Embrace the New World of 5G

Roland Berger

Introduction

Under the multiple impacts of policy, economy, society and technology, "5G" has become the hottest topic in recent years, especially in 2019, known as "the first year of 5G". At the same time, the definitions and understandings of 5G are not agreed yet. Based on a global authoritative database, its extensive project experience and expert network worldwide, Roland Berger has built a "5G Ecosystem panorama for the first time, clearly defining the industry ecology of 5G, which has a wide span and far-reaching influence.

5G is an ecology that integrates the communication industry with a uniform standard, delivers services as an industry and drives disruptive changes through communication industry with applications supported by comprehensive services. In nature, 5G is still a set of communication standard jointly developed by experts from different countries and industries. It is the "universal language" of global communication and relevant industries and the "representation of time" for the development of communication technology.

With the advent of the 5G era, 5G pushes application scenarios cross "from 1 to 3", with industries being influenced and empowered exponentially growth. Based on this, Roland Berger take the three 5G core potentials of "high bandwidth, low latency, pan connection" as the evaluation dimension, and built the "5G Industry Impact Index" model for the first time, linking 5G technology and industry to help international and Chinese companies understand the impact of 5G technology on the industry and find unique positioning and coping strategies for the 5G ecosystem.

In this report, we focus on three application areas of "Industry 4.0" in "5G to lead the industry breakthrough", "remote medical" in "5G to stimulate industry. innovation" and "VR / AR" in "5G to promote industry value-added", to analysis the changes and the latest developments of companies in this field. At the same time, Roland Berger has actively participated in various industries to help companies build business strategies in the 5G era to better embrace change and get prepared in the new era.

The United States and Japan, which promotes 5G construction by enterprises, while South Korea is a successful example of global 5G commercialization led by the government. With the clear definitions of 5G ecology, clear plans of the development path, clear guides of the innovation direction, cooperation and win-win, South Korea government promotes the development of 5G services in the layout of terminal application. The experience of win-win cooperation between government and enterprises is a great lesson for us.

China has a large population, a diversified industrial structure, and a strong innovation power. It is the best experimental field for R&D and implement of 5G technology. For the future development blueprint and direction of 5G in China, Roland Berger suggested 4 principles of "environment, wellbeing, people and cooperation. To drive 5G infrastructure by policies, and to support the implementation of government procurement projects, to embraces players around the world with an open cooperation and partnership.

I. New Era - Gain insight into the essence of 5G

1.1 The game-changing 5G ecology

5G ecology compromising of 5G standard, 5G service and 5G applications is an essential part of modern economy and life. It is an industry ecology featuring large span of industries and widespread influence that integrates services with a uniform standard and drives disruptive

changes through communication industry with applications supported by comprehensive services. Under this background, both the communication industry and service users will feel the difference brought by it.

Figure 1: Panoramic view of 5G ecology
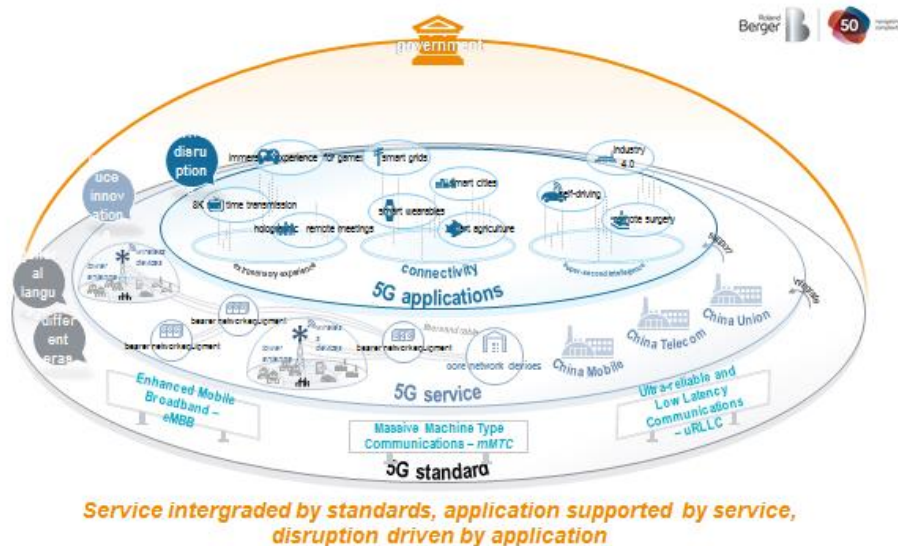
In nature, 5G is still a set of communication standard jointly developed by experts from different countries and industries. It is the "universal language" of global communication and relevant industries and the "representation of time" for the development of communication technology, which defines the technical aim for communication industry in the short run, namely, Enhanced Mobile Broadband, Massive Machine Type Communication and Ultra Reliable &Low Latency Communication. The standard is also referenced by organizations and enterprises for joint R&D of technology and specification preparation in the aim of guiding and coordinating the development of service and application among different industries.

