China is poised to win the 5G race

Key steps extending global leadership

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Executive Summary

The remarkable growth of China's technology and innovation in the international stage has demonstrated the country's determination to become a global leader in the digital space. Mobile technology, as an innovation enabler, has become a focused area China hopes to command, particularly after its diversion from the global norms in the 3G and 4G era. Committing early in the standardization process will give China an edge to influence internationally and generate notable economic impact domestically.

All eyes are on China now as the country is in a leading role in the race of 5G development. The top-down national agenda that came with a series of key initiatives has provided instrumental support to create a complete ecosystem in the market – from technology R&D, equipment, network, terminals, platform, to application development. Intense engagements from the entire value chain are developing new use cases and service platforms that may serve as international test beds for 5G innovation.

China's preparation for 5G is well underway, as it enters the third phase of 5G testing while the government has officially reserved considerable contiguous spectrum for 5G purpose. With the global unified standard set to finalize in the next year or so, China has brought forward its timetable of the commercial launch to 2019, potentially becoming one of the first 5G-ready markets in the world.

5G opens up new possibilities for a multitude of life-transforming applications – from 3D video to immersive media, autonomous vehicles and the enablement of smart cities, thanks to the ultra-high data rates, enhanced capacity and reduced latency. It is also the key to unlock other technologies such as artificial intelligence (AI), robotics and the Internet of Things (IoT), therefore providing tremendous potential in China that could not be underestimated.

Nevertheless, demand will build up progressively in the domestic market as it will be limited by the near-term supply of devices, equipment and compelling applications. Operators also will take a gradual approach in network deployment, thus implying a slower 5G take-up path than 4G. Adoption will take off as economies of scale builds up in the market. We expect 5G connections in China will reach 576 million by 2025, representing over 40% of that globally.

The promise of 5G will give telecom operators a competitive edge over the growing challenges from over the top (OTT) players. To capitalize on the new technology, they need to take essential steps from both business and technical perspectives. The ability to offer customized connectivity to support differentiated services over the more agile and flexible virtualized network, buoyed by network slicing and mobile edge computing, will be transformational. However, that requires the support of substantial fiber, sophisticated cloud and analytics capabilities, and transformed support systems. After all, 5G is a convergence play, and poised to change the industry landscape. Monetizing 5G requires new business model innovation and cross-sector partnership in the more machine-centric environment. Imitating an OTT model has proven to be unsustainable as operators have different DNA against technology companies. They should instead leverage their strengths to engage in deep service innovation. To a further extent, the need for acquiring non-core assets, technologies or capabilities to offer new and differentiated services such as the IoT will become an important driving force to industry consolidation.

While the outlook is bright, 5G will not completely change and disrupt the telecom landscape or the industries in the short term. Operators should be realistic and learn from history to avoid over-commitment. They have to work out their strategies for 5G and move fast to deploy new services. Capitalizing on their 4G investment is important since LTE is expected to remain dominant in the fast-growing market for the next decade.

Introduction

The road to 5G standardization has become clearer after the 3rd Generation Partnership Project (3GPP), a collaboration of telecom standard development organizations, officially ratified the first release of a non-standalone version for the 5G New Radio (5GNR) standard in December 2017. This interim standard helps telecom industry move toward a single and global standard for 5G. Supported by a large group of operators and equipment vendors, the decision to accelerate 5GNR will facilitate large-scale trials and enable early deployments of standardized commercial 5G network sooner. Non-standalone 5GNR will rely on an operator having an existing LTE network as an anchor, while adding 5GNR carriers to boost speed and reduce latency.

Network equipment manufacturers are very confident that 5G will become a reality by 2019, a year earlier than the previous deployment timelines. Based on the current progress, the first phase of the global 5G standard could be released in 2018 and the final phase in 2019. 5G should be fully standardized by the end of 2019, paving the way for mobile network operators to roll out the 5G services from 2019 to 2020.

Asia has been spearheading the 5G development showcasing the technology in major sporting events like the Winter Olympics hosted in the region. Among them, China is probably the most committed across all levels. After missing the opportunities in the 3G and 4G era, China has been determined to make 5G a top priority on its national agenda, striving to take a leadership role in the global landscape. Targeting for a commercial launch in 2020, China is set to reap the benefits of its early participation in setting the standardization, building the industry chain and pushing research and implementation of 5G-related technologies.

China is on the right track to become the winner of 5G

With 5G, China has been eyeing the opportunity to be a leading technology innovator, after its diversion from the global network norms in the 3G and 4G mobile technologies. China's active role in the 5G development in recent years has demonstrated the country's determination to gain technical leadership in the international 5G stage.

Rising influence in the global 5G technology landscape

China has been expanding its influence on the 5G standard-setting process. Its ambition was revealed back in 2013 when the Ministry of Industry and Information Technology (MIIT), with the National Development and Reform Commission (NDRC) and the Ministry of Science and Technology (MOST), jointly founded the IMT-2020 (5G) Promotion Group to push forward the formulation of 5G standard in cooperative mechanism with the EU, US, Japan and Korea. Operators and technology vendors, both domestic and international, participate in this group, providing important inputs to 3GPP to support the development of a global unified 5G standard.

In the state level, the Government has drawn up supporting policies under its national strategy including the 13th Five-Year Plan and Made in China 2025 to support industry R&D and strive for 5G commercialization in 2020. It also pressed for the need to engage in the formulation of international 5G standard and make China become one of the main players. The Premier of China's State Council has highlighted 5G as one of the emerging industries to be accelerated in the latest Government Work Report in March 2017. The MIIT has constructed the 5G Development Guidance document aiming to make 5G an important infrastructure for China's economic and social development. The NDRC also released a guidance document on information infrastructure construction projects for 2018 that directs 5G networks to be built in at least five cities to form a continuous coverage.

Year	Initiatives	Description
2013	Made in China 2025	The plan pointed out that China should break through the 5G mobile communication technology comprehensively
2015	13th Five-Year Plan (2016-2020)	The plan proposed that China should promote the development of 5G actively and launch it in 2020.
2014-2015	National 863 Program	▸ National major projects aimed to promote 5G key technologies development ▸ They looked to verify and improve 5G technical schemes ▸ The program supported the global unified 5G standardization
2015-2017	National Science and Technology Major Project	

Source: MIIT

Taking a leading role in developing 5G technologies will enable China to gain a greater share of the intellectual property behind the universal 5G standard, thereby increasing its global influence. Eventually, it will enhance China's bargaining power with foreign patent holders and help lower costs for mainland telecoms equipment makers, chip companies and other enterprises in the supply chain.

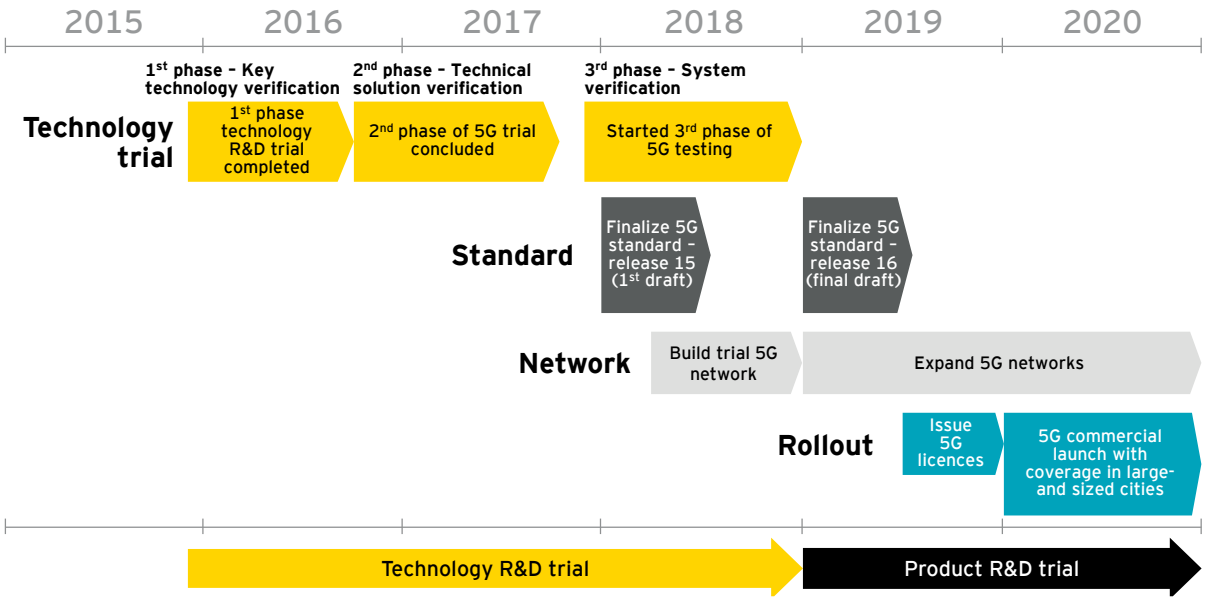
It will also give Chinese companies an edge internationally in new frontiers such as autonomous driving and the IoT. On the domestic front, the economic stakes for 5G is attractive, led by large-scale job creations and incubation of new devices, applications, and business models that could significantly stimulate the Chinese economy. According to a study from the China Academy of Information and Communications Technology, the 5G market could account for RMB1.1 trillion (US$166 billion) or 3.2% of mainland China's entire GDP in 2025, generating 8 million jobs and adding RMB2.9 trillion in economic value by 2030.

Building a strong ecosystem to generate economic impact

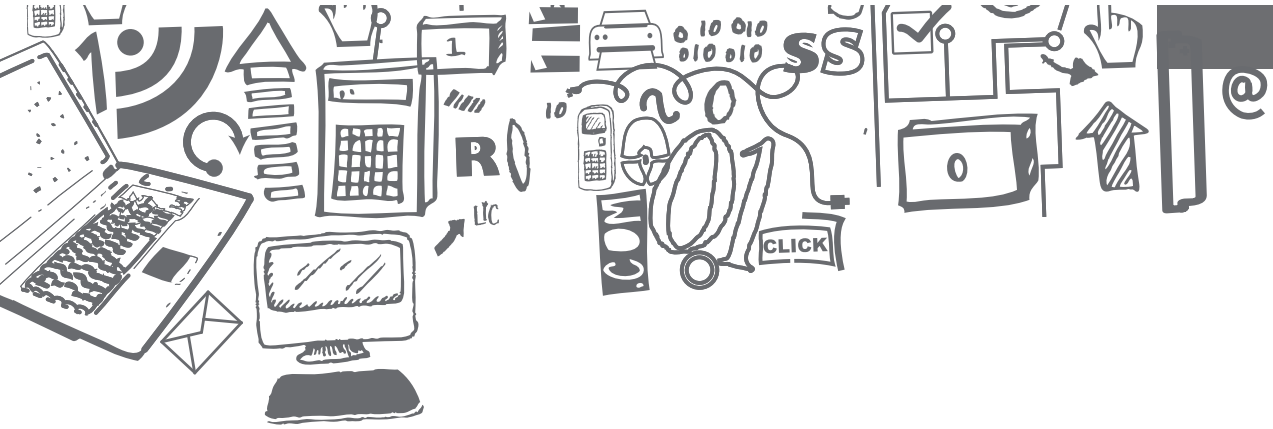
Proactive government support and industrial capital investments has helped shape a self-sustained 5G environment in China. This will create a rich ecosystem comprising equipment and device manufacturers, chipset suppliers, telecom operators and application and platform providers which largely reduces the investment risks of the industry chain.

China is one of the pioneers in 5G R&D, which sees the world's first 5G test being guided and planned by the Government. Ahead of schedule, the country has already started the third phase of 5G technology R&D tests, which both domestic and international companies have joined the field trials, aiming to get pre-commercial 5G products ready when the first version of 5G standards comes out by mid-2018. Meanwhile, the industry regulator has called for a bigger push to experiment with more 5G-enabled applications, with added focus on the integration of chips, systems and other instruments.

Timetable for China's 5G development



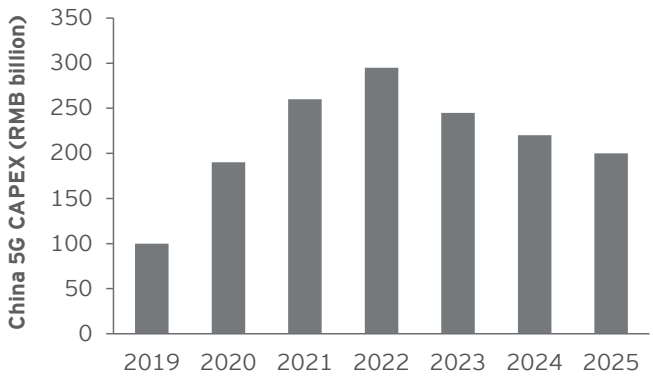
Source: MIIT, SCMP, China Daily



To get ready for 5G commercialization by 2020, the Government and the telecom industry are all taking the necessary steps. Mainland telecom equipment manufacturers, already in a leading role of the global telecom equipment market, are investing heavily in 5G research and patent development-related projects. Their active engagements with global operators in supplying pre-5G mobile infrastructure show that they are making way to spearhead the 5G equipment market. Scaling up the equipment supply will reduce the unit cost and encourage the world to adopt 5G earlier than it would have been. As demand for 5G services heightens, there will be a boom in new companies such as application developers, and sales of equipment. It will spur new revenue for telecom and hardware makers, and benefit internet companies and application developers in a longer term.

All Chinese operators have announced plans to invest in 5G network deployment from 2019 onwards, and are building out 5G innovation centers and conducting external field tests in major cities in preparation for 5G. Indications show that their 5G network investments will be progressive over a longer period, which is unlikely to mirror the spike in 4G development strategy. EY expects China's 5G capex will amount to RMB1.5 trillion (US$223 billion) between 2019 and 2025.

5G capital expenditure forecast in China



Source: EY analysis

Taking the leadership role to innovate 5G

China has been evolving from a follower in the 3G era to an active participant who seeks to beat foreign firms in the 5G era. The trend matches the rise of Chinese telecom companies in the international arena. In late 2016, a Chinese operator led the 5G System Architecture project, which determined the structure of 5G networks. The move came shortly after polar coding, a technology backed by Chinese telecom equipment maker, was approved as part of the global standard for 5G. Recently, the company unveiled in a large international telecom event the world's first commercial chipset that meets the standards of 5G wireless networks.

