioning capabilities of PaaS/IaaS integrated services simplifies the usage of PaaS components on the cloud. The DevOps environment, multi-dimensional monitoring, and intelligent O&M capabilities are provided to implement unified capability exposure, management, and operation of network-wide DICT capabilities, enabling the cloudification of IT systems for China Telecom's 31 provincial branches. In the pilot project, the billing time of telecom services is shortened from two days to eight hours and the IT capacity expansion period from months to minutes. In addition, the BSS and OSS share hardware, thereby reducing investment by 30%.



A number of industries have recognized that cloudification will be implemented sooner or later, and sooner is better than later.

“ China Telecom proposes that network operators and cloud service providers enhance openness and accelerate digital transformation of industries by working together and sharing resources to achieve cost-effective and high-quality construction and operation. ”

Multiple networks and clouds and the CN2 network

Cloud-network synergy is the convergence of multiple clouds and networks, not only those of operators. Therefore, China Telecom proposes that network operators and cloud service providers enhance openness and accelerate digital transformation of industries by working together and sharing resources to achieve cost-effective and high-quality construction and operation.

China Telecom has upgraded and reconstructed its CN2 network based on the idea of sharing multiple clouds and networks, to implement the following features: 1. Multi-network access is

provided for users through either 5G, private line, or SD-WAN. 2. Multi-cloud access services are provided, allowing users to access both eCloud and third-party clouds. China Telecom will deploy and interconnect third-party public clouds in advance. 3. 100 Gbps interconnection is supported between multiple clouds, and 400GE is supported between availability zones. 4. APIs are open and can be mutually invoked between clouds and networks. 5. In terms of technology, SRv6 and EVPN technologies are used E2E to implement one-hop cloud access.

Strengthening hotspot areas with cloud, network, and edge

Currently, China Telecom has more than 600 IDC equipment rooms, and has strengthened its development in areas such as Beijing, Tianjin, Hebei, Yangtze River Delta, the Greater Bay Area, Sichuan, Shaanxi, and Chongqing, forming cloud-network-edge synergy. China Telecom believes that operators need to transform and provide public cloud, industry cloud, and hybrid cloud services in addition to conventional services. China Telecom is currently building three capabilities for its eCloud.

First, the primary business of China Telecom will be cloud services instead of traditional wired and wireless network services. Second, China Telecom will open up its cloud and network capabilities, strengthen cooperation with software suppliers, hardware suppliers, integrators, and third-party cloud service providers, and provide one-stop integration services for customers. Third, we will attract more cloud applications and build a cloud ecosystem for eCloud.



Cloud-network-app aggregation platform

Most users now migrate services to the cloud, and in response to this China Telecom and its partners have developed a multi-cloud aggregation platform together to help users purchase clouds, networks, applications in one place and be billed only once. This platform is interconnected with mainstream public clouds. APIs of cloud service providers and network service providers can be invoked and integrated to provide services for customers. Moreover, API-level interconnection with the public cloud is implemented. Open, interconnected, and shared cloud, network, and data services are beneficial to constructing new, cost-effective, and superior infrastructure to realize the digital transformation of society. A new round of technological evolution and industrial revolution is gathering momentum. To keep up with this trend, the key is to develop the digital economy and accelerate the commercial application of next-generation information technology. China's economy has shifted from high-speed growth to high-quality development.

Digital transformation will improve efficiency and provide an effective way to achieve high-quality economic development. Cloud, network, and data services that are open, interconnected, and shared are critical to promoting the construction of this new high-quality infrastructure.

In view of this, China Telecom has proposed four initiatives. First, the number of national Internet backbone direct connection points should be increased from 13 to 31 provincial capitals. This will reduce new infrastructure costs and optimize user experience, turning each provincial capital into a smart connection point. Second, IDCs can be connected from any operator's network to reduce traffic diversion. Third, the 5G edge cloud and UPF of the three major operators should be open to each other. Fourth, the public cloud can be open and interconnected. The common goal is to make the new infrastructure affordable and easy to use.

An Intelligent Upgrade: From Connections to Connectivity

We are shifting from individual connections to the concept of universal connectivity, which will power a digital, connected, and intelligent society where all things are connected.

By **TongQing Gao**, Vice General Manager,
China Mobile Communications Group



In the past, we talked about connecting people to people, with the evolution of mobile phones allowing us to use voice and data services anytime, anywhere. But today, we're gradually seeing a transition to connecting people to things, things to things, and eventually universal connectivity.

Powered by 5G, cloud, and AI, we're entering a fully connected, intelligent world.

Three drivers of intelligent universal connectivity

There are three key factors stimulating the transition into connected everything:

There are three key factors stimulating the transition into connected everything. Firstly, a digitalized economy and society require intelligent universal connectivity. The second driver is new infrastructure. Third, the digital transformation of various industries is gaining momentum.



Firstly, a digitalized economy and society require intelligent universal connectivity where the digital economy is the main force after agriculture and industry. According to the China Academy of Information and Communications Technology (CAICT), China's digital economy accounted for 35 percent of GDP in 2018, up from 23 percent in 2013 and which is expected to exceed 50 percent in 2030.



The second driver is new infrastructure. China defines 5G, AI, and the industrial Internet as "new infrastructure", highlighting the role of these technologies in facilitating an intelligent society. Led by 5G, new infrastructure will be based on cloud and use AI for universal connectivity across all aspects of our lives.



Third, the digital transformation of various industries is gaining momentum. And impacted by pandemic, five typical scenarios have developed - infrastructure, social governance, production, work, and life – framed by three requirements: online, intelligent, and cloud-based.

Connections and intelligence accelerate intelligent universal connectivity

Our goal is to achieve universal connectivity enabled by intelligent technology, which will benefit both carriers and society.

5G alongside optical broadband for optimum connectivity and integrating 5G with AICDE to construct a smart system.

Having built the largest 5G premium network and covering all of China, China Mobile is applying

China Mobile is also working on 5G standards and technologies with the industry ecosystem.

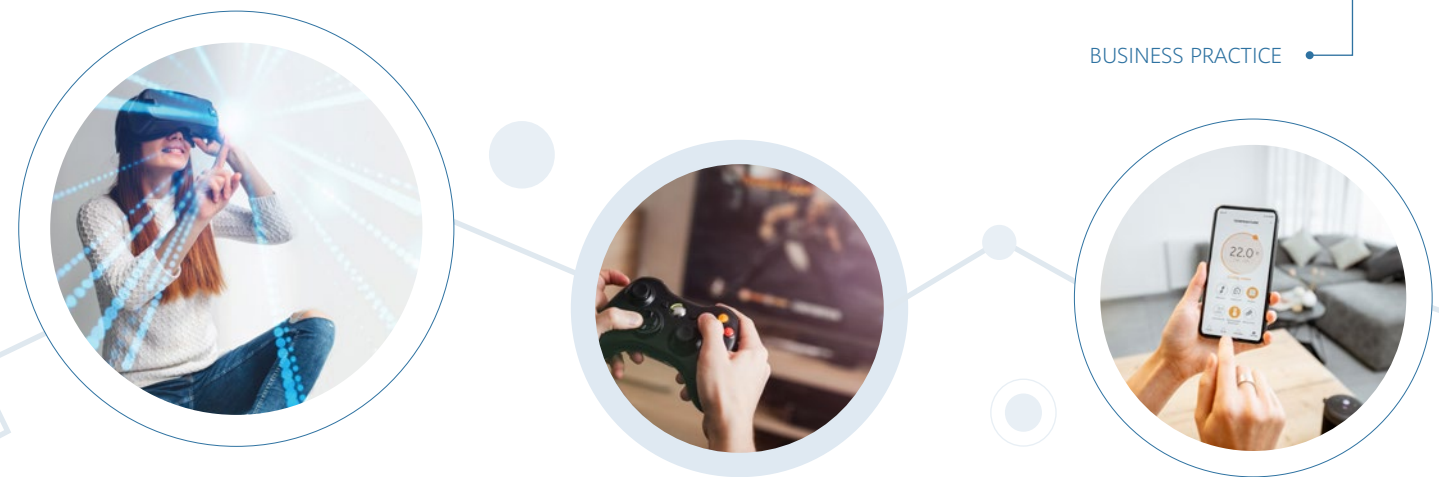
The R15 standard has incorporated basic 5G capabilities, and R16 and R17 will go deeper. The goal of R16 is to build more stable, comprehensive, and diverse 5G networks with optimized operations, while reducing costs and improving efficiency. In this process, China Mobile has played a leading role, implementing numerous projects and proposals. As R17 comes into play, it will define 5G services specific to certain industries, and 5G capabilities will integrate with OT, IT, and AI for cross-domain collaboration.

In terms of optical broadband, China Mobile focuses on upgrading infrastructure networks and service quality. To better serve high-value customers, China Mobile has built a private network for governments and businesses, offering high reliability, security, efficiency, and low latency. The network covers more than 95 cities in China and seven cities abroad. It draws on 200G technology to provide ultra-high bandwidth and introduces SDN to implement flexible scheduling and fast access to cloud.

The evolution of access networks is also bringing with it new gigabit speeds. As such, China Mobile is pivoting towards "full-gigabit", which will include gigabit in 5G, home broadband, Wi-Fi, applications, and services. This will ensure the ultimate user experience for smart lifestyles.

When it comes to intelligence, China Mobile leverages its advantages by incorporating it into the business, data, and technical platforms. This yields an Ability as a Service (AaaS) structure, where technologies, data, and services complement each other. And together, they produce an intelligent system that enables connectivity.