5G service providers including communication network device manufacturers and telecommunication operators together provide the society with wireless communication

service. Communication network device suppliers include manufacturers of 5G devices that make up the core network, manufacturers of optical transmission devices that make up carrier network and that of wireless access devices such as antenna, base station and optical fiber. Telecommunication operators refer to China Mobile, China Telecom and China Unicom. Guided by the standard, these communication enterprises cooperates to build service infrastructures meeting the specification of 5G technologies through constant innovations, thus delivering complete communication services capable of disrupting current communication applications.

5G applications that will be directly used in our daily life will dramatically change our existing production methods and life styles and is also the ultimate commercial form of three technical aims of the standard. Based on demand for telecommunication service resources, its terminal applications may be divided into large bandwidth-enabled super experience, multi-machine-enabled IoE and low-latency-enabled ultrafast intelligence. The overall upgrade and innovation of communication service in the era of 5G will drive the new technology development supporting AR/VR, IoT and artificial intelligence from consumer-restricted, communication-enabling and low volume 4G to game-changing 5G that will cover government, enterprises and commerce.

The development and operation of ecology at such a large scale cannot be achieved without the macro control and promotion of the government who as a participant in the service purchasing and application innovation needs to drive the development of industry chain thus improving people's livelihood.

1.2 5G Standard: the universal language and a representation of time

Dating back to the era of 1G, communication standards were spontaneously developed in

different countries such as NMT in North Europe, AMPS in the US and Australia, TACS in UK, C-450 in west Germany, Portugal and South Africa, etc. These standards have guided the participants in the communication ecology to continuously update relevant products and services based on the same standard. However, since each country implements an individual standard, it is very difficult to universally use communication devices and services, which hinders in a large scale the development of international roaming and other inevitable trends. In order to promote communication interaction beyond industries and countries, the UN established ITU to take charge of development and issue of international communication standards. ITU will put forward proposal, collect technical specifications prepared by major organizations and develop the final version of communication standard protocol. In this way, the isolated local languages of different countries have gradually developed into a universal language that may be used in global communication industries and relevant vertical fields.

Figure 2: the evolution from local language to universal language of international communication standard
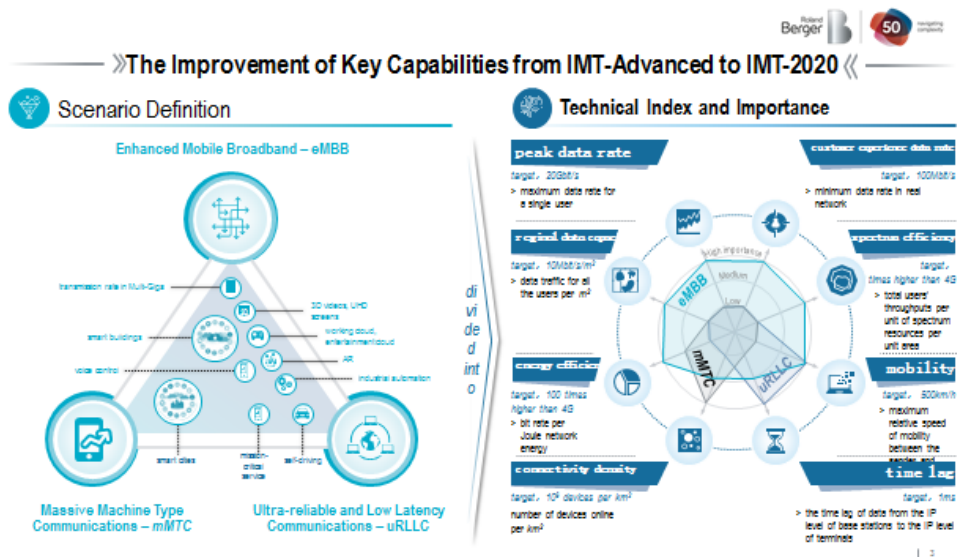

Source: Roland Berger

ITU proposals the vision of 5G in 2012 aiming to realize eMBB up to 20Gbps, mMTC of one

million machines per square km and uRLLC of 1ms. The vision also defines breakdown of each technical project and the quantitative aim of each program. It is expected that the international 5G standard document IMT-2020 will be released in 2020.