With the top-down national pledge and commitment, China is already in a leading role in the 5G development, from setting the standard, R&D, network infrastructure technology, building the industry chain to engaging in focused use-case scenarios. Quickening the pace of 5G R&D is one of China's goals to showcase technology in the 2022 Winter Olympics in Beijing. In the capital, the local government has planned for the commercial-level demonstrations of 5G networks in Beijing's subsidiary administrative center, the 2019 Beijing World Horticultural Expo, Beijing's new airport and the 2022 Winter Olympics.

China is well-equipped for 5G thanks to factors like widespread fiber availability, small cell deployments, 4G maturity and supportive governments. The market is establishing itself as the test bed for 5G innovation in the global digital economy. China could emerge as a frontrunner, with the Government expecting 5G to be commercialized by 2020, while operators hoping to push ahead the schedule by late 2019.

The early start of 5G R&D and the vastness of China could easily put it as the biggest 5G market as it launches commercialization in the next two years. We expect that the number of Chinese 5G users will reach 576 million by 2025, covering around 40% of the Chinese population. This represents some 41% of the 5G connections worldwide.

Gradual adoption with devices being the key

The established 5G ecosystem is poised to create strong 5G demand in China. However, early 5G networks will most likely be served as a hotspot technology to supplement existing mobile broadband in the first-tier cities. The less aggressive than 4G network rollout strategy means that 5G adoption in China is going to take on a gradual growth path.

New technology requires appropriate devices to support in order to fully exploit its performance. With the first 5G reference smartphone design debuted in October 2017, 5G-compatible smartphones supporting multiple sub-6GHz and possibly millimeter wave (mmWave) frequencies as well as potentially a 4K or 8K screen will be available by the first half of 2019. However, mass production of end user devices will only be possible when the 5G standard finalizes. To address the device availability, an international chipset maker has recently forged a deal with several key Chinese handset vendors to supply components to enable OEMs to rapidly build mobile devices at large scale for global expansion. They also launched a 5G initiative hoping to bring 5G-ready devices to market in 2019.

Nevertheless, China will initially face a less mature device ecosystem. This suggests a premium price point for 5G consumer devices which will only decline when economies of scale kick in, as well as limited scope for subsidies from operators. The rise of device availability will drive new contents and applications. A wider set of ICT services will be offered by means of new 5G terminals in the forms of 5G-enabled intelligent machines, robots, drones and smart things. As network and new services expand, 5G adoption will scale up rapidly.

China sees 5G as a game-changer

An important stimulus for 5G deployment is the continuous need for greater capacity to support operators' customers. In China, operators are saying that they will need to upgrade their networks between 2020 and 2022 because the current LTE technology is not efficient to upgrade capacity that will match customer demands. From a technical perspective, 5G can be a remedy because operators can use it to get to a lower cost per bit and therefore serving customers with improved cost efficiency.

A significant limitation of operators' performance has been their reliance on selling access without successfully selling higher value services. As access commoditized, profitability has fallen, which operators should move outside their comfort zones to find new opportunities that will be enabled by 5G. Services supporting IoT and analytics will help generate new revenue and 5G has the potential to enable operators to offer new services.

China is already investing heavily on new technologies such as AI, connected cars and big data analytics, as part of the strategic push from the national plan. Internet heavyweights, technology companies, telecom operators and software or application developers have made hefty R&D to help China evolve into a new global leader in innovation. Embracing 5G will drive the expansion of "super-connected era" and the fusion of new technology and real economy. New trends in industries will emerge. Various smart applications and values of service will also come along. Smart manufacturing, transportation and medical service will be common, which will drive economy to grow with quality, efficiency and power. It will also greatly improve people's lives in the society.

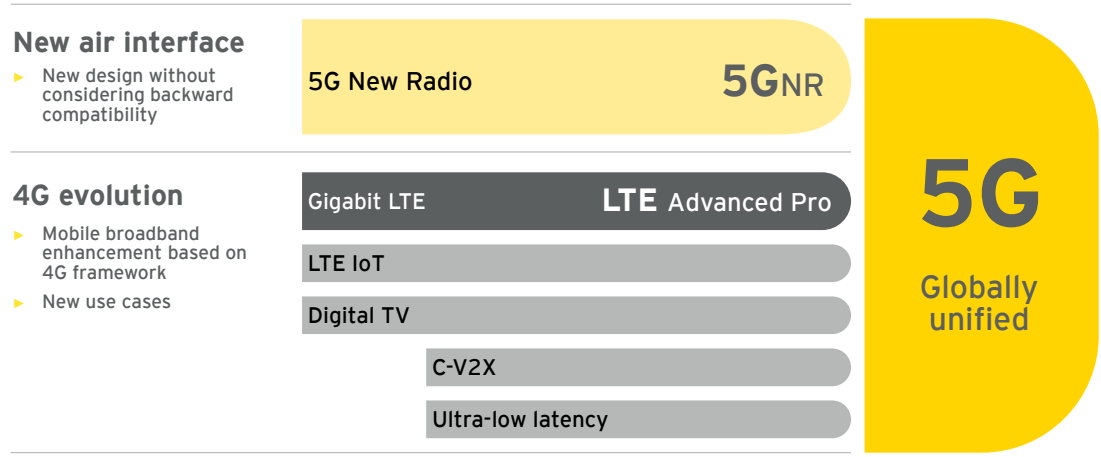
What is the 5G standard?

The development of 5G standard has two schemes. One is to improve the technology step by step, based on the current 4G LTE technologies to improve the network capacity and performance – 5G LTE. Another scheme is to design completely new network structures and wireless technologies to construct a whole new mobile communication network – the revolutionary 5G New Radio (NR).

5GNR is a new wireless radio interface that will support revolutionary improvements in throughput, capacity and efficiency, particularly at frequencies above 6 GHz, more commonly known as mmWave. This opens up massive amounts of new spectrum and offering new capacity.

On devices, mmWave support will require a new product architecture and significant technical design and integration effort, and thus will be disruptive for customers. The standard is still being defined, with the non-standalone version completed in December 2017.

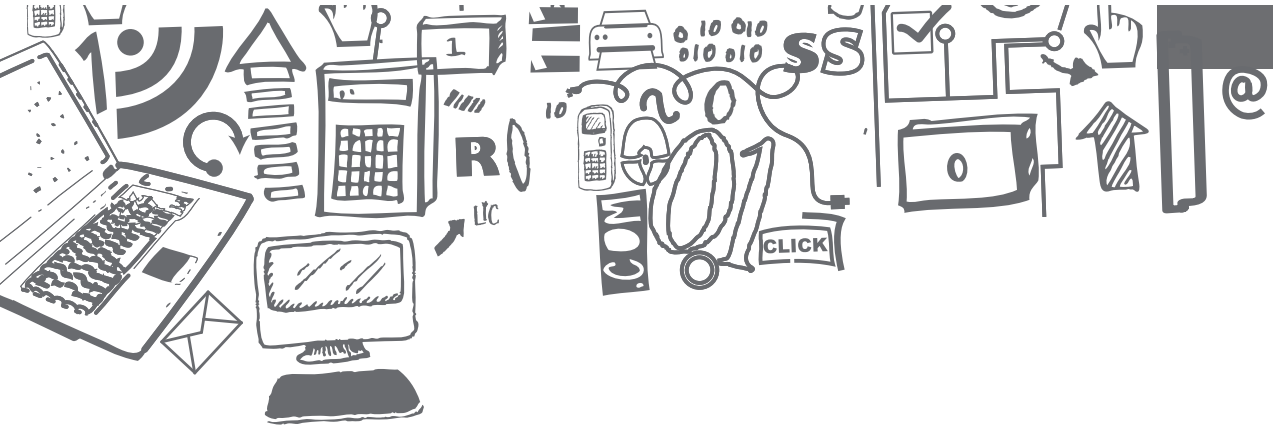
5G LTE is an evolution of LTE Advanced Pro Release 14. It is an essential part of a true 5G system that entails many LTE Advanced Pro features such as consistent user experience, seamless handoff, low-cost, high coverage and longer battery life requirements of LPWA applications. The 3GPP has agreed to submit 5G LTE along with 5GNR as a 5G candidate to the International Telecommunication Union (ITU), which is scheduled to be completed in June 2018.



Source: Qualcomm

In contrast to the complexity of integrating a completely new technology and product architecture for 5GNR, existing wireless infrastructure will only require a software upgrade to support 5G LTE in most cases. 5GNR will require new infrastructure and large numbers of new cell sites. As a result, large-scale deployment of 5G LTE networks are likely to be sooner than that of 5GNR, which will not see mass-scale commercialization until the 2019-2020 timeframe. 5G LTE product transition is also going to be simple and straightforward like moving from LTE to LTE Advanced. However, it will be 5GNR that renders a disruptive change for customers although it will take time to evolve to support all the use cases such as massive machine type communications targeted for 5G.

The next-generation mobile communication system is more than just about speed. 5G fixed many of the technical weaknesses of 4G technologies, which has significantly improved the quality of service, time delay, throughput speed, energy efficiency, and system performance.



5G performance KPIs

New spectrum

Higher bands to meet demands of speed and capacity, ability to aggregate all bands

New air interface

Support mass connectivity and increase spectral efficiency

New architecture

One physical network supporting multiple virtualized networks

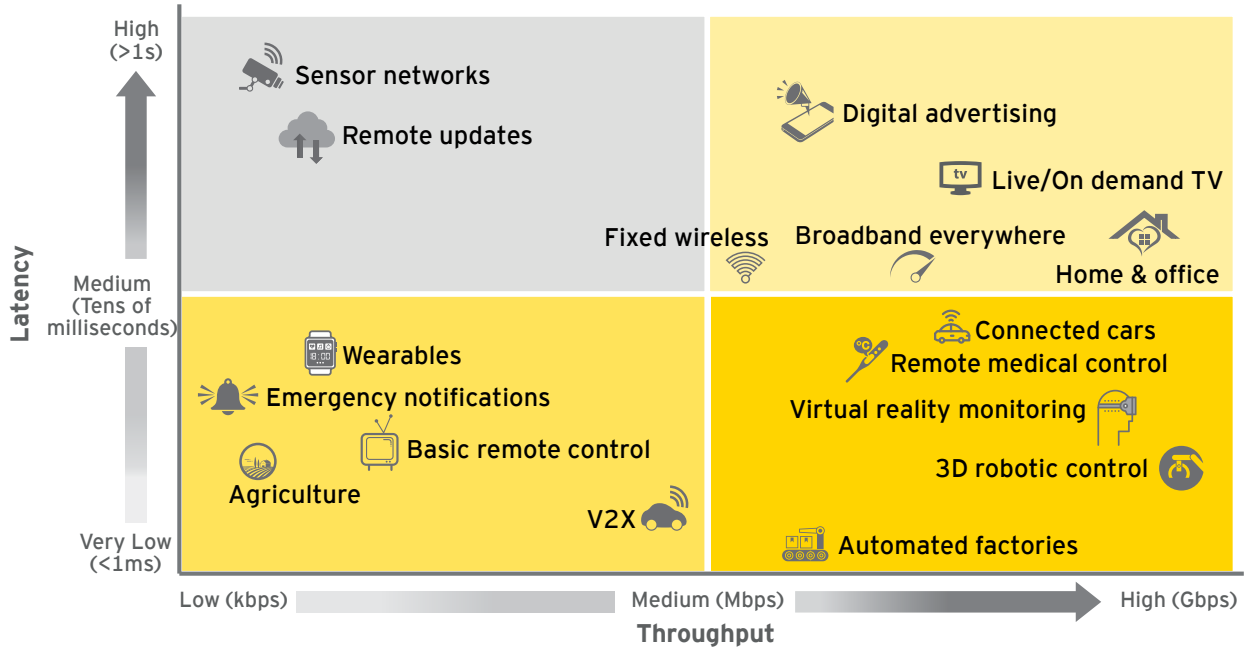
Enhanced data rate	More connections	Mobility	Mobile data volume	Lower latency	Longer battery life
Over 10 Gbps	1M / km^2	500+ km/h	10 $Tb/s/km^2$	~1 ms	Over 15 years
▸ 10-100x of 4G	▸ 100x of 4G	▸ 1.5x of 4G	▸ 1000x of 4G	▸ 1/10 of 4G	▸ 10x of 4G

Source: GSMA

The disruptive capabilities of 5G will pave the way for new innovative applications that the current LTE technology cannot support. Some of the widely promoted examples include industrial automation and utility services, vehicle-to-vehicle and vehicle-to-infrastructure transportation, home automation, augmented reality (AR), virtual reality (VR) and many more.

The vastness of China's population combined with the incredible deployment speed makes the country a dynamic, challenging and increasingly competitive market. 5G will transform traditional industries in a way the previous generations of cellular technologies are not able to. The success of 5G can only be built upon the success of the entire ICT ecosystem. Communication-enabled ICT and industry innovation will be the real driver in creating a bigger market for 5G.