AI is at the heart of this system. China Mobile dedicated seven years to developing its Jiutian AI Platform. Jiutian AI transitions mobile cloud to intelligent cloud, providing more than 100 applications for 900+ million users. At the same time, it features an open architecture, making it a necessary social tool.



Interconnectivity builds on technological progress and cross-industry cooperation. China Mobile is open to innovative collaboration to achieve cutting-edge results in today's fully connected, intelligent world.

Intelligent universal connectivity enables innovation

China Mobile defines four growth engines — consumer, home, business, and new.

In the **consumer** market, China Mobile is focusing on five key services to deliver an immersive entertainment experience. These are 5G + real 4K live broadcast and 5G + VR for video; video ringtones; MiguPlay, a cloud gaming platform with interactive ultra-HD games; 5G + AR, for example users can make video duets with friends or even celebrities; and lastly Caiyun cloud drive that supports rich media forms.

For its **business** market, China Mobile builds 5G SA networks for industry verticals and is dedicated to providing 5G private network services. Customers have the option to customize networking depending on their WAN, LAN, and local service requirements. Technological capabilities address networking, deployment, and support, offering E2E slicing, edge computing, super uplink, QoS enhancement,

frequency collaboration, and capability exposure. Additionally, China Mobile pools a group of experts for one-stop operations and delivery, including pre-sales and after-sales services.

The **home** market is also growing rapidly thanks to full gigabit and home cloud. Intelligent connectivity enables the management and control of gigabit networks and devices. At the same time, intelligent sharing allows families to share through multi-screen interaction and dedicated applications. Intelligent control solutions connect specific devices and services across all rooms. These services address the individual needs of each home and customer, promoting the growth of smart home services.

Ultimately, interconnectivity builds on technological progress and cross-industry cooperation. China Mobile is open to innovative collaboration to achieve cutting-edge results in today's fully connected, intelligent world.

HKT B2B Network Service Innovations

Most B2B customers are undergoing digital transformation to improve efficiency and become more agile at innovating new services. Our reliable connectivity and managed services create a tailor-made platform for supporting B2B customer business transformation.

By Peter Lam, Managing Director of Engineering, HKT

Most of our B2B customers are currently undergoing digital transformation. The demand for high-quality ICT services is growing, creating an entirely new B2B market that's driving telecom operators towards a new phase of development. In view of this, HKT has implemented continuous network service innovations to maintain market leadership.

The B2B market normally includes government, MNC, SMEs, and the carrier business, which is characterized by high growth potential and high profit margins. It remains the most competitive market segment and a new growth engine for many telecom operators.



HKT's ultra-broadband strategy is to move from access and connectivity to content, application, and transactions.



HKT's B2B market ultra-broadband strategy

HKT's ultra-broadband strategy is to move from access and connectivity to content, application, and transactions.

On the access network side, we aggressively rolled out territory-wide fiber coverage, including FTTO to support mission critical applications in the B2B market, to capture business growth opportunities with high-speed broadband.

On the core network side, we've leveraged the tremendous traffic usage stimulated by our extensive fiber coverage in the access network

to build a high-capacity core network in a cost-effective way. We provide a full range of cloud-based applications to meet emerging business needs, with a robust SLA that's one of our key differentiations from our competitors.

For our flag-ship Carrier Ethernet data service, HKT is able to commit 100 percent to our SLA thanks to our sophisticated design for network resilience. New applications in cloud is a market trend that's fueling future growth, and we're aggressively developing new applications to meet emerging B2B market needs.

Extensive fiber coverage and network nodes enable ubiquitous ultra-broadband services

Leveraging our extensive network nodes and territory-wide fiber coverage, HKT can provide ubiquitous ultra-high-speed connectivity with resilience protection. For some remote areas, it's more economical to serve customers with mobile broadband solutions.

HKT also boasts international network coverage. As a top ten global traffic carrier, we have 125

points of presence across 76 cities utilizing over 60 submarine cable systems.

We're able to provide end-to-end high bandwidth low-latency services to local and overseas customers. The high bandwidth low-latency services are particularly welcomed by the BFSI customer sectors.

“Typical B2B service requirements cover voice, Internet, data, payments, IoT, video surveillance, Wi-Fi, and securities, and B2B customers’ requirements are continually increasing.”

Challenges in the Hong Kong B2B market

Although the penetration of broadband services for individuals and households has hit new levels, we’re well aware of the threat posed to traditional broadband services. We predict that the B2B market will be a new growth engine for many telecom operators. Today, typical B2B service requirements cover voice, Internet, data, payments, IoT, video surveillance, Wi-Fi, and securities, and B2B customers’ requirements are continually increasing. For ease of operation and cost efficiency, B2B customers normally require simple connection services to support multiple

applications. In addition, they require instant bandwidth upgrades, quick service provisioning, a 100-percent SLA commitment, real-time proactive service performance monitoring, and higher service quality at a lower price point.

Therefore, we need a completely new network design to improve our cost base. And we need our service provisioning and maintenance process review to become more agile, so we can maintain our competitiveness in the market.

A cost effective solution to lower CAPEX

Our analysis shows that typical CAPEX investment profile for network infrastructure is that core network equipment typically accounts for 7 percent of total CAPEX and that edge network equipment and fiber infrastructure form the bulk of investment in network infrastructure.

Therefore, we’ve adopted a flexible fiber solution for both B2B and B2C customers to lower CAPEX on fiber infrastructure and access networks. We use direct fiber to serve mission-critical customers such as the police, hospitals, and BFSI customers. CAPEX for the B2B market can be incremental and we can greatly reduce it by leveraging our large B2C high-speed broadband customer base and

Huawei’s GPON technology.

In April 2020, HKT became the first mobile operator to launch 5G in Hong Kong. Mobile access solutions play an important role in serving the B2B market. For example, it’s more cost-effective to deploy a mobile access solution for services that don’t use much data.

Mobile access can also be used as interim solution for voice, data, broadband, and video surveillance when a customer’s premises are not yet covered by fiber. Moreover, mobile access is the ideal backup for a fiber solution.

CE2.0: A Multiple Services Multiple Access Platform

Our flexible Carrier Ethernet 2.0 network supports multiple services through multiple access platforms to achieve high cost efficiency. It can support all of our B2B services such as data line, Internet, Wi-Fi, Enterprise Centrex, and 5G mobile backhaul services, whether they’re served by direct fiber, PON or DSL. This greatly expands our service coverage and flexibility to better serve our existing B2B customers. More importantly, it’s a secret weapon through which we can attack our competitors’ customer base.

B2B customers are always looking for dual carrier service diversity. And for good reason – they have a tendency to put some of their connectivity services in the hands of our competitors. In view

of this, we’ve built a twin CE 2.0 network, but with a different equipment vendor at different site locations, to simulate a virtual competitor’s network environment. This provides a three-level resilience solution. With the virtual carrier network, we can commit a 100-percent SLA for our CE 2.0 service. The virtual carrier network not only helps to protect our customer base, but also attracts customers away from our competitors.

The virtual dual carrier configuration has helped us win many projects in recent years, especially mission critical applications in the banking and financial sectors, and emergency services from the police, fire department, and health authority.

Serving B2B customers with emerging technologies

Most B2B customers are undergoing digital transformation to improve efficiency and become more agile at innovating new services. Our reliable connectivity and managed services create a tailor-made platform for supporting B2B customer business transformation.

We provide customized solutions for different B2B sectors such as finance, insurance, retail,

manufacturing, construction, and education by integrating connectivity, CPE, cloud, and security solutions. Emerging technologies are increasingly driving the application of innovative solutions that converge AI, IoT, and cybersecurity. HKT is the major service provider of IoT solutions for Smart Workspace, Smart Campus and Smart Shopping Malls, and we widely apply AI in our B2B applications.



AI-powered video analytics

The smart surveillance camera system is one of HKT's AI-powered video analytics solutions that's helping the government to monitor illegal waste disposal by construction companies. To avoid paying waste disposal charges, some companies dispose of their waste in remote areas without permission from the government. We installed the smart surveillance camera system to provide real-time monitoring in such areas. The images captured by 4-megapixel cameras are processed by a sophisticated video analytics system. The government is instantly notified of suspected incidents, creating an effective and cost-efficient solution to an ongoing problem.

On the flip side, the system is also used as part of smart construction sites, with a whole suite of applications available to improve worker safety and work efficiency. These include location tracking, asset tracking, mobile attendance, danger zone alerts, and fleet management. The video analytics system also ensures that site workers wear necessary safety protection equipment such as helmets, reporting any violations instantly.



C-V2X application at Hong Kong Airport

HKT has helped Hong Kong International Airport to develop an autonomous driving system for their baggage carts. In the past, a driver needed to drive to and from Sky Pier to the Passenger Terminal through a single lane bi-direction private road inside the airport. The driver turnover rate was very high because of long hours and the tedious nature of the work. Moreover, the baggage carts move at a maximum speed of 30 km per hour, occupying the road for sufficient time to block fire engines

from passing – a problem that autonomous driving can solve. Our C-V2X RSU and camera solution is installed at both ends of the road and at the fire station entrance. If a fire engine is in transit, the RSU sends information to the OBU in the baggage cart, which then stops to let the fire engine pass.

As emerging technologies are applied, we will continue to provide groundbreaking services and strong SLAs for our B2B customers.