Figure 3: Definition and technical parameter breakdown of 5G scenarios in IMT-2020
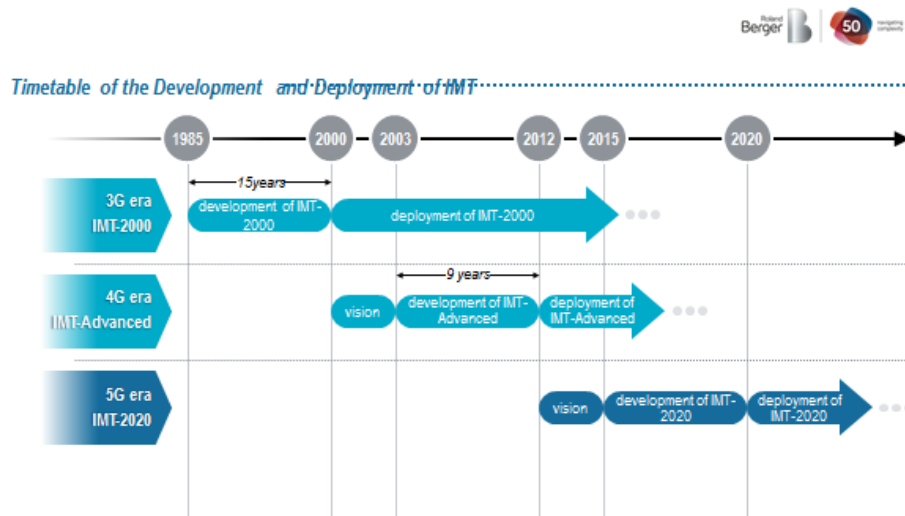

Source: Roland Berger

Therefore, 5G is not simply a kind of technology, but a set of communication technology standard jointly developed by different countries and industries. It integrates the communication industry with a universal language so that all technical experts and business elites around the world may realize coordinate to create technical miracles in communication industries.

The communication standard is never achieved overnight from the 3G era. It takes ITU ten years to develop the new generation of communication protocol standard. Meanwhile, the industry participants tend to simultaneously develop new generation of communication products and services while drafting the technical specification for technical specification groups. By the time the standard is fully implemented, a variety of new technologies are

already competing against each other in the market. It is through such upgrade that keeps the communication technologies continuously advancing.

Figure 4: the evolution of communication technology in different eras

Take the current 5G standard as an example, it is only a representation of time during the course of communication technology development which serves as its short term aim. With the development of communication technology, ITU may collect new technical specification that will involve more frequency spectrum, functions and scenarios, derive more technical aims and realize more technical visions. All future technologies are likely to be the development results of 5G era, or be labeled as the next generation technologies.

II. New Era - Internet of Everything Enabling Three Application Scenarios

2.1 Technology iteration - 5G pushes scenarios cross "from 1 to 3"

The application of mobile communication technology in the iteration of 1G, 2G, 3G and 4G

gives birth to more and more application scenarios. In the voice era of 1G, people can only transmit voice via analog communication; the text era of 2G marks the opening of digital communication, when SMS and low-speed Internet access, text browsing and other functions are supported; in the image era of 3G, Internet access and social applications are becoming more common, kicking off the era of smartphones; now in the video era of 4G, with the great increase of communication speed, online games, video, live streaming and other richer communication functions are achieved, promoting the birth of a large number of mobile application enterprises.