High speed and low latency of 5G fuels demand of new services ("in yellow areas")



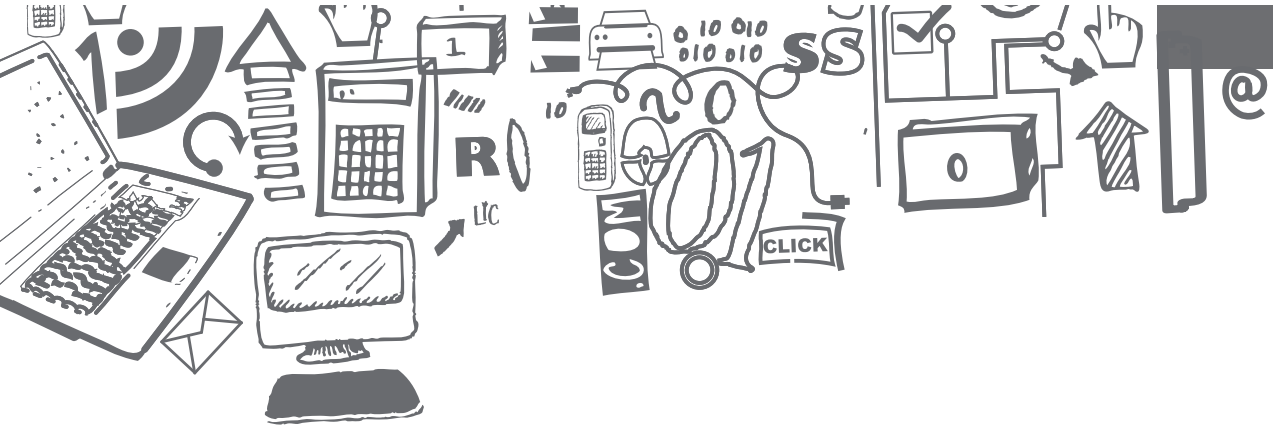
Source: EY, GSMA

4G continues to be instrumental

Despite all the fervor from the industry to accelerate deployment, 5G will not completely replace 4G. In fact, some of the early deployments will be based on the LTE core, so 5G deployment will be gradual and co-exists with advanced LTE networks for many years to come to provide a relatively seamless user experience.

4G LTE is still in the middle of its lifecycle globally and has yet to reach its peak adoption. China saw 4G penetration jump from 8% in 2014 to 67% in November 2017[1], showing strong growth in high-speed mobile internet adoption. This is a healthy sign for 5G as it has created ample demands for faster mobile broadband and more data-heavy applications. Although 5G is expected to handle things that 4G cannot, LTE will exist in the next 10 years and continue to deliver value. That means operators should not stop investing in 4G. Identifying the best mix of old and new mobile communication systems are important aspects that should be taken into consideration.

1. Data from GSMA Intelligence, 5 April 2017; MIIT figures



LTE continues to evolve with higher speed upgrade along with the release of new cellular IoT solutions like Low Power Wide Area Networks (LPWAN) as operators are eyeing the immense revenue opportunity from the IoT market. Yet the spectrum of IoT applications is so broad that each IoT use case presents unique requirements for bandwidth, range, latency and other connectivity features. Today, there are numerous connectivity options, both cellular and non-cellular, offering different capabilities that cater for specific types of IoT services. However, no technology (not even 5G) fits all the specific needs of an IoT solution or device.

The IoT capability comparison – 5G vs 4G IoT

	5G	NB-IoT	LTE-M	LTE	Wi-Fi 802.11n
Throughput / Data rate	10Gbps	200kbps	1Mbps	>10Mbps	450Mbps
Spectrum	Licensed (700-900MHz)	LTE bands (900MHz)	LTE bands	4G bands	2.4/5 GHz unlicensed
Coverage	Very good (<15km)	Excellent (22km)	Excellent (34km)	Excellent (<100km)	Small (<300m)
Latency	Very low	Low	Low	Low	High (no guarantee)
Battery life	Long (10+ years)	Long (10+ years)	Long (10+ years)	Low	Low (3 months)
Overall cost	Low	Low	Low	High	High

Source: EY analysis

Many of the present IoT projects work fine with the low data rate solutions they require to function, along with the low costs, low power consumption and extensive coverage features. This explains the fast-growing deployments of cellular LPWAN in licensed spectrum, including LTE-M and NB-IoT. Backed by strong government support, all Chinese carriers have deployed NB-IoT networks and developed capabilities to cover more of the value chain, helping China emerge as the leading country for the LPWA technology.

The parts of IoT that fall within the exclusive purview of 5G are those that are either much larger in scale or are mission-critical, which demand low latency. In China, massive scale IoT applications could include logistics tracking, energy and grid management, while mission-critical applications could include connectivity for robotics in industrial settings and traffic management in cities.

Wi-Fi will continue to be a complementary solution

5G, and specifically 5GNR, has the potential to be disruptive in wireless hotspot connectivity. Despite that, Wi-Fi is also evolving and is achieving gigabit speeds with the latest version of 802.11ax. The ax standard solves the congestion problems of Wi-Fi by completely redesigning how Wi-Fi works and taking some best practices from LTE, making it significantly faster and less congested. It will also improve battery life.

From a technological point of view, 5G cellular is powerful enough to substitute existing Wi-Fi and could provide a much more consistent user experience. However, it needs a strong business case to justify the transition given the two technologies have very different market positioning. Any proposed replacement technology must have a demonstrable and sustainable competitive advantage in at least one dimension (technology, financial, operations and so on), or it will fail.

Wi-Fi is a technology which is a local-area wireless network based internet service. Despite using unlicensed spectrum, Wi-Fi has gained mass adoption commercially due to its cost effectiveness, devices support and ease of deployment. Various versions of Wi-Fi have been in place today with 4G LTE to supplement indoor connectivity and help offload the network traffic. Wi-Fi also has access to a large trunk of spectrum, owing to a lengthy base of experience. Through dense deployments, spectrum is optimized via specialized protocols and is reused efficiently via small cells. Its massive installed base has helped Wi-Fi achieve the economy of scale that is very difficult to be replaced.

In China, Wi-Fi is widely used as an indoor connectivity solution like everywhere in the world. Operators will continue to implement a strategy of heterogeneous networks (HetNet) comprising 5G, LTE and Wi-Fi, which is the most cost-effective option to cooperate wireless WANs and LANs.

The lessons of 3G and 4G

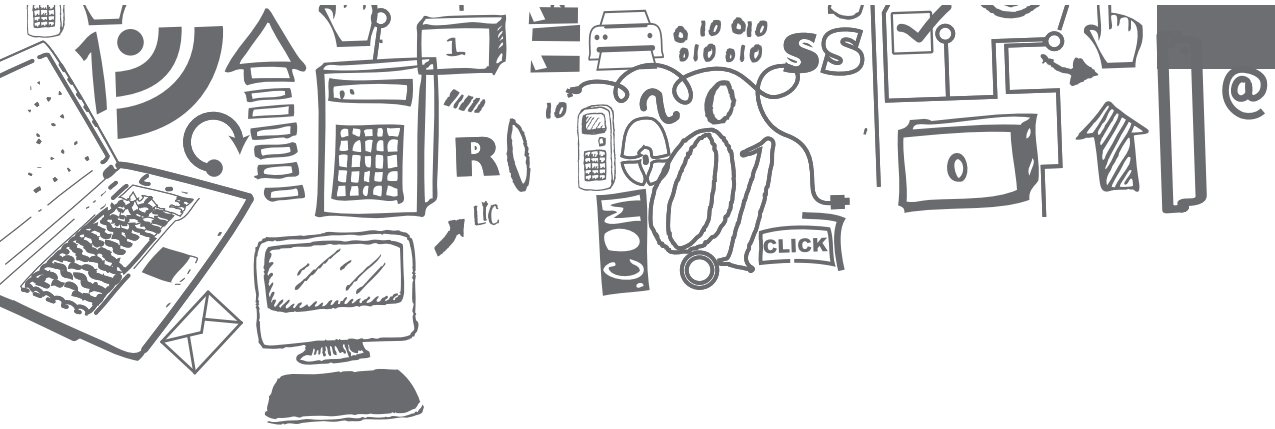
Transitioning from 4G to 5G is a technology shift, similar to the evolution from the voice-dominated 2G to data-driven 3G. Executing the 5G plan would not be successful without learning from the lessons of the previous technology iterations. 3G, being the most noteworthy, painted an ideal picture on how it could have changed the world by delivering high-speed data and video, leading to an over-optimistic demand projection by the industry. It was misguidedly promoted largely on the basis of engaging 3G device form factors and "killer applications", which either failed to excite the consumer base or could not be delivered by the technology.

Excluding the factor of China's homegrown technology standard, operator write-downs, delays and frustrated performance expectations have made 3G an unsuccessful platform globally. Industry data shows that, with only 2.5 billion subscriptions worldwide at peak, 3G took around 10 years to reach 1 billion connections, only slightly shorter than the 11 years 2G took. 4G has much improved, taking just under seven years to reach that figure.

From the business perspectives, there are several reasons why the great promise of 3G and 4G for consumers failed to realize globally including China, which are related to decisions that operators took.

Devices failed to deliver user experience – The lack of compelling 3G-enabled devices largely inhibited the user experience. Customers were disincentivized to access the multimedia contents such as video call, mobile TV and music downloads or could rarely experience the power of the internet on a small screen. The high cost of 3G-enabled devices also hindered the take off.

Lack of applications and innovation – 3G failed to deliver multimedia services such as video streaming as it had promised to. Many 3G services were complicated and not user-friendly. The poor device user interface failed to deliver enriched experience, making the applications non-appealing to consumers. These problems were inherited by the 4G age even though the bandwidth was largely boosted. Telecom operators were disrupted in face of competition from the internet telephony (VoIP) providers and OTT providers, which provided a much more intuitive experience and innovation. Failing to reap the benefits of the killer applications and value-added contents, operators remained mostly as a connectivity provider, generating profits out of mobile broadband data and new smartphone sales throughout the 3G and even 4G age.



Overpriced tariff – Moving from 2G to 3G, the high 3G data tariffs kept subscribers away. Consumers were lucky if they got few hundred kilobits download speed, at a very high cost, which could hardly help them experience the power of the internet. They did not get an affordable data package until operators upgraded the capacity to 4G. On the other hand, consumers were getting more compelling services offered by VoIP and OTT providers at a flat-rate or even free.

Poor coverage and performance – The poor and limited coverage in many cities including those in China, especially during the early launch stage, added to the poor user experience. 3G network performance was also subpar as signals were often downgraded to 2G or deemed unreliable. The inferior quality of service was a result of the inability to plan or invest in adequate infrastructure including towers, base stations and backhaul.

Over-bidding on spectrum – This is probably the most critical factor for the short life of 3G. Operators made huge investments for 3G spectrum, as governments around the world conducted auctions to raise revenue. Over-expectation on multimedia applications led operators to radically overestimate the expected average revenue per user (ARPU) of 3G services. Thus, they overcommitted in spectrum auctions and build-out, which resulted in a wave of write-downs earlier this decade. The costly spectrum bids led to many delays as some governments such as the US had to re-run the auctions after having discovered that companies couldn't afford to operate. Regulatory regime also aggravated the situation. For examples, penalties were imposed for those who failed to meet the rollout target associated with the 3G licenses in the UK, while China had prioritized the licensing to the operators adopting its homegrown standard.

At the same time, operators faced new competition that was not foreseen when they had paid billions for their 3G licenses, from flat rate wireless VoIP, Wi-Fi, converged services pushed by non-mobile operators and the threat of mobile broadband based on WiMAX.

The pitfalls of 3G and 4G

	3G	4G	5G
The promise	▶ Mobile Internet ▶ Services and applications ▶ Multimedia	▶ Mobile broadband ▶ VoLTE ▶ Internet of Things	▶ Internet for everything ▶ Ultra HD / 3D video ▶ Immersive media
The reality	▶ Instant messaging ▶ Social networking	▶ HD video streaming ▶ Music streaming ▶ Photo sharing	▶ Mobile cloud? ▶ AR/VR? ▶ Critical IoT?
The challenges	▶ Expensive data tariff ▶ Poor and limited coverage ▶ Non-appealing device ▶ Bandwidth failed to deliver multimedia services ▶ Poor user experience	▶ Abundant All-you-can-eat data plan ▶ Explosive traffic growth caused network strain ▶ Handset subsidies	▶ Demand of fibre backhaul ▶ Cell densification
Competing technologies	▶ Wi-Fi ▶ VoIP	▶ OTT ▶ WiMAX	▶ Wi-Fi?

Source: EY analysis

While it had taken 10 years to establish 3G, 4G didn't run into the same trouble as 3G had done due to the fact that it was an evolution and an upgraded version of the 3G standard. Overlaying on existing 3G networks, 4G is an advanced form of 3G that marks an audacious shift from hybrid data and voice networks to a data-only all-IP architecture. Operators stepped up 4G network deployment globally to reap the benefits of its cost and spectral efficiencies and to support more advanced offerings, by exploring network sharing deals to share spectrum and rollout costs.

Having said that, 4G uptake was fueled by the timely introduction of smartphones that harnessed faster speed of the technology to deliver compelling user experience for mobile internet. The proliferation of low-cost smartphones and tablets from Chinese manufacturers have expanded 4G to the next billions with lower affordability, helping 4G to reach mass adoption around the world.

Despite the stimulated growth, 4G deployment was not without problems.

Handset subsidies and network strain – With operators' aggressive handset subsidies to drive penetration and the offer of unlimited data tariff plans to drive usage, 4G data traffic exploded and quickly caused strain and overload of the networks. As data took off, bandwidth pressures were increasingly in backhaul and transmission rather than access, so there was pressure to increase spending tackling the bottlenecks to improve customer experiences.

Spectrum harmonization – Spectrum harmonization was an issue to enable international roaming and interoperability. The early launch was complicated by the non-uniformity of spectrum, which included the existing 2G or 3G frequencies, or new frequencies between the 700MHz and 2.6GHz band. There was also a domestic time-division (TD) version of LTE in China which received priority support from the Government. However, a local standard without global acceptance will hinder international roaming. Spectrum availability was also a big issue in many countries despite less so in China.

Operators or the industries should not expect 5G to completely change and disrupt the telecom landscape or the industries, at least in the short to medium-term. They need to be realistic and learn from history to avoid overcommitment. They have to work out their strategies for 5G and move fast to deploy new services.