Future Role of the Telco in a Transformed World

The complexity and breadth of digital transformation means that effective transformation of the telco is going to take many years. The cycle of this transformational change is out of sync with the speed of change in the industry in terms of technology and business model.

By Martin Creaner, Author & Former President & CEO, TM Forum











The 10 digital transformation journeys of the Telco

There is an ancient parable about a group of blind men examining an elephant, and trying to work out what sort of creature it really is. Each touches the elephant in a different place, the trunk, the tusk, the leg, the tail, and so on. Each comes to a radically different conclusion about what sort of animal they're dealing with. Some believe it's a snake, some think it's a bull, some a wall, some a rope. While this parable has its root in texts over 2000 years old, it continues to express a universal truth. When we don't manage to take in the full picture we can end up drawing wildly diverse conclusions.

Digital transformation runs into the same problem. We all become obsessed with the pieces we're interested in, and accordingly, we see transformation as primarily a technology challenge; or a new digital service opportunity; or a cultural change; or a customer engagement issue. Transformation is all of the above, and more.

In my recent book *Transforming the Telco* I talk about telco digital transformation in terms of 10 distinct journeys that embrace every aspect of the telco. Each journey represents a distinct transformation challenge that the Telco must address to fully deal with digital transformation.



-  *Journey 1: From discrete network elements to an autonomously managed, virtualized communications and cloud infrastructure.*
-  *Journey 2: From reactive product-specific security to a uniformly orchestrated security-centric organization.*
-  *Journey 3: From limited data exploitation to a uniformly orchestrated data-centric enterprise.*
-  *Journey 4: From closed management systems to an open API driven platform-centric architecture.*
-  *Journey 5: From a limited portfolio of traditional services to a diverse portfolio of digital services.*
-  *Journey 6: From managing a limited set of suppliers to thriving in a vibrant ecosystem of partners.*
-  *Journey 7: From operating a limited set of Business Models to utilizing multiple Business Models in core and adjacent markets.*
-  *Journey 8: From a traditional Telco organization and culture, to a digitally native organization and culture.*
-  *Journey 9: From focusing on traditional channels to adopting multiple channels to market.*
-  *Journey 10: From one dimensional management of customer relationships to 360o omni-channel management of the customer experience.*

The complexity and breadth of digital transformation means that effective transformation of the telco is going to take many years. Furthermore, the cycle of this transformational change is out of sync with the speed of change in the industry in terms of technology and business model. As a result, many telcos have embarked on comprehensive digital transformation programs only to find 12 months into the program that there has been a game-changing shift in technology or competition that forces them to re-evaluate their entire transformation plan.

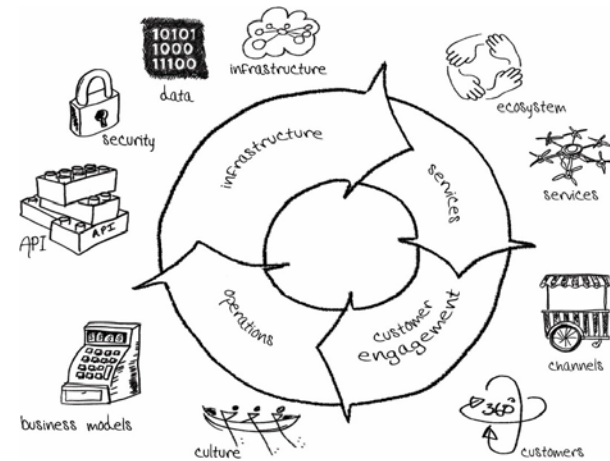


Figure 1: the 10 transformation journeys of the Telco

To be fair, in each one of the 10 transformation journeys, it's possible to find a range of interesting and valuable projects that represent real transformation progress. While telcos understand the potential scope of each of the 10 transformation journeys, there's a consistency on which bits they're comfortable addressing and which pieces they try to steer clear of. As with any enterprise, they're looking for the high impact initiatives for the least cost/risk.

Over the past 18 months, we've seen strong transformation progress on some of the journeys such as virtualization and cloudification of infrastructure (core, RAN and Edge), streamlining of the customer journey and the end-to-end customer experience, and in the trialling of a whole range of new B2C and B2B digital services. Unfortunately, we've seen much less progress in the whole area of cultural change, the shift towards being cloud native and the evolution of the telco business model to better compete with the new generation of digital service providers.

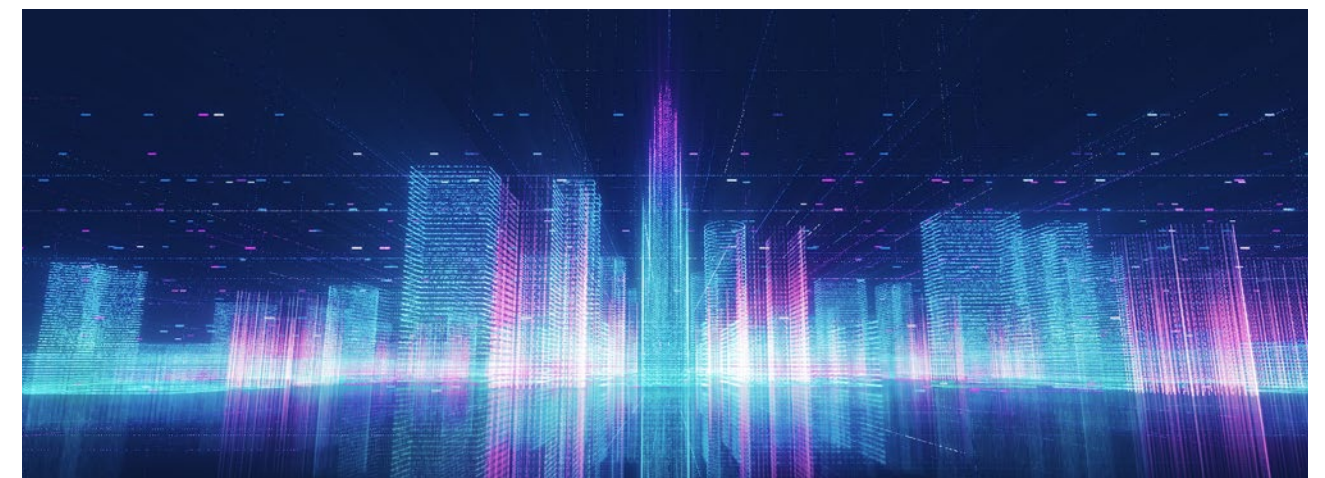
Making the 5G business case work

Competing at the level of digital services is not simply a nice to have capability for the digitally transformed telco. In a recent piece of work I was involved in with Keystone Consulting, we looked at the business case for 5G in 2025 – assessing the new “connectivity-based revenue” potential that 5G offers against the total cost of rolling out and operating 5G. The first simple *but devastating* takeaway from this analysis is that the cost of rollout of 5G in 2025 will be higher than the new “connectivity-based revenue” that will be generated from consumers and enterprises by 5G.

This means that if the telco rolls out 5G and behaves in the same way as it behaved with 2G, 3G and 4G it will not make a return on that investment. And the gap between “new connectivity-based revenue” from 5G and the cost of rolling out and operating a 5G network will

be substantial – to the order of approximately US\$160 billion per annum (somewhere between 6 to 10 percent of the value of the industry).

There are of course alternative projections on the size of the 5G industry by 2025 that vary in scale from the above numbers, but many of them agree with the fundamental point that new connectivity-based revenue growth from 5G will be less than the cost of deploying and maintaining that 5G network. Furthermore, the experience of most telcos in rolling out 5G during 2019 and early 2020 reinforces this argument. There are very few telcos that have managed thus far to price 5G at any significant premium to 4G. As a result, the long-term success of 5G will depend on whether the telco can use it as a mechanism to open up new “non-connectivity” revenue sources.



Finding the new revenue

There are no shortage of ideas for where this new “non-connectivity” revenue will come from. Telcos are exploring everything including Industrial IoT, digital health, home entertainment & gaming, smart retail, smart events, smart homes, connected cars and beyond to find the sweet spot for generating new 5G digital service revenue to close that predicted 5G revenue gap. Each of these opportunities shows promise assuming that telcos can focus in on the right use case, orchestrate the right ecosystem of players to bring a complete solution to the customer, and execute at the speed the market demands.

One of the key differentiators that the telco may be able to bring to bear in securing an opportunity in these new services will come through their deployment of edge cloud capabilities, either directly on the premises of the target industry, or at the edge of the network, accessible by all. Edge promises to be a critical capability for a wide range of emerging 5G 2C and 2B digital services and whoever controls the edge will be able to position themselves at the heart of new service revenue opportunities.