Figure 5: Scenario change from 1G to 5G
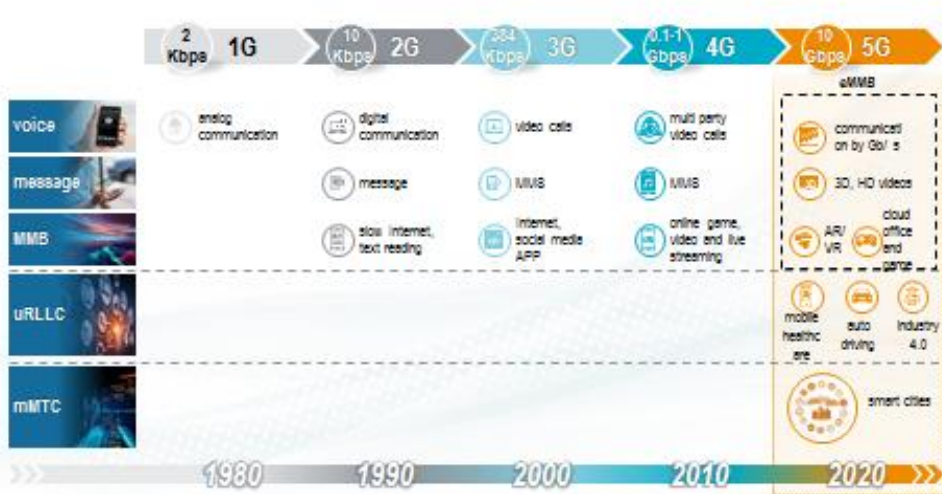
Compared with previous generations of mobile networks, the 5G application scenario will enjoy a leap-forward development. It will achieve a stride leap in the field of mobile communication, re-upgrading 3D, UHD video, AR/VR, cloud office and other immersive interactive modes, while bringing out two new application scenarios. The low-latency communication scenario with superior reliability will bring mobile medical care, autonomous driving, Industry 4.0 and other application into reality, and the large-scale machine-like

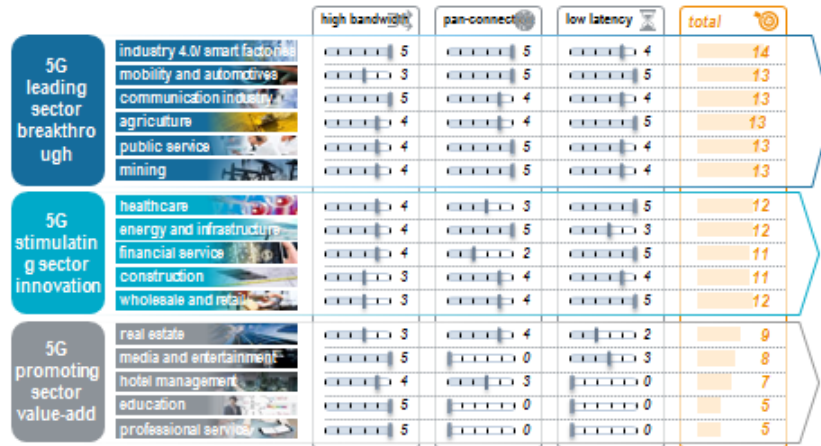communication scenario will be widely used in smart cities and smart homes.

2.2 Focus on the impact-build a 5G industry impact index model

Based on the global authoritative database and its extensive project experience in global communication standards, digital transformation, AI planning, Industry 4.0 and IOV, Roland Berger has built a "5G Industry Impact Index" model, which aims to help global and Chinese companies intuitively understand the impact of 5G technology on the industry, and find their unique positioning and coping strategy in the 5G ecology.

In the 5G industry impact model, we take the three 5G core potentials of "high bandwidth, low latency, pan connection" as the evaluation dimension. "High bandwidth" is used to assess whether the birth of ultra-high-speed, large-scale transmissions and related apps will bring about significant changes in the industry, "low latency" is used to assess whether ultra-high security and ultra-low latency continuous connectivity is required according to the nature of the industry, and "pan-connection" is used to assess whether the large-scale application of IoT devices will improve the efficiency and effectiveness of the industry.

In this framework, we use the 5G Industry Impact Index model to evaluate 16 sectors and according to 5G impact dimensions and application potentials on these sectors, divide them into three types: "5G leading sector breakthrough", "5G stimulating sector innovation" and "5G promoting sector value addition".

Figure 6: Segmentation of three types of industry under the Roland Berger 5G Industry Impact Index

		high bandwidth	pan-connect	low latency	total
5G leading sector breakthrough	industry 4.0/ smart factories	5	5	4	14
	mobility and automotives	3	5	5	13
	communication industry	5	4	4	13
	agriculture	4	4	5	13
	public service	4	5	4	13
	mining	4	5	4	13
5G stimulating sector innovation	healthcare	4	3	5	12
	energy and infrastructure	4	5	3	12
	financial service	4	2	5	11
	construction	3	4	4	11
	wholesale and retail	3	4	5	12
5G promoting sector value-add	real estate	3	4	2	9
	media and entertainment	5	0	3	8
	hotel management	4	3	0	7
	education	5	0	0	5
	professional service	5	0	0	5

Source: Roland Berger 5G Industry Impact Index model; HIS "The 5G Economy Jan 2017"; Roland Berger analysis

2.3 Strategically - 5G reshapes industry development pattern

● 5G leading sector breakthrough: take Industrial 4.0 as an example

For the first type of sectors, 5G is a very important and missing key technology in the industry evolution. 5G technology is a must for the development and breakthrough of these sectors. Representative sectors include Industry 4.0, transportation sector, communications Internet sector, public service sector, agriculture sector and mining sector.