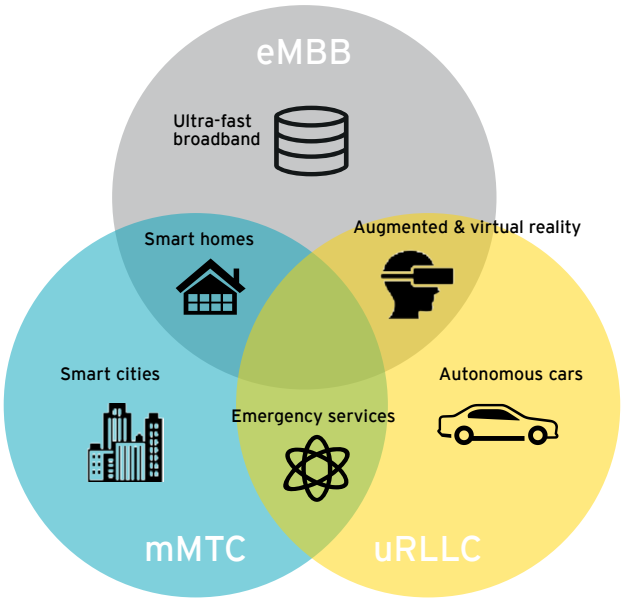
Spurring the innovation of new 5G use cases

Industry consensus envisages 5G to meet different requirements in various extreme scenarios. As proposed by the ITU, the multiplicity of use cases that 5G supports can be grouped into three primary areas:

- Enhanced mobile broadband to consumer mobile devices
- Mission-critical services – emergency services and other public services requiring ultra-reliable, very low latency communications such as autonomous vehicles or even drones as a service
- Massive IoT – concerned with connecting millions or billions of low-power sensors with low data rates; examples include smart homes and buildings, e-health and smart grids

China-led IMT-2020 5G Forum has drawn an overall picture of 5G based on the country's situation. It envisioned that mobile internet and the IoT are two main drivers of future mobile networks in China which will touch many aspects of life in the future. Meanwhile, Chinese equipment manufacturers and telecom operators are actively demonstrating a range of potential 5G use cases, with a goal to take the consumer broadband experience at a much enhanced level as well as to foster wide industrial uses.

5G use case scenarios



Enhanced mobile broadband (eMBB)
- Require high bandwidth, in some cases ultra-high reliability

Ultra-reliable, low-latency communications (uRLLC)
- Demand reliability and millisecond latency
- Not necessarily high bandwidth

Massive machine-type communications (mMTC)
- Concerned with connecting millions or billions of low-power sensors with low data rates

Source: EY, ITU, TM Forum

In developing new use cases, Chinese TMT companies are working intensively with focused industry segments – media and entertainment, automotive and public transport, while energy and utilities, logistics, healthcare, security, finance, industrial and agriculture are considered as alternatively potential markets. For example, transportation scenario is an important 5G use case to China, with mobility requirement above 500km/h for high-speed railway.

Enabling video everywhere through ultra-fast broadband

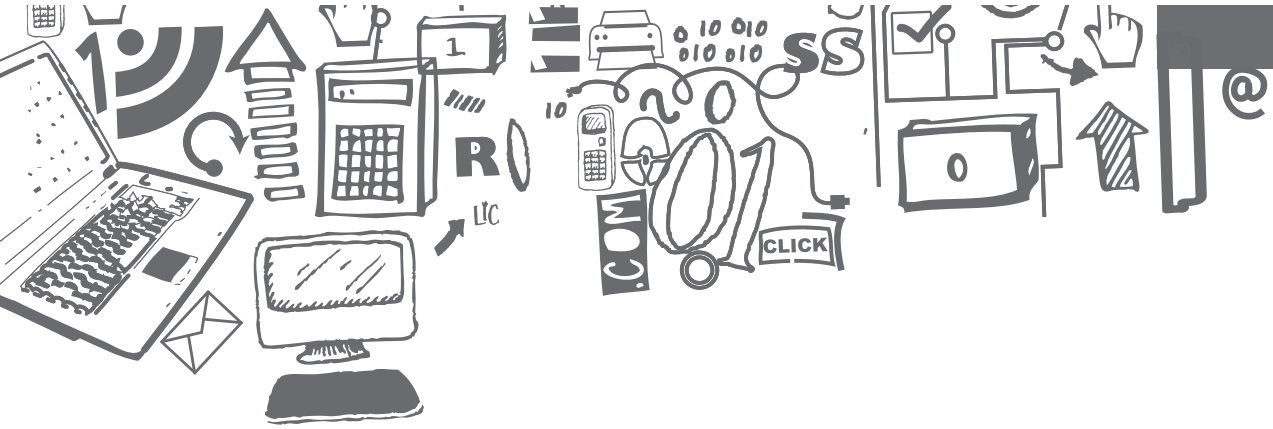
The rapid domestic development of 4G has driven China's emphasis on 5G to cater for the future needs of the fast economic development. Offering better, faster and more reliable mobile broadband is therefore high on Chinese operators' initial agenda for 5G.

Many data intensive applications, both consumer-oriented and B2B, are on the verge of merging. Recent developments of 4K, 8K, 3D Videos, expanded use of HD TV, streaming audio and video services, and interactive video on many devices, are key driving factors for this group of use cases. The enhanced data capacity, the high data rates and the enhanced broadcast and multicast features of 5G will essentially serve these use cases, providing the TV feature for in-home screens and realize the media vision for mobile TV.

Chinese equipment maker has worked with telecom operators to demonstrate real-time ultra-high definition (UHD) video transmission with a throughput of over 800Mbps[3] as well as completing the pre-commercial trial of the world's first UHD IPTV over 5G fixed wireless access[4].

5G can enhance user experience further with faster mobile broadband speed, but to provide an immersive experience of higher end video and media services requires an innovative app design and new device form factor. To this end, mobile broadband alone will not deliver sufficient revenue to justify 5G.

3. "Softbank and Huawei demonstrates 5G use cases," Huawei press release, 8 September 2017
4. "Huawei launches 5G microwave bearer and trials 4K over 5G FWA," Telecom TV, Nov 2017



Fixed wireless access will complement fixed-line broadband

Driven by interest in the US, fixed-wireless access (FWA) is another early use case that offers China a good opportunity to enhance and complement its improving fixed broadband infrastructure. With multi-gigabit speeds and massive capacity, 5G can provide a fiber-like experience without the expenses and time of deploying fiber. By eliminating the need for fiber connectivity over last-mile networks, 5GNR deployments could profoundly disrupt the home broadband and pay-TV markets, as well as offering massive capacity boosts for locations such as stadiums and malls. This is promising for smart home as well as enterprises.

China is in the progress of upgrading its fixed broadband infrastructure, as part of its Broadband China initiative. Broadband has maintained rapid growth in the last two years as the Government continued pushing to elevate internet speed and price cuts. Fixed broadband penetration reached a modest level of 78.9% of households by the 1st quarter of 2018[5], outpacing the target set by the 13th Five-Year Plan of 70% penetration in 2020.

Strong wireless networks such as 5G can fill the void to achieve a ubiquitous fiber coverage at high speed to cater to pent-up data demand. 5G FWA services can achieve indoor data rates of around 2Gbps, which has the potential to enable new consumer and enterprise services. Some studies have suggested that 5G FWA could reduce the initial cost of establishing last-mile connectivity by as much as 40% compared to fiber-to-the-premises deployment[6]. A Chinese network giant has been driving a wireless-to-the-premises (WTTx) solution as an equivalent of fixed wireless access. The company has already provided the technology using 4G and 4.5G technologies but expects it to become more viable through the lower latency and higher speeds offered by 5G. It claimed a significant breakthrough in 2017 with a successful 5G pilot in partnership with a Canadian operator[7] and announced the launch of an end-to-end user trial which will allow access speeds up to 2Gbps at home via the fixed-wireless trial network[8].

Widespread commitment to immersive media

AR and VR are among the most impressive use cases for 5G. The massive boost to mobile data performance and stability makes 5G an ideal technology for these immersive media applications.

AR and VR technologies, which rely on real-time video technology to work, require high bandwidth and are pushing the limits of connectivity. High screen resolution and low frame latency are essential to immersive AR/VR systems. Leveraging the high capacity, uniform experience with consistent high data rates and lower latency, 5G is central to providing mobility, improving social experiences and addressing nausea induced by visual delay and battery efficiency of devices. Both technologies won't thrive and realize their true potentials until 5G is rolled out.

AR and VR are developing at breakneck pace with a surge of applications. Alone or blended together, they are undoubtedly opening up both real and virtual worlds. Hardware and software vendors are driving the excitement of AR and VR with all those headsets, smart glasses and applications such as the popular mobile game Pokemon Go. These immersive media applications are not only emerging as important technologies for entertainment and gaming, but also have extensive vertical applications that have yet to be explored. Increasingly, AR and VR are widely used in industries like gaming, retail, hospitality, tourism and manufacturing.

5. "China broadband adoption status report – Q1 2018," June 2018, Broadband Development Alliance
6. 5G Asia, October 2017
7. "Telus, Huawei hail successful 5G wireless-to-the-premises pilot," TeleGeography, 26 June 2017
8. "Huawei, Telus announce 2Gbps WTTx trial," TeleGeography, 16 February 2018

Virtual reality
The process of generating realistic images, sounds, and other sensations that replicate real environment and simulate a user's physical presence. Consumer and entertainment-oriented applications initially drove the industry.

Augmented reality
Transparent displays with digital elements (graphics, images, audio, or other information) overlays upon the real-world environment. Enterprise and utility-oriented applications initially drove the industry.

Mixed reality
The merge between real and virtual worlds to produce new environments and visualizations where physical and digital objects co-exist and interact in real time.

AR and VR technologies are increasingly becoming a two speed market

Augmented reality

- AR delivers virtual elements as an overlay to the real world
- Developed into apps and used on mobile devices to blend digital components into the real world in such a way that they enhance one another
- Used to display score overlays on telecasted sports games and pop out 3D emails, photos or text messages on mobile devices

Key industries

medical, education, commerce, and public safety

Virtual reality

- VR offers a digital recreation of a real life setting
- Typically achieved by wearing a headset or head mounted display equipped with the technology
- Used prominently in two different ways:
  - To create and enhance an imaginary reality for gaming, entertainment, and play
  - To enhance training for real life environments by creating a simulation of reality where people can practice beforehand

Key industries

gaming, entertainment, training, education, therapy

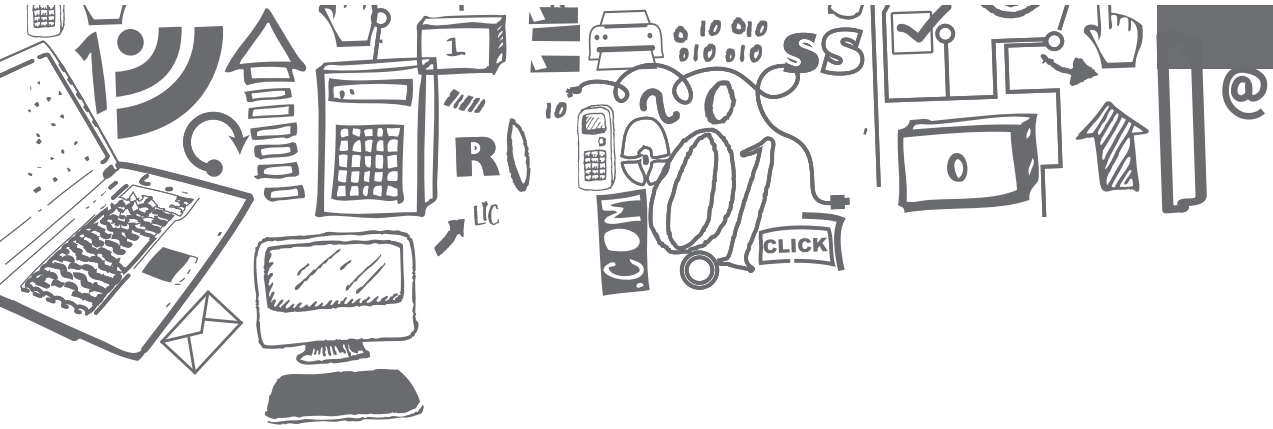
More capacity, lower cost

Low latency

Uniform experience

- VR and AR do not always operate independently of one another
- They are often blended together to generate an even more immersing experience.

Both the Chinese Government and the business segments are adamant about becoming leaders in virtual and augmented reality. The 13th Five-Year Plan has included VR as a focus area for economic growth. Formal central-Government initiatives include Internet Plus and VR+, with the latter apparently aimed at expanding the use of VR and AR technologies in traditional industries. New R&D labs are being formed by both the central Government and partnerships between private firms and municipalities. Another striking idea involves building VR towns, which could host VR and AR companies while incorporating the technologies into nearly every aspect of municipal operation and daily life.

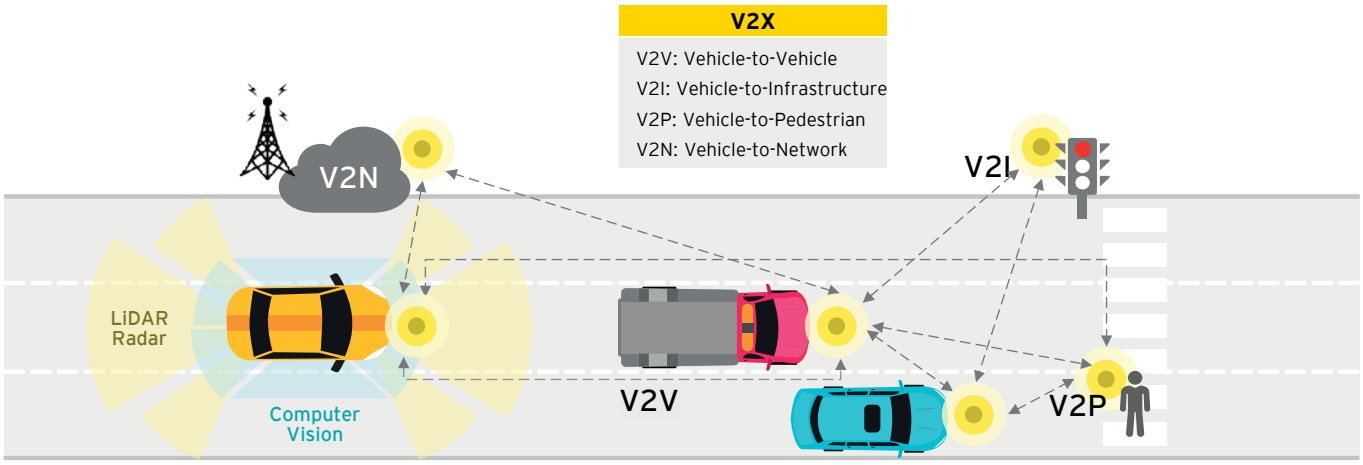


Numerous major Chinese internet and technology firms are actively exploring VR and AR. They are spending on multiple fronts with significant ventures under way. These companies are also funding their in-house VR programs, creating spinouts that move into VR, and investing in VR startups both at home and abroad. Currently, there are at least 200 startups working in China's VR industry. China is translating to a very vibrant new market for virtual reality, with a forecasted market size of US$8.5 billion by 2020[9]. The proliferation of these applications will be a driving demand behind network requirements for lower latency and more bandwidth, as well as more efficient content distribution.