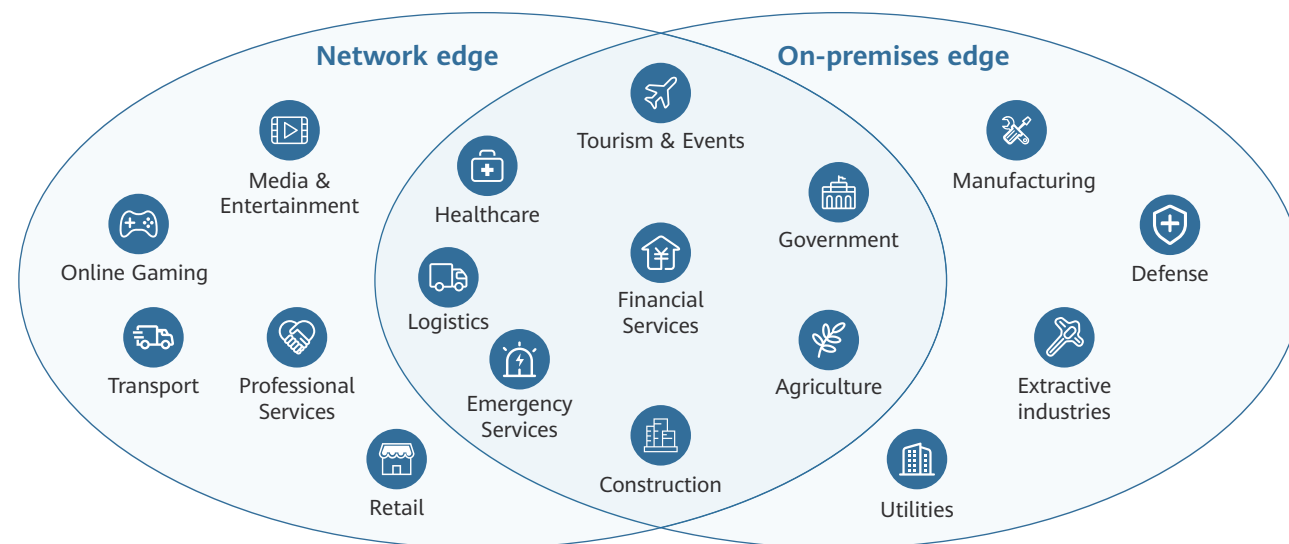


Figure 2: Operators interest in different edge use cases

A good example is the opportunity surrounding home entertainment & gaming. The popularity of online gaming is high and set to continue to increase demand for all types of advanced networking infrastructure from fiber to the home to 5G mobile private networks.

There are a growing number of partnerships being put in place between telcos and online gaming providers such as Google Stadia and Hatch gaming, and the services are proving popular. This

is good news for the telco, but it's at the touch point between the network and the cloud that that things really get interesting. The hyperscalers are seeing increasing demand for more responsive cloud services to meet the needs of this market, and this requires critical parts of the cloud service to be hosted near the consumer - at the edge. Telcos are currently ramping up their investments and partnerships to ensure that they have an important role to play in the future of the edge.

“The telco also has the option of investing in the development of their cloud and AI expertise to retain in a position of power in a world of virtualized networks and cloud edge services.”

The importance of platforms and their business models

Whichever services telcos eventually hit on to close the 5G revenue gap, it's widely accepted that platforms will play a hugely important role in how these services are delivered. Multi-role platforms are becoming the predominant business model in the digital era. They enable the platform owner to grow revenue and market capitalization quicker and at lower cost than traditional business models.

The capabilities of a generic telco platform will be hugely important in enabling the telco to establish a strong position in either B2C or B2B new digital services. These capabilities will include the traditional strengths of the telco infrastructure offerings, combined with the more advanced

capabilities that next-generation autonomous networks are just now beginning to offer such as network slicing, customized on demand, and self-serve networks. On top of these capabilities will be the BSS and operations systems that will be incorporated in the platform to offer a more complete solution to the customer.

Time and again, vertical industries have expressed their preference for buying “solutions” from telcos rather than simply buying “connectivity”, so of critical importance to the future success of the telco will be how they develop this platform and then build the necessary ecosystem to bring as complete a solution as possible to the end customer.

The future structure of the telco

The decisions facing the telco regarding where to position themselves on the digital landscape are huge. Taken as a whole, the traditional telco industry would be seen to have moderate expertise in the area of cloud and AI and low expertise in the area of platforms and ecosystem development. If they do nothing, their cloud and AI expertise will atrophy and they are likely to end up as a **hyperscale dependent telco** in an

unenviable low-margin position, reliant on their hyperscaler partners for much of their network and platform infrastructure. This industry position can be made to work for telcos that are willing to compete primarily on price for a limited set of undifferentiated services.

The telco also has the option of investing in the development of their cloud and AI expertise

to retain in a position of power in a world of virtualized networks and cloud edge services. I call this the **transitional telco**. In the short term it will prove to be an important position in the industry, but may not be tenable in the long term as the speed of innovation of the hyperscalers may make it difficult for these telcos to compete on price with telcos that are simply taking whatever network and edge capability the hyperscalers are offering.

They could instead decide to focus their investment on developing their platforms and ecosystems and become a highly competitive **services players**. This could prove to be a good position for the telco to adopt, particularly if they're able to leverage their already impressive existing customer base and relationships, and

upsell into other services. However, this position has relatively low barriers to entry and so constant innovation by the telco in terms of services and business models will be essential to thrive in this position.

Ultimately, the telco could choose to go big and invest in both their cloud/AI capabilities and their platform/ecosystem capabilities. To do this, the telco will not only need money but will also have to take a long hard look at themselves and their internal processes in terms of how they stack up against the real cloud native and digitally native players. However, the few that manage to successfully become this **cloud-native telco** have the opportunity to become a true digital giant in the coming decades.

Conclusions

The future of the telco will be determined by how well the telco handles the enormous challenge of 5G monetization and digital transformation. If they handle it well the telco can secure a position as one of the engines of growth of the digital economy for the coming decade. If they handle it poorly, they will slide backwards to become a utility connectivity provider competing primarily on price. The decisions the telco takes today in terms of investment in cloud, AI, platforms, and ecosystems will resonate out into the future.

TECHNOLOGY PROSPECT



Optical communications has significant implications on information exchange and allows for much more efficient and secure data transmission. Not only does it have the potential to transform the future, but it is already an integral part of today's digital revolution.

By Liang Ye, Partner of Strategy and Transactions, Ernst & Young (China) Advisory Limited

Optical communications lay the foundation of digital economies and empower a wide variety of industries

Optical networking has transformed our lives by providing the foundation for digital economies and empowers a wide variety of industries, from modern offices to hotel rooms, and from medical diagnostics to

smart cities. According to the most recent studies, we are seeing some significant technological advancements in optical communications that lead to a huge market of new applications and opportunities for investment.

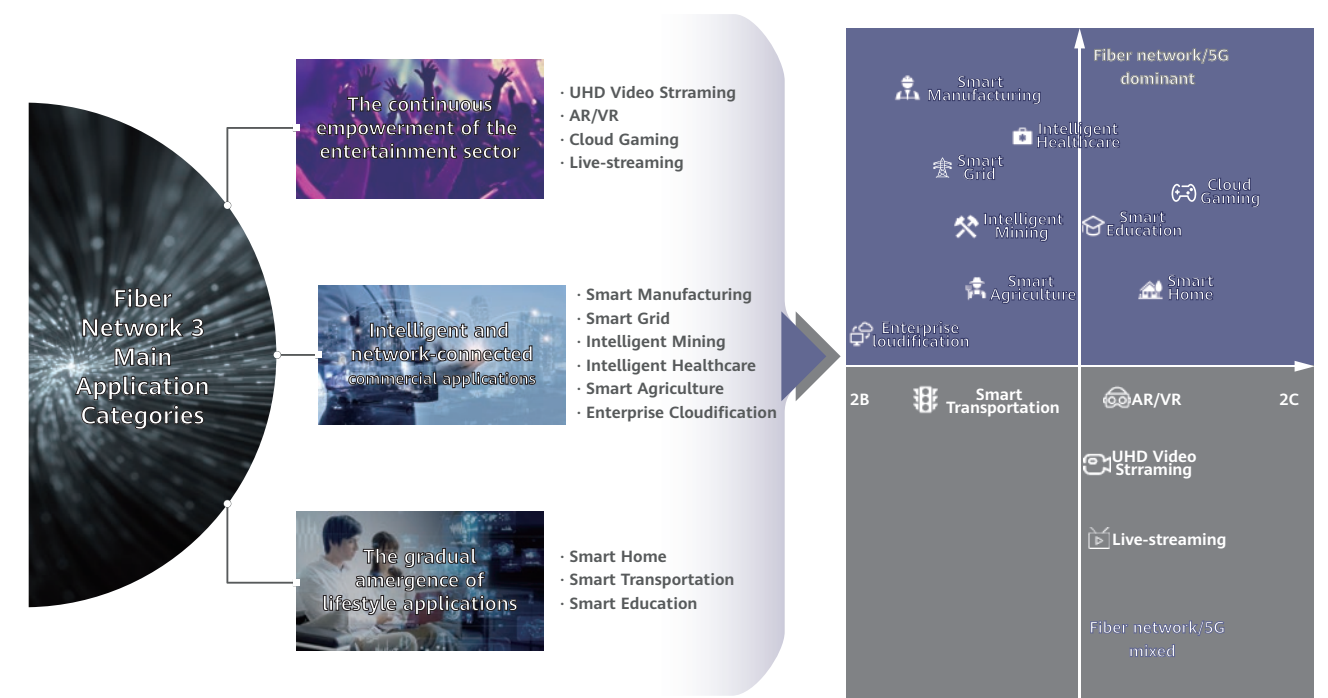
Technological advancements drive the future of optical communications

Technological advancements empower progressive fibre network upgrades. Here we highlight 4 major technologies.

- Wi-Fi 6 offers speeds up to 40% higher than its predecessor.
- 10G Passive Optical Network enables up to 10 gigabits of data to be transmitted at a time within a shared internet access network.
- Terabit Ethernet supports transmission rates up to 200 and 400 Gigabit per second.
- Next-generation flexible Optical Service Unit enables multiple service channels within a single optical transport network and is adjustable for differential bandwidth allocations.