Taking Industry 4.0 as an example, the development, application and breakthrough of the sector rely strongly on the characteristics of 5G, such as pan-connection, low latency and low energy consumption. By powerful wireless connection, edge computing and network slicing technology, 5G will help wireless automation control, industrial cloud robots, predictive maintenance, flexible production and other sectors achieve breakthrough, driving the real implementation of Industry 4.0 and further promoting the birth of the future factory.

Predictive maintenance, as a key innovation and potential flashpoint in Industry 4.0, involves real-time monitoring of machine status, identification of anomalies and automatic performance of maintenance work, which can reduce machine maintenance costs and downtime on a large scale, and adjust and optimize machine settings with real-time feedback on data. Predictive maintenance has a high demand for pan-connection, low energy consumption and other features of 5G. The high load-carrying capacity of 5G will increase the number of connected devices by more than 100 times, resulting in the detection and predictive maintenance of the entire supply chain, coordinating and optimizing the entire production cycle, and the low energy consumption of 5G chips will also significantly reduce predictive maintenance costs.

In the context of the 5G driving Industry 4.0, all participants in the 5G ecology are in win-win cooperation to carry out related technology and application research. Huawei and Beckhoff unveiled a key technology that could enable future smart factories in April 2018: wireless programmable logic controller (PLC) based on 5G technology. During the successful concept validation experiment at Hanover show, two companies demonstrated the use of a 5G-based prototype of a wireless industrial network between two collaborative PLCs, replacing the traditional cable communication mode. Compared with the current wired network system, the direct integration of cellular technology in PLC will be able to achieve industrial automation in a more economical and environmentally friendly way. NTT Communications Corporation and NS Solutions, a leading Japanese company, announced their new operating robot in March 2018. Operators can operate the robot remotely in real time by just connecting via the 5G network provided by the telecom company. At present, the robot can synchronize with the operator's upper body movements to make corresponding actions, and such technology will be used in the future in the workshops or dangerous environment.

Roland Berger, from Germany, as the standard maker of Industry 4.0, actively participates in

the wave of Industry 4.0 in the 5G era. Roland Berger has created Intelligent Factory Assessment Model (EPA) and Industry 4.0 Evaluation Standard System to help enterprises conduct intelligent factory maturity assessment. It also enters the factory site and works together with the factory operation team to formulate the implementation plan of Industry 4.0 in the 5G era for leading manufacturing enterprises through seminars, helping enterprises carry out the digital upgrade of intelligent workshops and intelligent factories.

And Roland Berger, as a practical think tank for Industry 4.0, has helped a number of leading manufacturing companies transform to Industry 4.0. With more than 100 projects in cooperation with Bosch, Roland Berger has helped it design plant automation strategies, big data business models and imagine the future plants, while helping Bosch establish intelligent predictive maintenance solutions, systematically analyze multi-dimensional real-time data across the value chain, and establish big data algorithms to calculate device failure patterns, so as to assess machine status, create a maintenance plan, dynamically perform checks and maintenance to prevent failures from actually occurring. The predictive maintenance system ultimately helps Bosch reduce unexpected failures by up to 75% and downtime by 45%, saving up to 30% of maintenance costs while improving the product quality. In addition, Roland Berger helps Bosch build IoT systems in 5G scenarios, effectively facilitating the integration of the entire production process, and further enhancing the flexibility, traceability, versatility and productivity of industrial production.

- ## 5G stimulating sector innovation: take telemedicine as an example

For the second type of sectors, 5G will provide an excellent innovation platform that continues to inspire innovative applications in the field. Taking the healthcare sector as an example, 5G technology will be expected to make telemedicine truly popular with its excellent performance, such as low latency and high bandwidth.

5G provides better technical implementation conditions for telemedicine, improving

telemedicine and tele-care by offering faster speeds, more stable connections, shorter time delays and greater capacity. With 5G technology, doctors can access image information faster, conduct remote consultations, and even carry out remote surgery. In order to achieve changes in the way patient applications are handled, patient data will need to be centrally stored in the future, and in the end, hospitals will be transformed into data centers and doctors into medical data specialists, revolutionizing the entire medical service.