High hope to make autonomous cars a reality

Much has been explored on the potential of autonomous vehicles such as accident avoidance, queue warning, congestion relief and energy saving. To achieve this, auto manufacturers and the wireless ecosystem are closely collaborating to accelerate Vehicle-to-Everything (V2X) technology development that leverages a network and other objects to give the car non-line-of-sight vision with longer range and cloud capabilities. V2X complements the autonomous driving functions such as Light Detection and Ranging (LiDAR) or computer vision functions that allow it to have peripheral vision.

V2X is a key technology enabler to enhanced advanced driver assistance systems (ADAS)



Improved active safety

- Allowing vehicles to coordinate their action to avoid collisions

Increased situational awareness

- Delivering a more predictable driving experience by gathering data from further ahead

Better traffic management

- Reducing distance between vehicles to enhance traffic management

See through

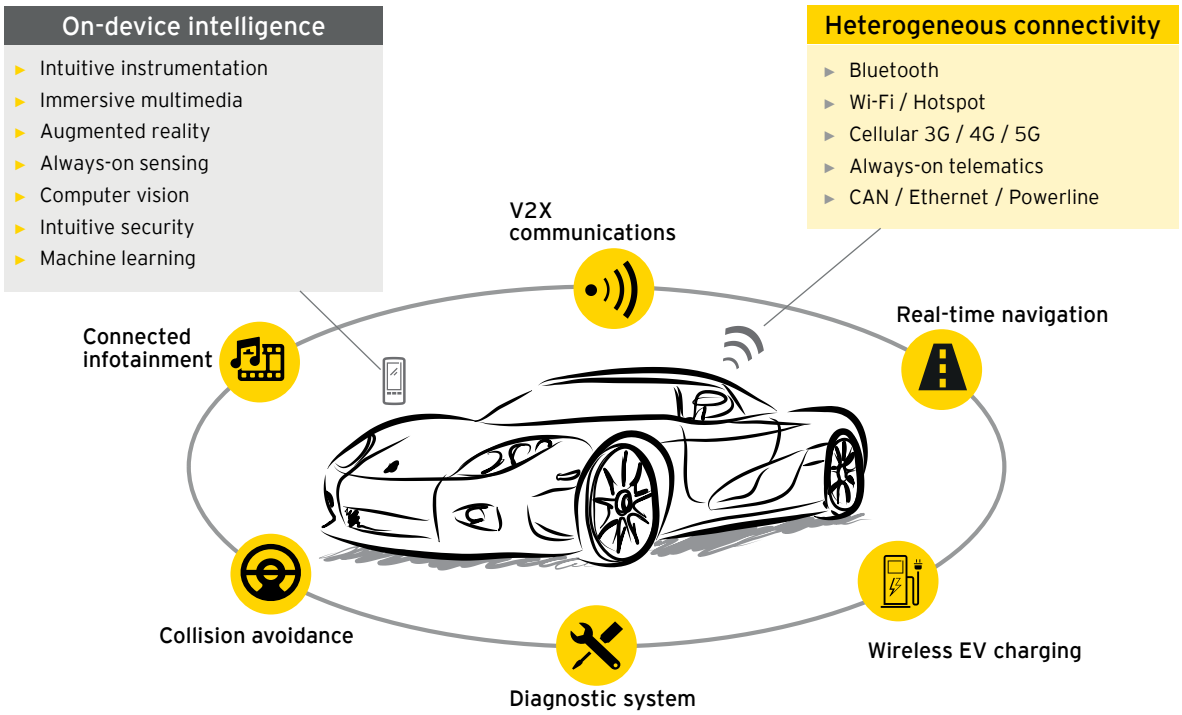
- Enabling small vehicles behind larger vehicles to see through the situation in the front

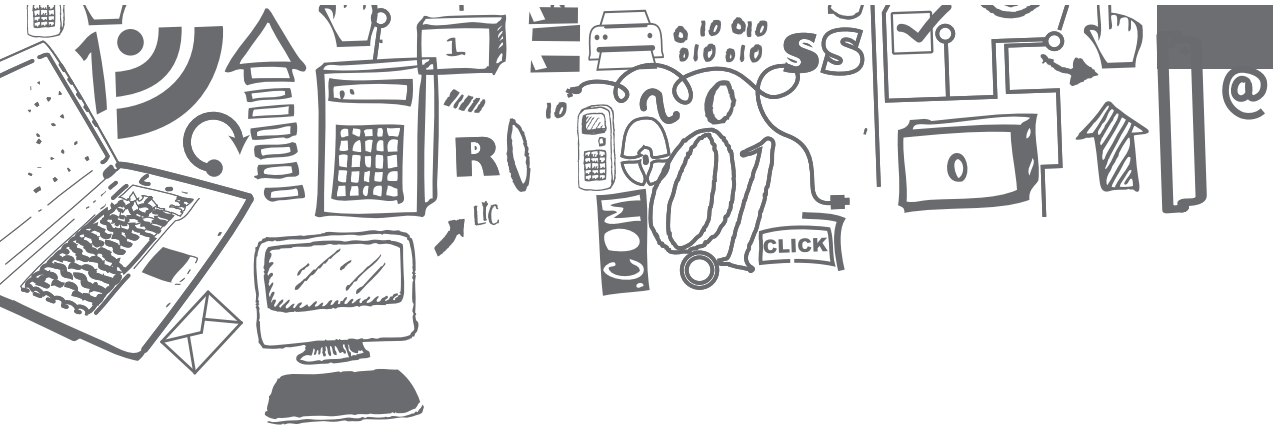
Source: Qualcomm

9. "China's Virtual Reality Market Will Be Worth $8.5 Billion and Everyone Wants a Piece," Bloomberg website, www.bloomberg.com/news/features/2016-05-15/china-s-virtual-reality-market-will-be-worth-8-5-billion-and-everyone-wants-a-piece, accessed 16 May 2016.

5G will build upon C-V2X (a cellular version of V2X) and bring new possibilities for the connected vehicle. The extreme throughput, low latency and enhanced reliability of 5G will allow vehicles to share rich and real-time data, fully supporting autonomous driving experiences. This will not only boost safety but also enable a broad range of use cases – from better situational awareness to enhanced traffic efficiency and connected cloud services. Autonomous driving will also improve passenger experience in the car, becoming a platform for digital video, augmented reality games and other streaming media services which can be boosted by 5G.

Autonomous cars require new levels of connectivity and intelligence





From a technology perspective, 5G will popularize intelligent cars although it won't work without an intelligent transportation system. While self-driving cars could be more than a decade away, there are several markets where uptake is expected to be faster. Among them, China has sought to position itself to spearhead the future of autonomous driving as seen from its high level of interest and investment.

As the world's largest auto market, autonomous driving has made significant headway in China with government backing. The country has come up fast with a regulatory structure – it has made "intelligent connected cars" a key direction of its 2025 roadmap for manufacturing upgrades, targeting to have self-driving cars for highway within three to five years and autonomous vehicles for urban cities by 2025. The draft will set out technical standards, including a common language for cars to communicate with each other, infrastructure and regulatory guidelines. With the country's first pilot zone opened in June 2017, Shanghai is expected to be the first Chinese city to build an intelligent-vehicle network covering 100 square kilometers by 2020. One of the Chinese internet powerhouses announced a US$1.52 billion (RMB10 billion) autonomous-driving initiative as part of a broader plan to promote the technological advancement of autonomous vehicles. It is looking to invest in 100 autonomous driving projects over the next three years.

China plans to be more ambitious than the western countries in adopting cellular data technology like LTE and 5G for vehicle communication, instead of the dedicated short-range communications (DSRC) standard commonly used in the US and Europe. It has been working on 5G and V2X technologies together to construct a cooperative environment. In September, China released its first standard designed for V2X application layer which will enable automakers in China to develop interoperable V2X applications for data interaction. The new standard also offers a mechanism for automakers to use a single communication technology for the development and commercialization of all V2X applications.

Chinese operators, equipment vendors and automakers are also actively engaged in the research, development, and solutions field-testing of real-life 5G autonomous driving applications. In July, a local industry group has demonstrated the world's first 5G-based remote driving technology with a consumer car.

5G will be one of the key enabler, along with driverless technologies, electric cars and government policies, that could help propel a national transformation. In addition, 5G technology will empower industries like ridesharing apps and car rentals, as well as improving carpooling and public transportation. A developed 5G networks will help China to achieve full autonomous driving in 2025. A research from CAIT forecasted that 5G-related investment in connect cars will reach RMB12 billion by 2030.

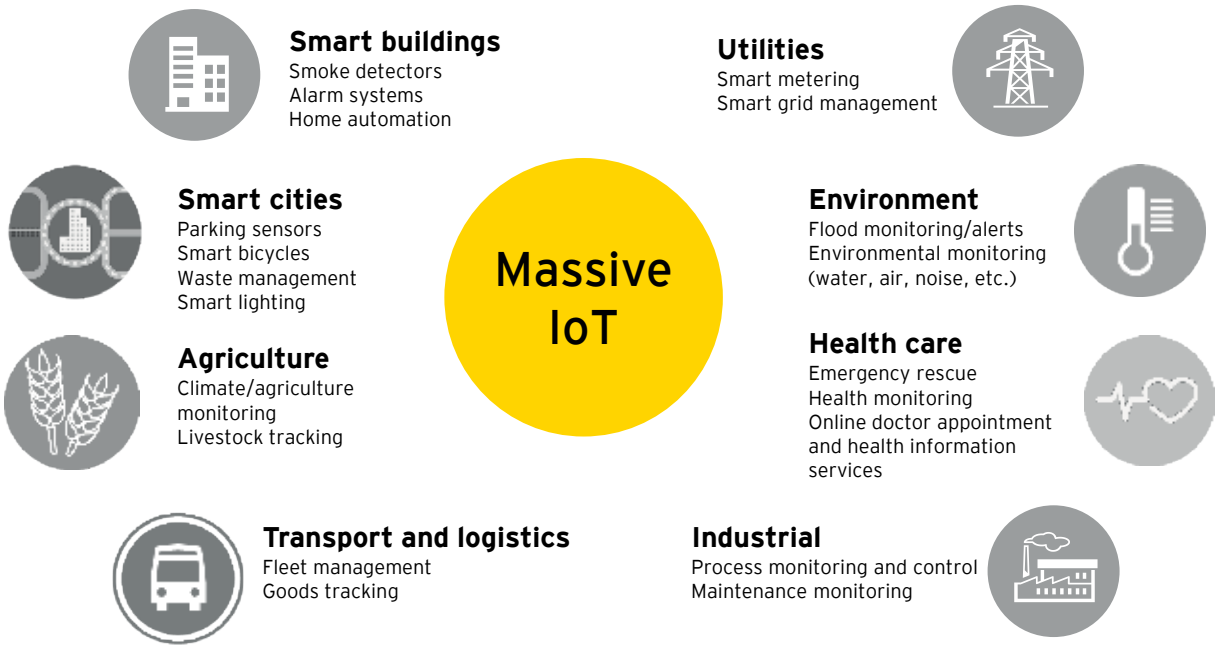
IoT is the long-term goal to redefine a wide range of industries

The Chinese government recognizes the key role of the IoT in various industries' efforts to modernize and remain competitive, and has incorporated the IoT in its 13th Five-Year Plan (2016-20). It also set ambitious IoT targets, where the MIIT anticipates more than 1.7 billion public machine-to-machine connections by 2020. To date, all Chinese operators have deployed the LPWA technology to target low-end IoT applications that require wide coverage but low data bandwidth. However, when it comes to huge number of connections with relatively efficient connectivity, Chinese operators are definitely thinking beyond the existing technology.

5G will make a difference in the realization of IoT. It will see growing importance in the IoT field in the years to come, as there will be more data-intensive and complex IoT deployments where ubiquitous fast mobile connectivity becomes apparent, but latency in existing cellular networks will be a limiting factor for many IoT applications.

Two types of IoT solutions and applications will revolutionize the 5G technology. First, a myriad of massive IoT applications requires high network capacity and efficient connectivity to enable the connection of billions of IoT devices – wireless sensor networks, connected home, smart metering and smart agriculture.

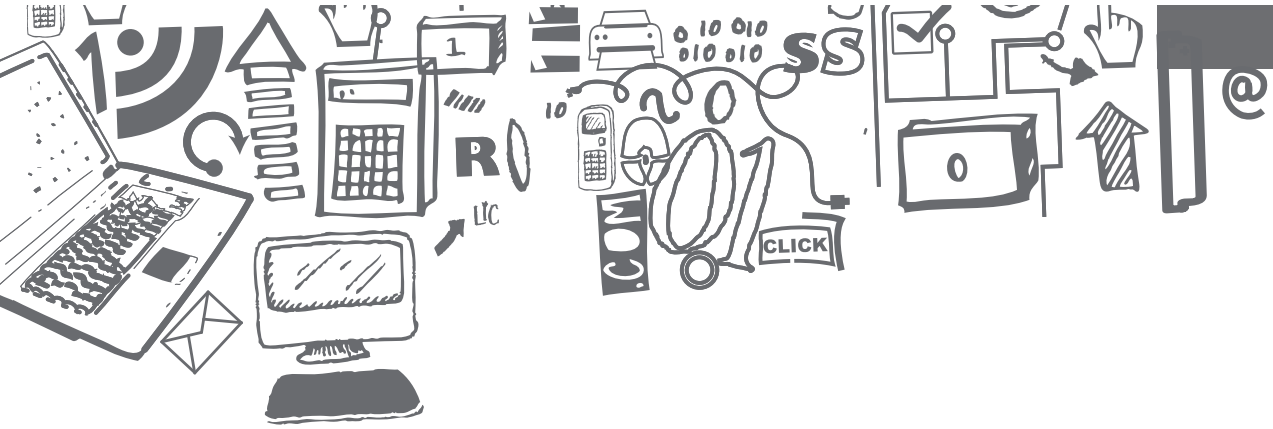
5G technology enables massive IoT verticals



On the other hand, critical IoT applications will have high demands on reliability, availability and extremely low latency where the volumes are typically much smaller, but the business value will be significantly higher. The mission-critical machine-type communication is envisioned to enable real-time control and automation of dynamic processes in various fields, such as industrial process automation and manufacturing, energy distribution and intelligent transport systems. Examples of such applications are connected vehicles, home automation and remote surgeries. In a broader scope, 5G will provide the foundation for building smart and safe cities.