Larger bandwidth, reduced latency, jitter and packet loss can be achieved with the incorporation of these technologies.

Optical communications act as the forefront of transforming information exchange. Up- and coming downstream applications have become the main driving force of the industry and can be categorised into 3 main sectors: entertainment, commercial and industrial, and lifestyle. The commercial/industrial sector has the greatest implication for fibre network, especially intelligent mining and smart grids.



Intelligent mining:

Real-time data transmission is crucial for mining safety, which is secured by fibre network with extensive site coverage.

Digital mines are equipped with a monitoring system comprising of cameras, sensors and a data centre to collect, transfer and process large volumes of data. Each mine requires an independent local network due to its geographical uniqueness and remoteness.

Besides, using fibre network technologies like Wi-Fi 6 can greatly reduce the risk of explosion caused by exposure to dust.

Smart grids:

Smart grids require low latency, high bandwidth and bidirectional data transmissions to a centralised management system. Built-in iterative learning capabilities analyse energy usage patterns to provide more precise electricity distribution.

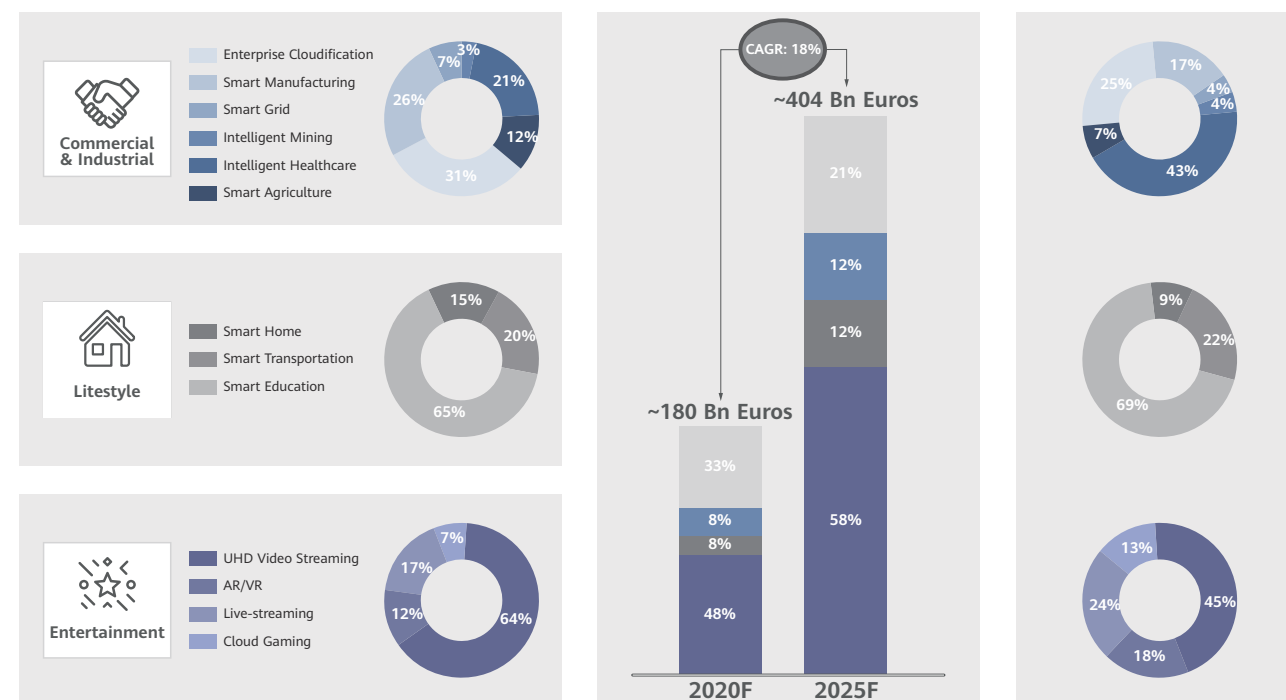
High quality of service ensures signal reliability and transmission speeds to meet real-time energy demands, long distance electricity sourcing and efficient distribution. These can only be satisfied by fibre network. Optical signals are also superior as traditional electrical signals are dampened under electromagnetic interference along cables, resulting in ineffective distribution.

“The primary driver of 2B market is the Passive Optical LAN (POL) establishments for enterprises. These centralised infrastructures have become much more prevalent to serve local network.”

- 2B market has higher growth rate than 2C market (at a CAGR of 19% and 16%, respectively).
- The primary driver of 2B market is the Passive Optical LAN (POL) establishments for enterprises. These centralised infrastructures have become much more prevalent to serve local network since using fibre optic cables is much more cost-efficient than their coaxial counterparts. The 2C market is primarily driven by the entertainment sector, which is expected to experience prosperous growth over the next five years, on account of increasing internet penetration and fibre network coverage rates. The entertainment sector occupies the largest market share of 48% in 2020 and will expand to 55% in 2025, while the lifestyle sector has the highest growth rate of ~30%.

A 400 billion euros market ahead

According to EY's analysis, in terms of the revenues of downstream telecom companies and LAN installation service providers, the total market size will be around 180 billion euros in 2020. The market is expected to grow at a CAGR of 18% and reach the size of ~400 billion euros in 2025.



Investment upturn indicates potential prospects

Positive trends are also reflected in the merger and acquisitions landscape. M&A activities along the industrial chain have shown stable growth over the past three years from around 65 billion euros in 2017 to 130 billion euros year-to-date. There was a 35% dip in 2019 compared to 2018's 105 billion euros due to the adverse effects of the capital winter.

However, the industry quickly bounced back in 2020 with a historically high total transaction amount recorded. While most industries have witnessed a definitive drop in revenues as the global economy struggles because of the pandemic, the optical communications industry has been largely immune to the negative effects of COVID-19 in terms of investment activities, which is a perfect telling of its potential prospects.

Breaking down by value chain, the upstream has

remained the M&A total transaction value stable; while the mid- and downstream has shown major growth.

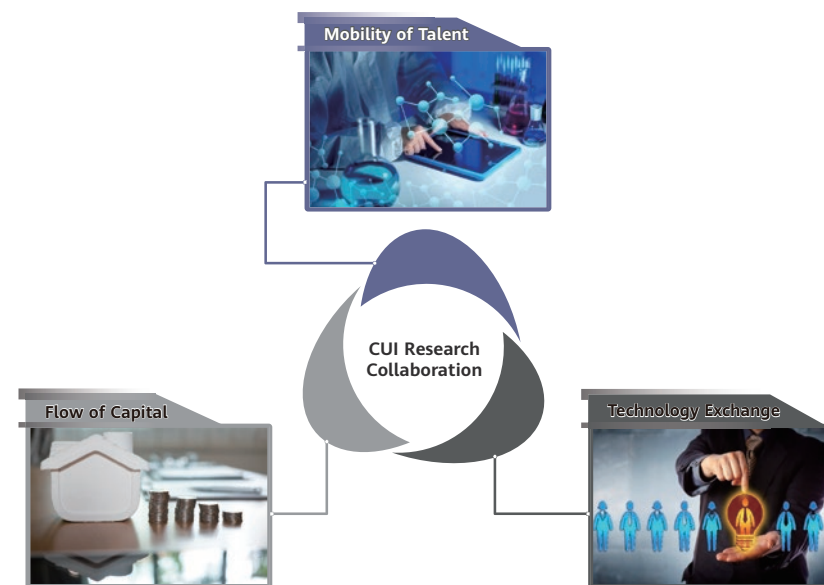
The midstream market consists mainly of fixed assets that can generate steady revenues. Investments within this sector have a relatively lower risk due to the high cost barriers, thus has continuously been an attractive investment opportunity. Midstream transaction values have grown from around 30 billion euros in 2017 to 45 billion euros year-to-date.

The downstream market has also shown substantial growth by around 170% in the past three years to 70 billion euros, as larger financial players are entering the telecom market to enrich their portfolios. The increasingly unified market verticals have also been contributing to M&A's steady growth.

CUI research collaboration to stimulate future growth

As the optical communications industry continues to grow with technological advancements and booming applications, investments opportunities have become more prevalent than ever. Companies, research organisations and academic institutions directly benefit from the rising capital inflow which boosts product development, leading to even more investments. Such positive cycle

allows the industry to flourish under University-Industry research collaboration. We can learn from the success stories of Silicon Valley and how the maturation of their UI collaboration has driven the digital revolution. With the rise of fibre optics in China and continuous capital support, Beijing ZOL-industrial park and Wuhan Optics Valley have thrived upon this model.



Another influencing factor is governmental support via national policies. One of the key success factors of Silicon Valley was the National Information Infrastructure Act of 1990. More commonly referred as the “information superhighway”, the Act included supportive policies such as tax and legal exemptions, funding, as well as trade stimulation. It positively encouraged education, investment and technological advancements within the ICT sector.

Overall, optical communications has significant implications on information exchange and allows for much more efficient and secure data transmission. Not only does it have the potential

to transform the future, but it is already an integral part of today’s digital revolution. Here are 3 key takeaways.

- Firstly, all sorts of up and coming applications in the ever-advancing optical communications industry generate more revenues for telcos.
- Secondly, the potential prospects of fibre networks continue to make it a major hotspot for investments.
- Lastly, the industry shall thrive under CUI research collaboration and governmental policy support.

Fiber Access and IP/Optical Networks: the Foundations of the Digital World

Due to the importance of fiber investment and its impact on global development, Omdia has created a new benchmark known as the Global Fiber Development Index.

By Michael Philpott, Research Director, Service Provider Consumer, Omdia

A world of applications driving ultrafast broadband

The importance of broadband

Broadband access, whether mobile or fixed, remains a key revenue source for telecommunication service providers. On a global basis, the sum of mobile and fixed broadband, pay-TV, OTT video, digital games and digital music will be worth \$1.4bn by 2024. Although a lot of attention is often placed on the smaller segments such as OTT video and digital gaming, likely because of their growth potential, by 2024 mobile and fixed broadband will still account for 62% of the revenues from this market.

The influence and impact of broadband access however goes far beyond direct subscription revenue. Increasingly, it is broadband connectivity that enables innovation and growth in other adjacent industry sectors as businesses rapidly digitize their platforms. Based on research carried out for the European Union, the ICT sector in Europe accounts for approximately 50% of all productivity growth.

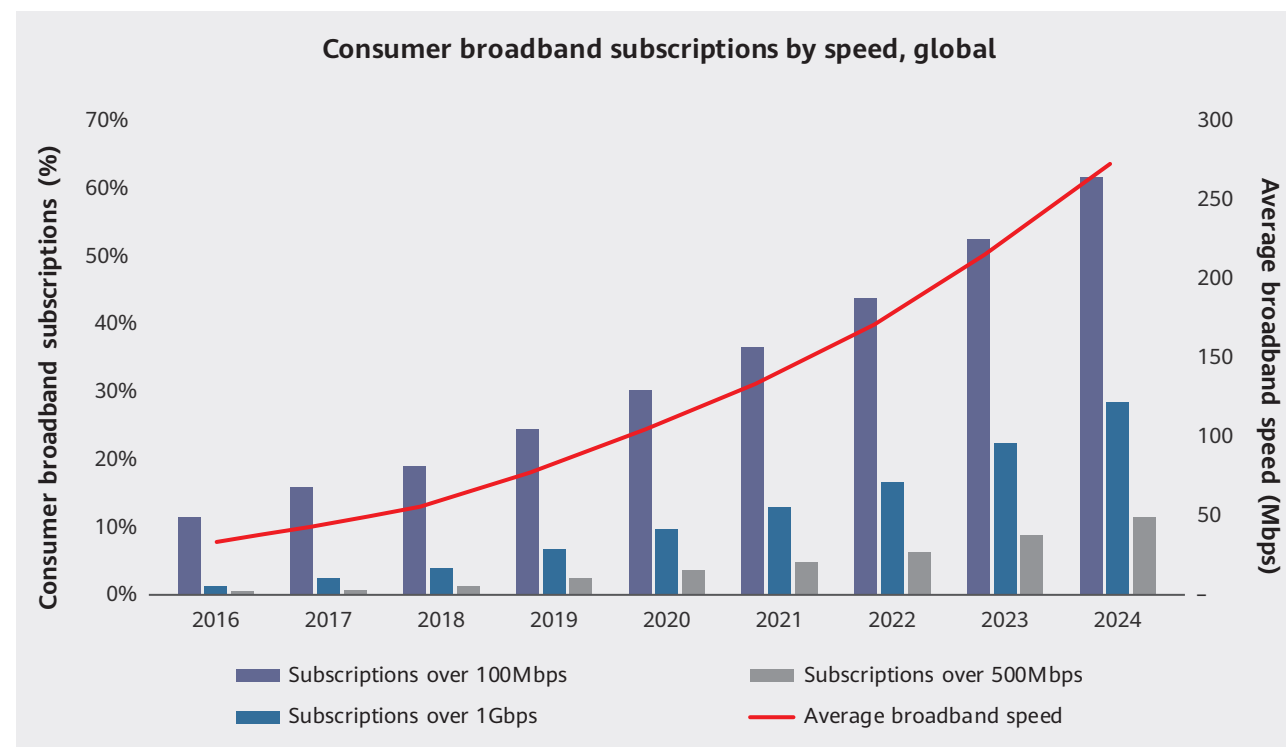


If anything, the COVID-19 crisis has only highlighted both consumer and business dependency on broadband connectivity as people move to remote working and education as well as of course digital communications and entertainment. This increased reliance on broadband connectivity has elevated the broadband service provider's role in both the home and society as a whole.

The move to a gigabit world

The leading trend in broadband continues to be the push towards ultra-high-speed services with many countries around the world already offering gigabit plus services, and the average broadband speed on a global basis over 250Mbps by the end of 2024 (see Figure 1).

Figure 1: The race to gigabit broadband services



Source: Omdia

Skeptics will say that this rapid growth in speed is largely marketing driven. However, there is a genuine need for speed, especially as both consumer and enterprise customers move to advanced, bandwidth hungry applications such as ultra-4K video, and ultra-high definition VR and AR.

Governments also now understand the importance of high-speed broadband networks on driving their

economies. There are now numerous studies that show that broadband investment, not just in terms of coverage but also in terms of speed, drives greater economic growth. For example, a study by the ITU suggests that a 10% increase in broadband penetration results in a 0.25 to 1.5% growth in GDP, and a study by the EIB outlines that a further 0.3% growth is possible for every doubling in speed.

As our reliance on broadband networks at home and work intensifies, it will also become important to monitor network and service variance so that reliability requirements are also met.

A step change in broadband quality demands further fiber investment

A futureproof network

This increased push for higher speeds requires significant and consistent investment in our broadband networks – and a big element of that is greater investment in optical networks in the core, backhaul and access networks.

Optical fiber is of course not the only broadband technology capable of delivering ultra-high-speed services – cable and 5G-FWA technologies for example are both capable of delivering gigabit broadband. However, optical fiber does have several characteristics that make it a truly futureproof technology, the two most important being:

- Limitless and fully symmetrical speeds
- High reliability and relatively low maintenance leading to low operational costs

FTTH is a core ingredient to optimum QoE

When benchmarking broadband services, the most common key-performance indicator (KPI) monitored is download speed. However, increasingly other network metrics such as

upload speed, latency and jitter are becoming equally important to meet consumer experience expectations. As our reliance on broadband networks at home and work intensifies, it will also become important to monitor network and service variance so that reliability requirements are also met.

As a simple example, if we take a typical consumer application such as cloud gaming, for a perfect level of experience Huawei recommends the following:

- a bandwidth of 48Mbps
- latency of less than 20ms
- jitter of less than 7ms.

By only considering headline speed, most broadband technologies other than basic-ADSL would be capable of meeting the minimum of criteria. However, network data provided by testing specialists such as MedUX have proven that FTTH services are the most consistent in meeting all the required criteria when latency and jitter requirements are also taken into account.

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Due to the importance of fiber investment and its impact on global development, Omdia has created a new benchmark known as the Global Fiber Development Index.

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The Fiber Development Index

Introducing the fiber development index

Due to the importance of fiber investment and its impact on global development, Omdia has created a new benchmark known as the Global Fiber Development Index. Unlike some other benchmarks that only track a single development metric such as say coverage or household penetration, the Global Fiber Development Index aims to capture all elements of fiber investment, specifically fiber access, mobile fiber backhaul, core fiber backhaul, and then the overall fiber QoS, which is currently measured by overall average download and upload speed.

Only by optimizing each of these separate investment areas can a country maximize the overall end-user broadband experience, whether that is provided via a fixed or mobile access-connection.



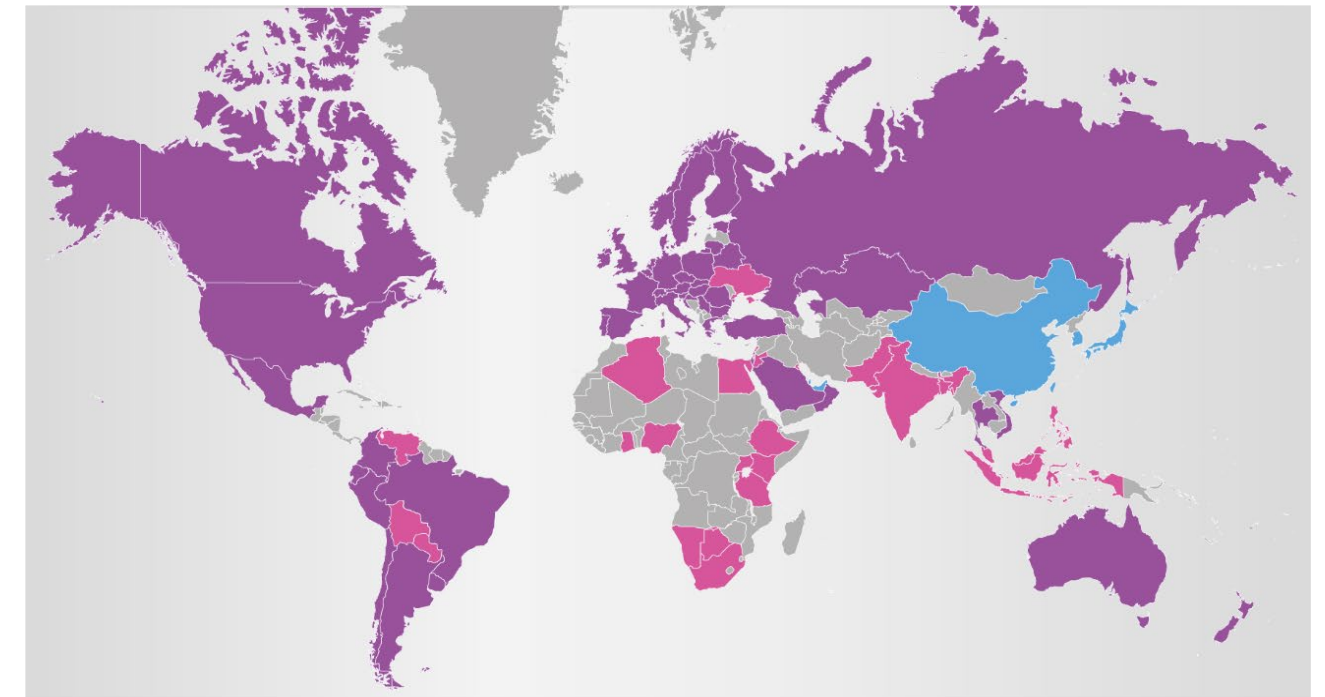
Global Fiber Development Index top-level results

The Global Fiber Development Index maps fiber investment in over 80 of the world's leading broadband countries. Singapore leads the 2020 index with an overall score of 8.3 out of 10. South Korea (7.6), United Arab Emirates (7.1), China (6.5), and Japan (6.4) make up the rest of the top 5 countries.