Several verticals such as the industrial, agriculture, health care, energy and utilities sectors are likely to benefit early from 5G in China. China has a vision to be a world leader in precision manufacturing. Accompanying the Made in China 2025 initiative to shift toward more high-end manufacturing, 5G networks offer manufacturers and telecom operators the chance to build smart factories and take advantage of technologies such as automation, AI, connected robots, AR for troubleshooting and the IoT.

5G can transform the agriculture industry further, making it possible for connected drones to stream live footage of animals to their owners, while also surveying the surrounding landscape. A Chinese vendor recently demonstrated how a 5G-enabled drone could transmit high-definition images to the cloud and generate topographic maps in seconds.



The high reliability and low latency of 5G can be applied in health care to make complex, remote diagnosis and robotic assisted surgery possible for patients in the rural areas in the future. In the energy sector, 5G technology has the potential to dramatically enhance the way utility companies network their grid assets and systems, therefore maintaining balanced energy supply and demand in the grid.

Chinese operators are making big bets on the IoT. One operator has said it would pay RMB2 billion (US$303 million) as subsidies to IoT device makers. It is planning to boost IoT connections by connecting all kinds of products to the internet, including home appliances, vehicles, and water and gas meters. Together with equipment suppliers, the operators will jointly develop 5G network-enabled use cases for industries, as well as exploring business opportunities to reach the full potential of IoT.

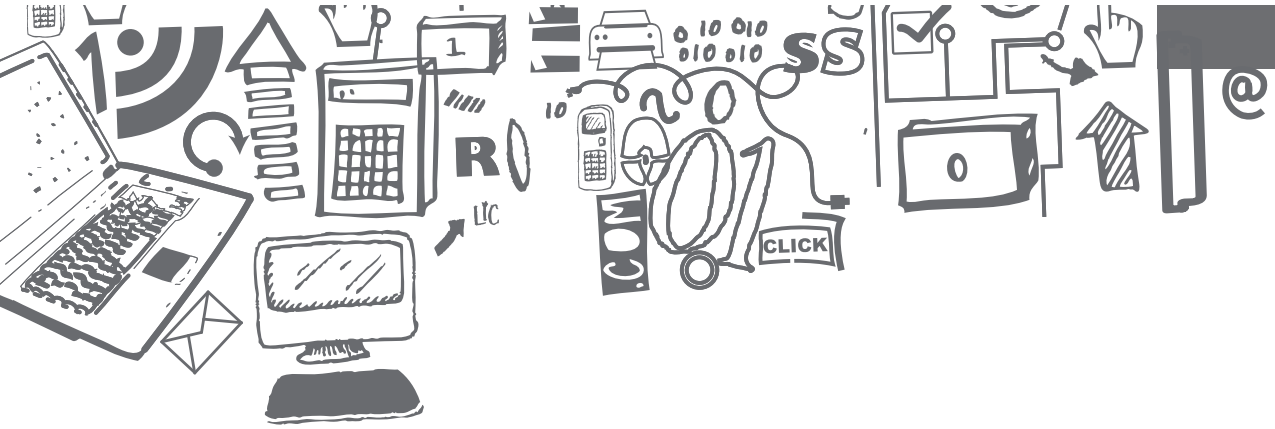
While IoT is seen as the biggest opportunity for 5G, this technology will not be widely available for at least five years, due to high development and deployment costs. Only when 5G coverage reaches scale will the IoT use case make sense in the market. Yet operators need to develop new business models to minimize network operating costs to deal with IoT applications with low data requirements and nominal duty-cycles, so as to justify the low average revenue per connection.

Key steps to capitalize on the 5G opportunity

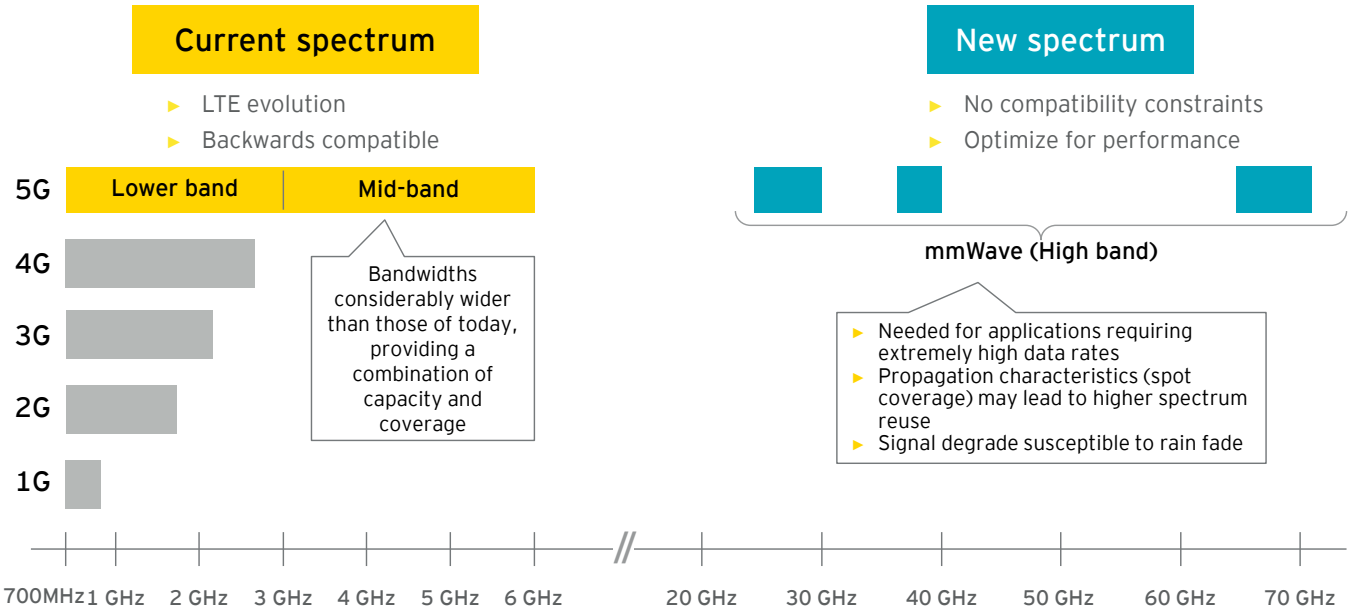
The boom of Chinese internet powerhouses has put enormous pressure on the telecom operators. 5G gives operators a competitive edge over rivals. But rolling out the 5G technology still has concerns – network buildout cost, insufficient spectrum, handset compatibility and technical complexities. Apart from the underlying technology, spectrum and regulation, there are wider business aspects that enterprises must not ignore if they are to capture the real growth opportunities that 5G represents. The business case for mainstream use case – enhanced mobile broadband – looks rather weak. This makes it difficult to justify the investments on 5G unless a more holistic approach is taken. To capitalize on the promise of 5G, operators must start preparing and taking necessary steps now.

Pick the appropriate spectrum

5G requires huge spectrum. Unlike the previous mobile technologies which used radio frequency below 3GHz, 5G will employ much higher frequencies since it is very difficult to find contiguous spectrum below 3GHz in most countries in order to achieve the required high bandwidth and throughput. The use of higher bands such as C-band (3GHz to 6GHz) and mmWave (30GHz to 100GHz) would effectively relieve the shortage of available spectrum.



Spectrum expands width from 1G to 5G



Source: EY analysis

Operators will face a decision on whether to employ new or existing spectrum for 5G, which will depend on the type of services they launch against the band characteristics and their strategies for rolling out the network. While the first question will usually involve a trade-off between coverage and available bandwidth capacity, there are other considerations such as device support, propagation and susceptibility to weather conditions, mobility support and cost implications. Currently, the expectation in most markets is that the enhanced mobile broadband or fixed wireless access will be the early use case and will use either mid-range bands or the higher bands (above 6GHz) primarily to target hotspots.

The expansion to mmWave bands is mainly driven by a need for more spectrum providing higher system capacity to handle the ever increasing traffic volumes. The first phase of 5G wireless access supports operation in spectrum up to 30GHz, with later phases expanding further up to 60 and 70 GHz. Although high frequency spectrum has the feature of high anti-interference, sufficient and reusable bandwidth, smaller size equipment and antenna with high gain rate, it has shortfalls such as shorter broadcasting range and stronger diffraction to the signal, which is easily affected by the weather or large obstacles. This makes certain regions such as the tropical areas in particular not suitable of using this spectrum. It is necessary to consider the work condition for high frequency bandwidth, which is often used cooperatively with other communication techniques.

Nevertheless, some operators and regulators are eyeing the lower bands closer to the current LTE frequencies for a more coverage-driven approach. It remains a strong business case for the lower bands in 5G for the rural areas. An US operator has announced its plan to use the 600MHz spectrum for 5G and LTE, while the EU has agreed using the 700MHz band for 5G across Europe by 2020. Spectrum limitation in the lower bands could inhibit the performance particularly for video services due to the limited bandwidth.

The Chinese Government has been proactive in getting ready for 5G. As a step to promote the development of 5G, China's MIIT has officially reserved a contiguous 500 MHz spectrum across the 3.3-3.6 GHz and 4.8-5 GHz bands for 5G services, with 100 MHz restricted for indoor use. This is in contrast to the fragmented frequency assignment in 3G and 4G. The ministry will make more spectrum available at low frequencies (below 3 GHz) for 5G, and will likely free up 3.6-4.2 GHz for future 5G allocation. The move is going to have an impact on the industrial chain as many countries and enterprises are planning to wait for China regarding the mid-band segment. When China has established the mid-band segment, it will speed up the maturity of the industrial chain.

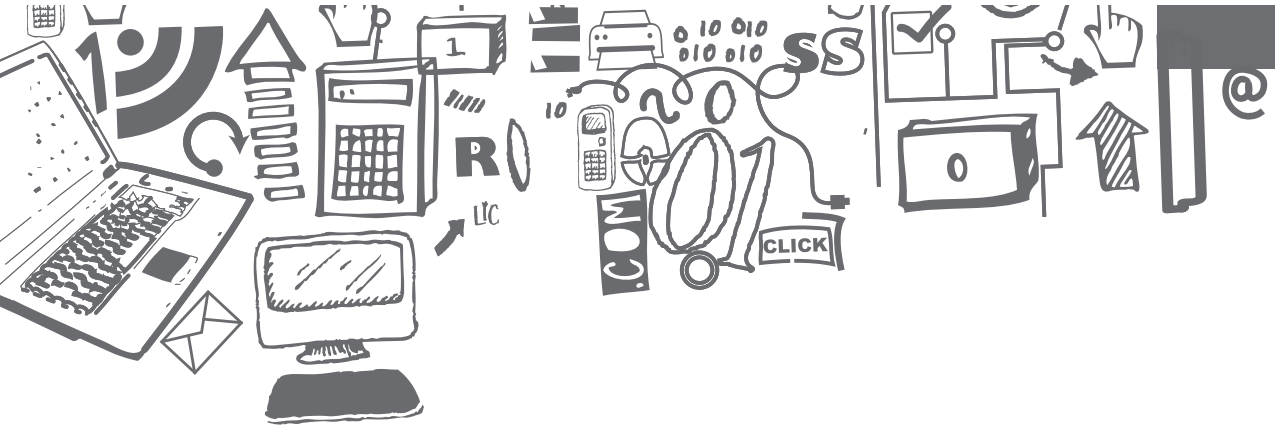
Although spectrum below 6 GHz is the best for 5G in the near future, the scarcity of it in China and the increasing difficulty in realizing international harmonization implies that it is time to seek for spectrum above 6 GHz. Preliminary studies show that a lot of suitable frequency ranges could be found between 6 GHz and 100 GHz in China. From the regulatory perspective, it is vital to perform solid researches on these bands, including channel measurements, system modeling and detailed studies on compatibility with currently used services.

A transparent spectrum policy will foster healthy 5G development

Governments and industry regulators have a pivotal role to play in driving long-term investments and R&D in the new technology which are essential to create a robust ecosystem. A supportive national strategy with clear legal framework, key initiatives and financial incentives are key to encourage network infrastructure buildout, equipment and device R&D and promote innovation capabilities from application developers. China's proactive national approach in 5G has put it in a strong position to lead the world in the 5G technology development.

On the regulatory front, a transparent and visionary spectrum policy will be highly beneficial to the industry players and provide them with investment clarity to plan and roll out their 5G networks and services. Regulators need to reassess licensing regimes, while ensuring auctions effectively reflect the changes in technology. They need to consider spectrum holdings holistically rather than in specific bands in future and conduct parallel auctions to speed up spectrum allocation. 5G can also be deployed on existing 3G or 4G band, so ease of refarming should be considered. Longer spectrum license durations like those between 15 and 20 years give operators considerable time to justify the expenditures on networks. Shared spectrum licenses that are similar in length will likewise attract most investments in platforms to enable sharing. In the US, the Federal Communications Commission (FCC) has encouraged more efficient uses of spectrum and promote robust network deployments in both urban and rural areas by driving alternative licensing arrangements that allow for shared access, instead of assigning exclusive licenses to specific operators.