Singapore scored a maximum score (10 out of 10) in Fiber to the Home (FTTH) penetration (99%), Fiber to the cell Site (FTTS) Fiber Penetration (94%), FTTH Population Coverage (100%), and both Download (195Mbps) and Upload speeds (204Mbps). Two areas where Singapore doesn't lead are in Fiber to the Business (FTTB) penetration (which China leads with 44%) and Fiber Backbone Length (in which area Oman is the leading country). Please also note that two other countries (Oman and South Korea) get maximum scores along with Singapore for FTTH Population coverage.

The first European country in the ranking is Sweden, resting in 7th position with a score of 5.1. Sweden is closely followed by Spain (5.0), Denmark (4.9), and Norway (4.8). The US heads the Americas region with a score of 3.7, positioned 19th in the world overall.

Figure 2: Omdia's Global Fiber Development Index (FDI) 2020 ranking



Cluster 1			Cluster 2			Cluster 3		
1	Singapore	8.3	17	Israel	3.7	34	Estonia	2.8
2	South Korea	7.6	18	Saudi Arabia	3.7	35	Kuwait	2.8
3	United Arab Emirates	7.1	19	US	3.7	36	Bulgaria	2.8
4	China	6.5	20	France	3.7	37	Slovakia	2.6
5	Japan	6.4	21	Canada	3.6	38	Czech Republic	2.5
6	Qatar	5.8	22	Oman	3.6	39	Australia	2.5
7	Sweden	5.1	23	Finland	3.5	40	Poland	2.5
8	Spain	5.0	24	Lithuania	3.5	41	Chile	2.4
9	Denmark	4.9	25	Thailand	3.5	42	Belarus	2.3
10	Norway	4.8	26	Uruguay	3.5	43	Ireland	2.3
11	New Zealand	4.5	27	Vietnam	3.4	44	Turkey	2.3
12	Portugal	4.3	28	Netherlands	3.3	45	Italy	2.1
13	Romania	4.2	29	Malaysia	3.1	46	Belgium	2.1
14	Russia	4.2	30	Ukraine	3.1	47	Germany	2.0
15	Luxembourg	4.2	31	Hungary	3.0	48	Mexico	1.9
16	Switzerland	3.9	32	Bahrain	3.0	49	UK	1.9
			33	Slovenia	2.9	50	Jordan	1.9
						51	Indonesia	1.9
						52	Croatia	1.9
						53	Kenya	1.8
						54	Brazil	1.8
						55	Austria	1.8
						56	Kazakhstan	1.8
						57	Venezuela	1.7
						58	Uganda	1.6
						59	Argentina	1.6
						60	Greece	1.6
						61	Tanzania	1.5
						62	Namibia	1.4
						63	Peru	1.4
						64	South Africa	1.4
						65	Bolivia	1.3
						66	India	1.3
						67	Botswana	1.3
						68	Paraguay	1.3
						69	Colombia	1.2
						70	Ecuador	1.2
						71	Philippines	1.1
						72	Algeria	1.1
						73	Serbia	1.1
						74	Lebanon	1.0
						75	Morocco	1.0
						76	Ghana	1.0
						77	Egypt	0.9
						78	Pakistan	0.9
						79	Nigeria	0.9
						80	Ethiopia	0.9
						81	Bangladesh	0.9

Source: Omdia

© 2020 Omdia

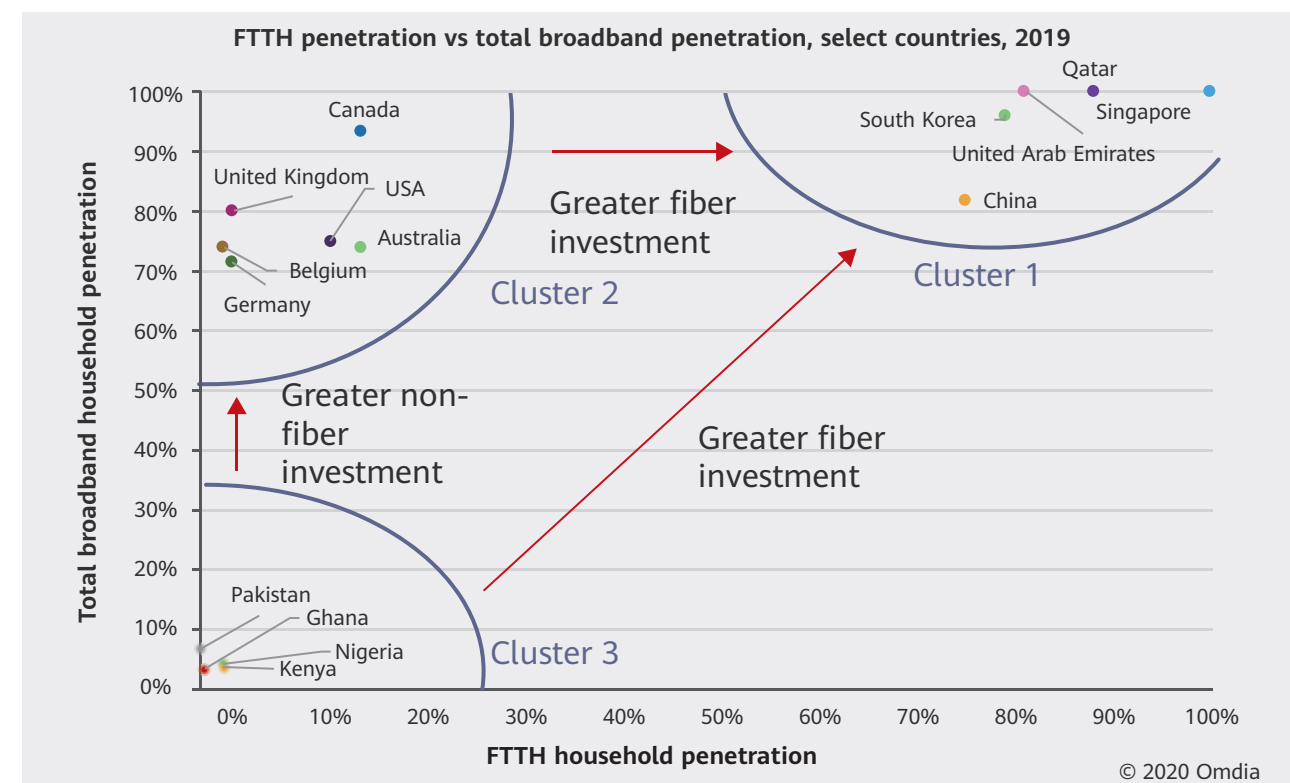
The creation of country clusters

The Global Fiber Development Index covers 81 territories of varying sizes, demographic and geographical profiles, as well as levels of broadband development. Due to these widely differing characteristics it makes it nonsensical to directly compare all of them with each other, which if done would, in Omdia's opinion, only lead to unfair and unhelpful conclusions and recommendations.

Therefore, to compare individual results of the Fiber Development Index Omdia created three different country clusters:

- Cluster 1: Countries with highly developed both broadband and FTTH penetration.
- Cluster 2: Developed broadband countries that have a high-level of broadband household penetration but relatively low FTTH penetration
- Cluster 3: Emerging broadband countries that have a low-level of broadband household penetration and have a relatively low FTTH penetration.

Figure 3: Fiber Development clusters enable more focused recommendations



Source: Omdia

More than access: the importance of IP/Optical for network infrastructure

The transition to IPv6 is underway

Over the next few years, driven by 5G and IoT, the number of connected devices and objects is set to rocket – reaching nearly 9bn end connections in industrial IoT and mobile devices alone. However, with

IPv4, the world is already running out of usable IP addresses. IPv4 enables 4.3bn IP addresses, but only 2.8bn of these can be used. Of these 2.8bn a third are assigned to large organizations and a further 1bn are used by hackers (and thus in the SPAM house). So approximately, there are 1-1.5Bn useable IP addresses, to connect already more than 5Bn end devices and growing.

Table 1: growth in devices

	2019	2024	CAGR
Industrial IoT (Global)	227M	776M	28%
4G and 5G (Global Mobile connections)	5,236M	8,270M	10%

Source: Omdia

IPv6 solves this problem by basically providing an enormous address space. However, IPv6+ or an enhanced IPv6 represented by protocol innovation such as SRv6, BIER6, and APN6, also combine AI capability which can be used to enable features such as differentiated guaranteed service and higher network resource utilities ratios, as well as swift provision and fast fault location. All key elements for tomorrow's broadband networks.