Yet regulators worldwide will need to align the international band harmonization progress with its spectrum allocation timetable. This would require greater efforts for 5G due to the opening up of a much wider spectrum. Government agencies have to collaborate closely on spectrum agreement, creating a supportive investment environment and encouraging government to lead by example through digital services. It is necessary to achieve further regional convergence in order to support the new ecosystem development at higher frequencies.



Spectrum plan of 5G in selected countries

Country	Regulator's moves related to 5G spectrum
China	The MIIT reserved 500 MHz spectrum across the 3.3-3.6 GHz and 4.8-5 GHz bands for 5G service, with 100 MHz restricted for indoor use. In September 2017, the MIIT announced a policy on wireless spectrum allocation which basically determined the 5G network frequencies.
Japan	The government will revise spectrum allocation process to encourage new players to enter the 5G market. It seeks to bring transparency to how spectrum is awarded and adopt something close to competitive bidding. By introducing competition, the government hopes to drive down charges in the country.
South Korea	Ministry of Science and ICT (MCIT) is in the process of setting the terms for a planned 5G auction of 3.5 GHz and 28 GHz spectrum in June. The government is trying to determine the best method of allocating spectrum in the bands, with one option being to allocate them evenly among the nation's three mobile operators.
Australia	The Australian Communications and Media Authority (ACMA) carried out the multiband spectrum auction for frequencies in the 2.1 GHz, 2.3 GHz and 3.4 GHz bands, in addition to the 1800-MHz airwaves left unsold after a 2015 auction, which will likely be used for 5G services. A total of five companies have secured frequencies.
EU	EU has identified the 3.5 GHz band as a pioneer for 5G and agreed that the use of the 700 MHz band for 5G across Europe should be coordinated by 2020. Several member states including Finland, France, and Germany have already auctioned the 700 MHz band. EU ministers have agreed on a roadmap for the rollout of 5G technology across Europe by 2025. The roadmap will provide consensus over the harmonization of 5G spectrum bands and how they will be allocated to operators across Europe.
UK	UK regulator Ofcom has auctioned both newly-available 3.4 GHz spectrum, earmarked for 5G services. Five companies have been involved in the auction, with the four UK-based network operators splitting the auction proceeds. The spectrum acquired has a 20-year term and converts to perpetual licences thereafter.
US	The FCC voted unanimously in 2016 to make spectrum bands above 24 GHz available for 5G, opening up nearly 11 GHz of high-frequency spectrum. The FCC is opening up unlicensed spectrum to allow a combination of exclusive-use licensing, unlicensed access and shared access schemes.

Source: Industry news (Telecom Asia, Total Telecom)

China is showing signs of moving toward a more market-based model for telecom services. The country revised its spectrum policy in 2016, potentially allowing the country's 5G airwaves to be sold via a market-based approach (such as auctions), instead of the typical administrative approval that was used historically. This could bring about a more level playing field, unlike the 4G deployment cycle which had resulted in an imbalance market as the Government tried to promote the Chinese version standard.

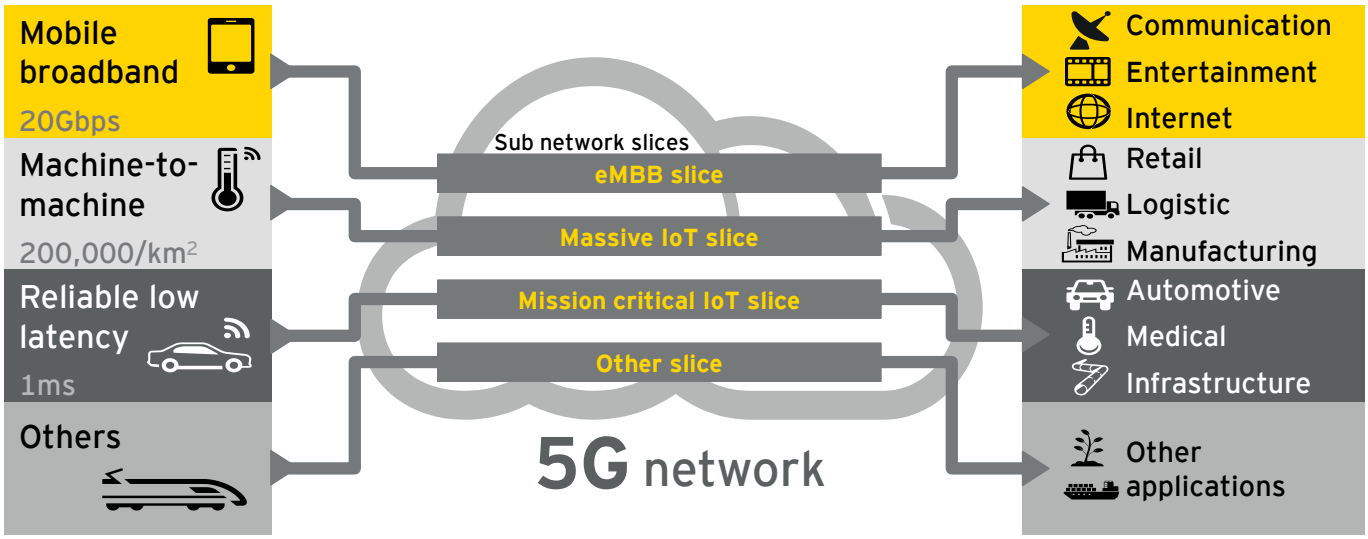
Invest in network slicing to pave the way for full network virtualization

The industry consensus is that 5G networks will be much more than just new radio access as these future networks will be an integration of cross-domain networks. To serve these new markets and increase revenues substantially, operators need to deploy a network that is flexible, highly scalable, cost and energy efficient to address as many applications and use cases as possible. The 5G system will imply major changes in the implementation and deployment of networking infrastructure.

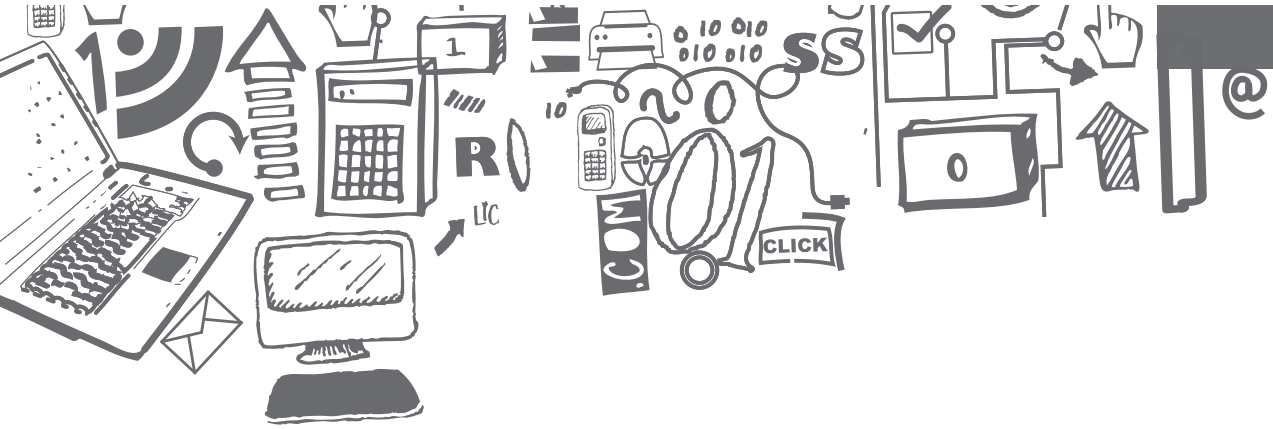
Separating software and hardware functionality in core networks through the implementation of software-defined network (SDN) and network functions virtualization (NFV) could be the best way forward for operators to comply with the strict availability and latency requirements of 5G. These virtualization measures, which allow traditional structures to be broken down into customizable elements that can be chained together programmatically to provide the right level of connectivity, lay the foundation for network slicing.

Network slicing allows operators to split a single physical network into multiple virtual networks. The partitioning of multiple network "slices" can provide customized connectivity to support differentiated services or business segments. The maximized elasticity helps address the cost, efficiency and flexibility requirements imposed by the large variety of industrial vertical services. All these vary from one service to the next in terms of data rate, latency, Quality of Service (QoS), security, availability and many other parameters. As a result, new products and services can be brought to the market rapidly and easily adapted to the fast-changing demands according to the needs of the industries.

Network slicing subdivides 5G network into virtual slices to tailor applications with very different requirements



Source: ITU



Multiple service providers, top equipment manufacturers, standards development organizations (SDOs), research institutes and associations are actively refining network slicing as part of the 5G journey. Technical trials, Proofs of Concept (PoC), R&D and business case development (enterprise extranets or industry verticals) are providing hands-on learning and establishing the value of network slicing. In advance of 5G, however, a number of the proposed features and functions of network slicing are already being tested on the current LTE networks with 5G standards in mind. Chinese operators are actively demonstrating network slicing in collaboration with vendor partners and the verticals.

A vendor study shows that network slicing enables new revenue generation, and lower OPEX and greater CAPEX efficiency, resulting in significant incremental contribution to the bottom line through new service launches. Network slicing, with cost-effective deployment of operational automation, could become the most economical way to manage service scalability.

Derive new business models with new 5G ecosystems

The changes of 5G are much more than just an enhancement of the cellular network to support traditional use cases. 5G is a technology evolution that powers other technologies such as IoT and AI, paving the way for the convergence of communications, computing and industries. 5G is no longer just about the telecom industry. It creates new markets and ecosystems with disruptive use cases that involve new business partnerships with industry players, system integrators and others. As a result, new business opportunities are opening up – both for those that have traditionally participated in the value chain such as telecom operators and for newcomers from other industries. Operators can approach 5G differently because it is very much about new use cases.

Operators have been trying hard to engage in product innovation with limited success during the 3G and 4G eras, in order to match those (if not excel) from the technology startups and OTT players. They should understand that telecom companies have different DNA and forget about finding a new position on the value chain. Instead they must expand their innovation horizons and embrace new ways of doing business. Capitalizing on their indigenous strengths in connectivity and analytics management to innovate services could help them differentiate over their unique position.

Currently, commercial model of 5G is still uncertain. Traditional communication and vertical industry should change from standalone innovation to cross-industry synergy, in order to jointly expand new 5G markets, exploring new applications and embracing the transformative 5G world. It requires close collaboration between all industries, developing a new ecosystem that will be facilitated by the right parties. This involves answering key questions: what are the demands of end users in each segmented market? How to correspond with national policies and regulations? How to find business models that are appropriate for the market? What are the revenue opportunities and where are their addressable markets?

Monetizing 5G requires new business model innovation. These models will be different from the previous generations of mobile networks because 5G is machine-centric rather than human-centric. In the 5G era, there will be a surging number of industries and businesses designed around platform-based business models. Such business models will be more viable over the more agile and flexible 5G networks that improve all the way from capabilities to provisioning and billing options.

In addition, 5G should pave the way for a larger number Business to Business to Customers (B2B2C) business models through APIs deployed at different levels (assets, connectivity and enablers). Operators can dynamically adjust resources to infrastructure demands, while connectivity and all network functions will be delivered as a service. With partnership-based business models, operators will tap into the opportunities to enhance the value of third party services. Partnerships will be established on multiple layers ranging from sharing the infrastructure to exposing network capabilities as a service end-to-end, and integrating partners' services into the 5G system through a rich and software oriented capability set.

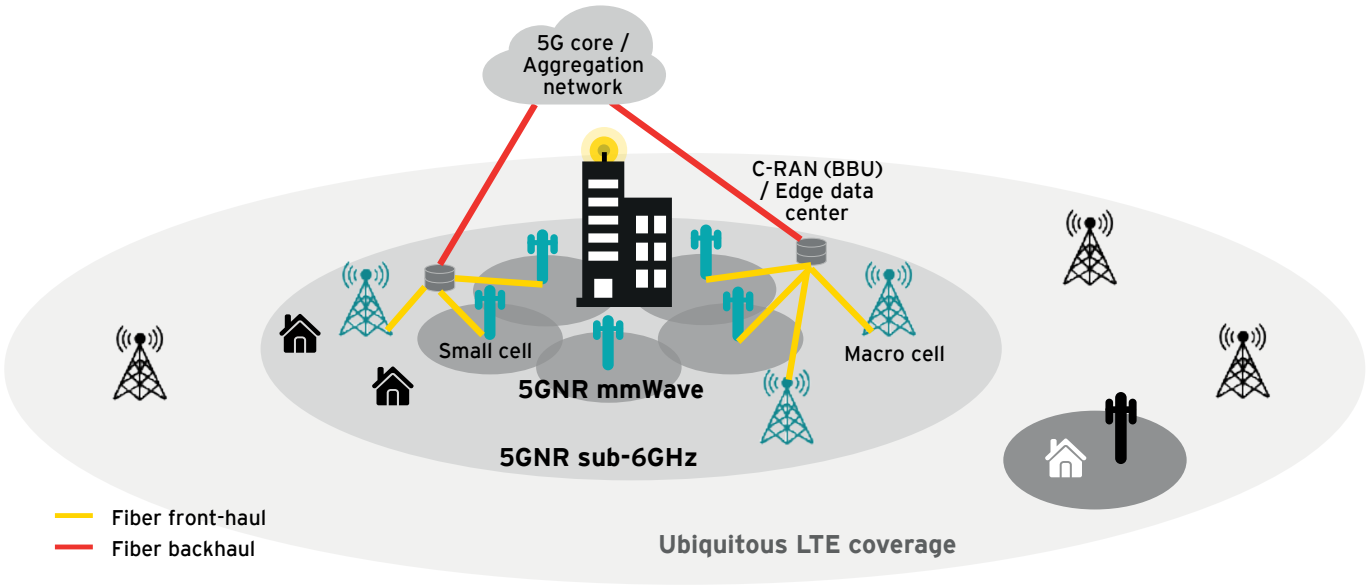
Chinese operators are aligned on the key verticals in which 5G can deliver value. As part of the business model exploration, one operator set up a 5G joint innovation center in February 2016, aiming at driving basic communication capability to achieve maturity, promoting the development of 5G innovation applications and constructing a multi-industry converged ecosystem. The innovation center engages closely with business partners in the telecom, internet and vertical industry, and it has attracted 42 business partners.

Substantial fiber investment key to activate complex 5G network

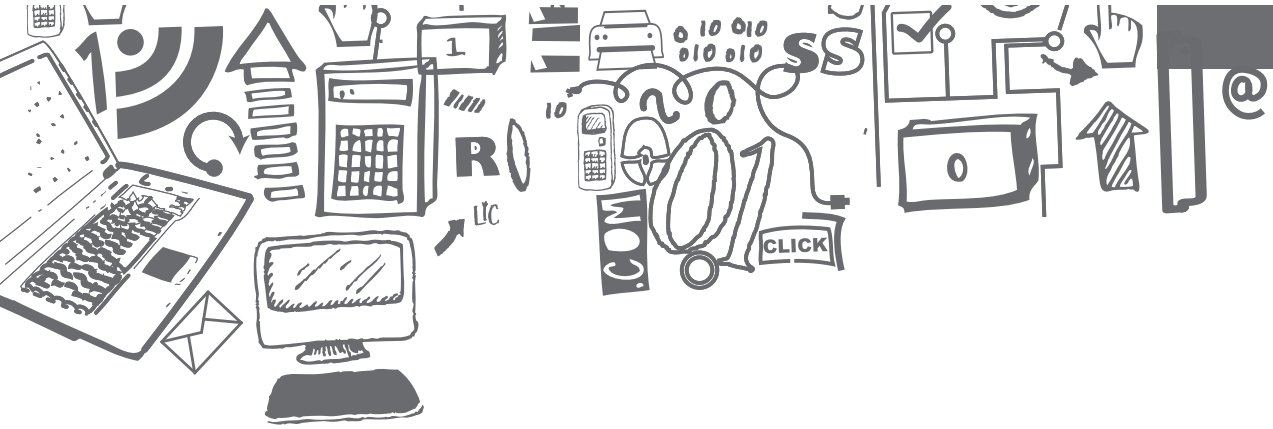
5G is as much about fiber as wireless. The ultra-high bandwidth and trillions of devices to be supported by 5G will magnify the challenge of how to accommodate the extraordinary increases in data volume and performance expectations. Fiber will play a huge role as the preferred technology for backhaul and front-haul, as well as a critical element of the low latency networks that will support the IoT. As data takes off, bandwidth pressures are increasingly in backhaul and transmission rather than access. Virtualization is likely to intensify the need for fiber behind radio head, because unprocessed or semi-processed radio signal requires fatter pipes than traditional backhaul. There is an imminent need to increase spending tackling the bottlenecks to improve customer experiences.

5G, which operates at much higher frequencies than LTE, implies a multiple-fold increase in cell density versus the current 4G networks. Such network densification is essential to providing the increase in capacity, particularly in high-traffic areas and necessary to meeting the demand for access both from subscribers and IoT. Furthermore, the use of millimeter wave will be associated with dense small cells more than ever due to their low propagation characteristics, to meet massive indoor coverage needs. This will put significant strain to the underlying transport networks that connect the Radio Access Network (RAN) to the packet core network. Front-haul, backhaul and various hybrid architectures will be needed to accommodate the cost efficient, backwards compatible and dense deployment of network infrastructure which is necessary to providing for the broadband and low latency demands of 5G systems. Having and building fiber is thus very important to activate the small cells.

A changing architecture for 5G network



Source: Qualcomm



In addition to network densification, new network topologies such as Cloud RAN or C-RAN are emerging which enable service operators to locate their base station equipment in the cloud – centralized units placed in data center facilities located at the edges of networks. Centralizing physical (or eventually virtualized) assets can save cost on real estate, translating into significant opex saving that includes the heating and cooling costs of locally deployed equipment as well as the power consumption of a network. C-RAN network architecture is expected to consume a large amount of fiber resources at the access layer for connecting the dense deployment of small cells to the centralized baseband units. To this end, there will be a huge demand of fiber resources when 5G deployments ramp up.

On the other hand, the emphasis of ultra-low latency of 5G also gives rise to the concept of mobile edge computing (MEC), where processing and storage capabilities are removed from the core network and placed at the base station in order to create new service opportunities for ultra-reliable network applications. Although it is in contrast to the existing centralization efforts, MEC could be built upon the existing Cloud RAN infrastructure to take advantage of the backhaul and front-haul links that have been converted from legacy to these new centralized architectures.

Despite the declining price difference between fiber and conventional coaxial cable, price is still a consideration in the event of massive fiber deployment. As a matter of fact, the cost of building fiber is not the same as the fiber itself, but the installation and authorization process can be lengthy and may require legal assistance. Operators must plan ahead to secure enough fiber resources, either by self-building or through backbone wholesalers, so that the transport would not become a bottleneck for 5G service delivery.

Early commercial rollouts will target spot coverage in major cities in China. Yet its enormous scale means that huge investment in small cells, new antennas and transmission upgrades with fiber backhaul is required to support the huge mobile data demand as a result of the upcoming 5G rollout. The Government has been investing on fiber networks in the last two years as part of the national initiatives to increase internet connectivity across the country. All three carriers are already active in the wireline broadband space, with increasing fiber optic cable footprints, which could serve as a backhaul for their 5G networks. Meanwhile, a Chinese carrier is building a 5G-oriented C-RAN front-haul network in the north-east Liaoning province, enabling its provincial subsidiary to effectively cope with the denser site deployment requirements of 5G, as well as further improving the existing LTE network coverage.

Build up cloud and analytic capabilities

It won't be possible to operate 5G networks without analytics. In an effort to support the multiple use cases, the role of data analytics is elevated by 5G. It comes in two aspects. From a multi-industry perspective, there are myriad of data sources to be collected and analyzed in support of the numerous benefits. 5G is positioned as an intelligent network that supports data and analytics use cases, helping it drive new industries in a way that wasn't possible previously. The implementation of mobile edge computing (MEC) will allow for this detailed moving data to be captured and returned to both the edge of the network and the end user device in real time. Behavior analytics can be used to predict what a user is likely to do and this information can then be used to design the best (highest customer experience) way to deliver network capacity.

Apart from supporting new business opportunities, data analytics will be critical to getting the complex 5G networks rolled out and operated. 5G network will be the platform for future service providers to deliver the new generation of services. They will be in a form of microservices which are small pieces broken down from large applications that are able to act independently of each other. These microservices allow for greater agility and better resource allocation and enable operators to meet the demands and challenges of 5G networks. As a result, network data is essential for managing the complexity of 5G networks – where to deploy capacity, how to balance capacity and coverage and where to scale specific network functions or application microservices.

To truly harness the expanded 5G network and service capabilities, operators need to move from pipeline to platform provider. This could see telecom operators transform into mobile cloud operators where access to content and applications is provided via open APIs that allow the network to be consumed on demand and monetized accordingly. This new "cloud native" operator will be able to manage and deliver services over a highly distributed, virtualized and on-demand environment. The extension of the cloud computing model to the telecom industry will unleash innovation and allow new players to access the ecosystem. Through cloud native infrastructure and microservices, 5G can provide operators with an opportunity to accelerate digital transformation strategies.

5G requires a very sophisticated cloud computing market, as the applications can't be efficiently managed outside the cloud. Security and privacy are key to gain enough trust from companies (and their customers) to deploy new business models based on these high levels of connectivity and interconnectivity.

Transform into highly automated supported systems

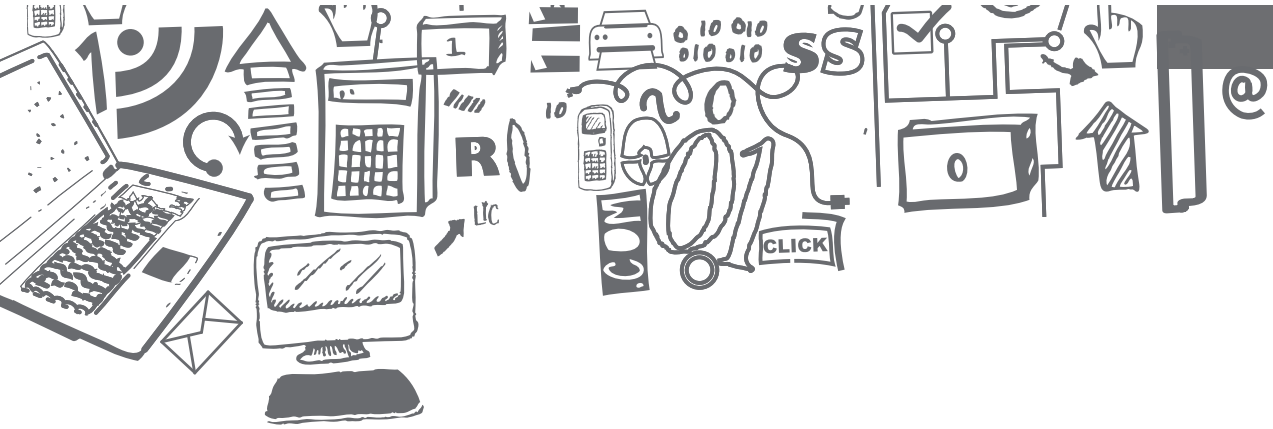
The transition to 5G will be an all-encompassing effort, seeing the transformation of user interfaces, connectivity, infrastructure and above all, operations. Such complexity will require a well-structured operations support systems (OSS) and business support systems (BSS) to provide essential business functions such as operations support and billing, and to deal with the more advanced analytics, automation and orchestration that are essential in 5G. Operators must replace and transform their legacy back office systems to get ready for the new services, new applications and new business models. Failing to do that will result in a bottleneck situation for operators and slows down business.

In the world of rapidly evolving 5G and IoT technology, go-to-market speed matters almost as much as the product. Companies need to enhance their expensive, slow and insulated BSS/OSS in order to deliver agile services with simpler and better customer experiences. 5G networks will be increasingly virtualized and software programmable, driving the convergence of IT and Telecoms, thus upgrading the OSS and BSS is key to supporting 5G network. The virtualized network infrastructure should be seamlessly integrated with the OSS and BSS so that the enhanced system would allow operators to respond automatically to clients.

A lineup of IoT and business services uses different billing structures to traditional residential broadband and video packages. On the customer side, operators need to boost their focus on customer autonomy by improving self-service options for sales and aftercare services, as well as to cut churn by improving the customer experience through better tools. All these require a revamp of the existing OSS and BSS platform.

Many operators built up the OSS/BSS over time through acquisition and overhauling the platforms may not be easy. Our 2017 survey[10] revealed that this was the biggest barrier facing operators on their digital transformation journey. Changes to the OSS and BSS stack require careful planning and analysis, combining with clear communication across the technology and business departments within a company.

10. 2017 EY "Digital transformation for 2020 and beyond – A global telecommunications study"



Explore the wholesale opportunity

As operators plan for 5G investments, a major consideration is how they could generate revenues and a Return on Investment (ROI). However, justifying the investment case for 5G isn't easy, and is even more difficult if the operator is in the developing world where demand for 5G services is low.

Operators can offer differentiated networks as a service to wholesale customers such as mobile network virtual operators (MVNOs) or enter into partnerships with verticals and specific segments by implementing network virtualization, edge computing and new back-office IT orchestration systems, based on the concept of network slicing. Such a step would be a departure from the traditional enterprise connectivity business model.

The dense network infrastructure requirements of 5G networks mean it would be unsustainable in some markets if all major mobile operators are required to deploy their own infrastructure. The hefty capital investments for 5G would make operators consider network sharing. Some countries are considering to create a national shared and regulated nationwide 5G backbone using the same model as the national fiber broadband network. While this move may be beneficial to smaller operators and MVNOs as they can start offering 5G services quickly, constructing a nationalized 5G network would however be very costly.

In view of the small cell deployments, front-haul and backhaul will be the most significant wholesale opportunity associated with 5G for fixed operators. In fact, 5G itself (at the high spectrum bands such as 24GHz and above) could also be used for backhaul, which means 5G license holders could be both customer and competitor for backhaul providers.

The road ahead

Unlike other countries where 5G is being driven by operators looking to gain a competitive advantage, it is part of the national goal in China to become a leading digital country. China is cooperating, as well as competing, with the west on 5G. It has invested massively to dominate 5G rollout and development and is well-poised to succeed.

China's TMT companies are taking the lead in the 5G race. Chinese operators are aggressive to get a head start for the commercial launch as early as 2019. Infrastructure providers, network operators, local authorities and the Government are all working to develop the required infrastructure. New devices and applications will join the market as soon as the network rolls out, which will connect the dots between TMT and the other verticals. Meanwhile, internet companies are making hefty investment in the new 5G-enabled applications such as autonomous cars and robotics in an attempt to make an innovation lead. Ultimately, the entire industry will transform and new industries will emerge. With a new ecosystem being developed in China, it will be interesting to see how the industries converge and collaborate in the years to come.

While other markets are catching up, China will enjoy the dominance due to its commanding influence throughout the value chain. Leading and shaping this technology will bring enormous economic advantages for years. It is crucial that Chinese companies leverage China's position in the 5G race to shape the global standards in their favor.

5G will change the landscape of the industry so much that operators will lose their competitive advantage if they don't act soon enough to evolve their businesses. They need to identify their key areas of focus rather than attempting to own everything. Developing a viable commercial model is key to determine their position in becoming a platform provider or a mere pipe provider, while leveraging IoT and other 5G digital services to monetize new growth. Finding ways to foster service innovation is a way to future-proof the businesses against the rising cannibalization from OTT players.

Since 5G is a convergence play, operators need to boost their capabilities by acquiring non-core assets and technologies to create converged networks and to compete better in a service oriented market. This is going to be an important driver to accelerate industry consolidation and M&A activity that could involve a vertical player, a technology solutions provider and even a wireline network operator.

There is a lot to be excited in 5G. That said, it is highly unlikely there will be considerable short-term gains from 5G investment. Protecting carrier investment in 4G and enabling a smooth transition to 5G remain important to the carriers who have invested heavily in R&D in 4G. Operators must make sure they get the most out of 4G which is still in the middle of its lifecycle.

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