Developing the next-generation of broadband networks is of course more than just deploying more optical fiber. To meet future needs we need those networks to be capable of connecting huge numbers of devices, guarantee end-to-end quality, and enable swift service provisioning. For this it is imperative that industry moves to IPv6 and IPv6+. Governments across the globe now recognize the importance of IPv6 and take up is expected to reach significant scale over the next 5 years.



AI-based networks will be critical to future success

During the COVID-19 crisis, broadband service providers have seen in some cases 2 to 3 times the number of customer service calls. To some extent this is positive for broadband providers as it shows not just a continued interest in broadband services, but a step-increase in them. However, it also provides a dilemma as of course service providers, like all industries, are having to manage their own workforce through the crisis. This includes support staff having to work from home, reduced staffing levels due to self-isolation, and field-engineers having to adopt new working procedures, especially when visiting customer premises. All this adds up to a scenario of increased levels of customer interaction multiplied by rising costs per interaction – especially when home visits are required.

This will not be a short-term phenomenon, as new procedures, as well as consumer weariness, will remain in force for some time. The result will be an acceleration towards 'zero-touch' service provisioning using AI-based networks and platforms in four key areas:

- **Deployment:** Providing a more intelligent network that is able to flex around the users' needs, speeding up time to service, reducing manpower costs and increasing operational efficiency
- **Provisioning:** creating a more 'OTT like' experience by enabling customers to turn new services and applications on and off at the touch of a button. This creates greater customer satisfaction as well as enabling new, easy to manage business models for the service provider.
- **Service optimization:** automated service optimization ensuring that customers get the best experience 100% of the time, resolving potential service issues even before the customer even notices
- **Troubleshooting:** remote troubleshooting using data analytics, so that when an issue does occur they can be resolved quickly and efficiently.

Conclusions

- **Fiber is essential for future GDP growth.**
Due to the COVID-19 crisis economic growth across the globe is at its lowest for many years. However, with significantly more people working and being educated from home, broadband access has never been more important. In order to achieve the best chance of bouncing back from the COVID-19 crisis, governments must look to invest in their national broadband networks.
- **Fiber connectivity is the most futureproof access technology.** Future broadband applications will require a mix of certain network KPIs such as high down and upload speeds, low latency and low jitter, if they are to provide the right level of experience to the end user. Based on network measurement data, an end-to-end fiber optic network is the best performing type of network across all such metrics. Furthermore,
- it is virtually futureproof, and is more reliable and secure than other forms of network – making it an ideal choice of infrastructure for residential and enterprise customers alike.
- **Not all countries are equal.** Although the endgame is the same, countries are all at different starting points and face different set of challenges. It is essential that stakeholders recognise these differences and set out ambitious, but highly-relevant, targets and strategies for their individual markets.
- **Investment in IP/Optical infrastructure is required to meet needs on end-to-end basis.** Networks will continue to expand in terms of scale and complexity. New technology such as IPv6 and AI will be key network investments if the new network challenges and requirements are to be met.

21st Century Visual Digitalization & Industrialization and Super Visual Experience

China will lead in 3D+8K/4K video technologies. The size of high quality 3D movies, shows, or sports event broadcasts using these technologies may reach petabyte-level, which ultimately will require a super network to transmit, giving audience the ultimate immersive and interactive experience.

By Cheng Xin Sen, CEO of Cameron Pace Group Asia & China

In December 2009, the blockbuster Hollywood science fiction movie *Avatar* was released worldwide. While topping the global box office, *Avatar* has also ignited a new wave of visual revolutions. Director James Cameron presented amazing visual effects to the audience through imaginative images and 3D, creating a new movie experience. Movies have since entered the 3D era, in particular in China. James Cameron and Vince Pace, a top cinematographer/engineer, jointly founded Cameron Pace Group (CPG), which has long been dedicated to promoting R&D of the world's top digital film industry and has significantly contributed to cutting-edge fields such as 3D stereoscopic vision. Films and various contents produced by Cameron or applying CPG's technologies have generated over USD12 billion in box-office and revenue, and won 10 Oscars and Emmy Awards. In China, an exclusive JV (Cameron Pace Group China, CPGC) was set up, with the aim to promote new cutting edge technologies, especially in the 3D areas.



Visual effects and Movie/TV markets are booming worldwide and in China

Movie/TV industrialization & digitalization have taken off in the US during the 1970s and 1980s. In the 21st century, the contents globally have also become more diversified to cater for a younger audience. In addition to good plots, this young audience are also seeking for high quality and stunning visual effects, regardless whether they are watching a 2-hour movie, 20-minute video, or even 20-second advertisement. This new era has also stimulated the prosperity of the movie/TV and visual effect markets. This trend is even more obvious in China. Market studies indicated that demand for UHD visual contents in China have increased from RMB 1 trillion in [2019] to RMB 4 trillion in [2022],



representing a compound annual growth rate (CAGR) of 59%. There has been a 14-fold increase in the number of movie screens in China between 2009 and 2019, with annual viewers increasing from less than 200 million to over 1.7 billion. As digitalization & industrialization continues to progress, the visual effect and movie-related industries will have a bright future.

Visual Digitalization & Industrialization and Stereoscopic Technologies

Today's movie and TV productions have evolved from shooting at actual scenes to shooting at digital stages or virtual productions. In the new *Avatar* movie, many scenes even use state-of-the-art under water visual capture technologies. In next 2 to 3 years, CPG is committed to building advanced digital platform in China to produce more higher-quality contents in the most effective way and will be featuring more Chinese characteristics. James Cameron and CPG are committed to bring more world's leading visual and digital production technologies and

methodologies to China, while integrating with the country's cutting edge ultra broadband, AI, cloud, edge computing, and storage to create and globally share contents with both Chinese and global audiences.

In the near future, cutting-edge movie technologies will also be applied to live cinematic and TV broadcasts. For example, the 3D live shooting technology used in *Avatar* will be utilized to broadcast live sporting events and performances, allowing viewers to watch live contents from either

a 6-inch mobile phone screen, a 60-inch TV screen, or even a 600-inch movie screen, while delivering an excellent viewing and immersive experience.

In terms of glass free 3D stereoscopic technologies, with the development of lenticular, laser, light field technologies, glass-free 3D will become a reality, delivering a more immersive experience without the need of any glasses or devices.



Ultra broadband, AI, and cloud drive the evolution of visual digitalization & industrialization

From the 2D to 3D+8K era, visual digitalization & industrialization is posing increasingly higher requirements on networks. More specifically, the uncompressed and compressed rates of 3D+8K images attain 60 Gbps and 500 Mbps, respectively. As such, without super broadband and 5G, audiences will be unable to enjoy high-quality 3D+8K content. From a different perspective, high-end content productions are demanding for bigger storage and rendering requirements. For example, from *Avatar* in 2009 to *Alita* in 2019, the rendering time and storage capacity had increased multiple folds, total rendering time, . This means that we require advanced solutions such as 5G, AI, cloud based computing and sharing and virtual productions etc further the automation for digital production processes, while achieving higher level of efficiency.

Without advanced technologies such as AI, cloud computing, virtual productions etc, traditional ways visual effect productions are becoming more cumbersome and complicated. With the new technologies, we believe that over 70% of the pre-production, production and post production works can eventually be semi- or fully automated. In the VFX spaces, we believe that AI and other new technologies will bring automation in three

different phases. In first phase involves increasing automation in the rendering, special effects production, and rotoscoping areas; the second phase involves increasing automations in design, texturing, and coloring areas; while the third phase involves increase automation in the grading areas. Automation will improve production efficiency considerably. To put it into perspective, work that used to take 1 to 2 years can now be completed within only 1 to 2 months.

In the AI and cloud era, we believe new technologies will be able to reduce the labor cost of digital production by 30% to 70% and improve the transmission efficiency by 20% to 50% over the next five years. Future digital visual production in the future will no longer rely on high intensive workforce. As an increasing number of advanced visual effect technologies are applied to live broadcasts in the future, storage and real-time rendering capabilities will have higher requirements. Operators' transmission networks will also be crucial to content producers. The leading networks, storage, AI, and other advanced infrastructures of Chinese operators will propel China's visual digital industry to a leading position worldwide in the coming decades.

“ We are convinced that with the development of network, cloud, IoT, and AI technologies, we will continuously provide the latest visual technologies to enterprises and consumers, and enable ordinary people to create content like directors. ”

Visual digitalization & industrialization will change our lives —○

In the long term, CPG and CPGC are aiming to cultivate and promote more cutting-edge technologies, especially in the 3D areas, in the movie, TV, mobile and even gaming industries. We hope that many of the new visual technologies will eventually enable more small businesses and even individuals to enjoy the benefits of these technologies at lower costs. As a result, they will be able to create and produce high-quality videos more efficiently, whether those contents are PGC or UGC. We are convinced that with the development of network, cloud, IoT, and AI technologies, we will continuously provide the latest visual technologies to enterprises

and consumers, and enable ordinary people to create content like directors. In the near future, we will be able to create high-quality content more efficiently and share it with more audiences through advanced real-time direct shooting, digital production, transmission and display technologies.

CPGC is honored to work with Huawei, operators, and industry partners to produce more remarkable content more quickly and cost-effectively. This content will be spread and shared more widely, bringing audiences a more immersive experience.