As early as July 2016, Ericsson united with King's College London took delayed "remote control and intervention" as 5G healthcare example, where the probe serves as a robotic representation of a biological finger, giving surgeons a tactile sensation during minimally invasive surgery and providing accurate real-time localization of hard nodules within soft tissue. The probe (robot finger) can identify the cancerous tissue and send the information to the surgeon in the form of tactile feedback. China Mobile also worked with the Second Hospital of Zhejiang Medical to carry out a remote B-ultrasound demonstration, with the delay between the doctor end and the check equipment at the patient end on the emergency vehicle less than 10ms. In January 2019, AT&T Inc in the United States, together with Rush University Medical Center, created the first 5G hospital in the United States. As an important technology, 5G will inspire innovative application scenarios of modern hospitals on a large scale and provide high-quality patient and employee experience, when fully implemented.

Roland Berger has also been operating at the forefront of 5G enabling telemedicine. It helped Switzerland's leading telecom providers analyze the innovative application scenarios and opportunities that 5G would bring to them, and finally, three innovative solutions with the most commercial application prospects and feasibility were selected from more than 20 innovations: telemedicine solution for chronic diseases, exclusive remote service solution for the elderly, and establishment of an e-health collaboration platform. At the same time, Roland Berger helped Siemens establish a tele-health demonstration project in Germany, seeking a

new medical business model for the 5G era. As predicted by HIS, 5G will provide more than $1 trillion in products and services for the global healthcare sector, and telemedicine will achieve more than $230 billion in market size by 2025.

- **5G promoting sector value addition: take VR/AR as an example**

For the third type of sectors, although the application scenarios begin to appear in the 4G environment, but 5G, as a technology platform, will continue to enable the sectors and promote sector value addition. Representative sectors include media and entertainment, real estate, hotel management, education, professional services and so on. Enterprises in such sectors should look to the future and dare to be the first to fully tap the value addition points 5G brings to the sectors, preparing for continuous leadership in the 5G era.

Taking VR/AR as an example, the emergence of 5G will bring it three major value addition points: product experience improvement, cloud upgrade imagination and product cost savings. The most advanced network has a latency around 40ms in the 4G environment, and the latency of 1ms or below brought about by 5G will strongly support users to still get a good VR/AR product experience in the mobile environment; and the storage and computing functions of current VR/AR products are still mainly concentrated locally, which limits the size and weight of VR/AR products. Up and down peak rates in the 5G environment will span from 20Mbps to 20Gbps, and more high-quality VR/AR contents and applications will be brought to the cloud. Cloud server-based data storage and high-speed computing capabilities, while meeting the growing experience requirements of users, significantly cut down the device prices, accelerating the evolution of the cloud VR/AR phase represented by ultra-high experience games and modeling, cloud-based hybrid reality applications.

Across the world, besides VR/AR enterprises, leading telecom and Internet enterprises are also eager and active to get involved in the creation of the cloud VR/AR system, trying to

seize the opportunity in the cloud VR/AR era and find their own unique industry positioning.

Amazon Verizon used 5G-enabled goggles for VR Live at the NBA All-Star Game in Los Angeles in 2018, where its lightning speed was fast enough to simulate a real-time stadium event; AT&T set up an edge computing test area in California, USA, applying low-latency complex applications and high computing power to the VR/AR field to continuously improve functionality and user experience, hatching new business models such as cloud VR/AR and cloud-driven games. Enterprises in China are also actively deploying in the cloud VR/AR sector. In January 2019, Huawei held 5G Cloud VR service press event in Shanghai, sharing its three service modules: Cloud VR development kit, Cloud VR connection service and Cloud VR developer community; DPVR, a 5G joint venture VR enterprise of China Mobile, actively demonstrated its PC VR game work Ganghun based on 5G edge cloud architecture at the mobile world congress (MWC2018) in Spain.

In China, China Mobile in Shanghai and Huawei provided a 5G DIS solution. Developed in Shanghai, it is the only commercially available 5G indoor product in the industry, and can be delivered in batches. In February 2019, China Mobile in Shanghai and Huawei provided Hongqiao railway station with the first 5G indoor digital system. At the launching ceremony on February 18th, China Mobile in Shanghai and Huawei demonstrated the network operation capability of the 5G indoor digital system (up to 1.2Gbps peak rate), and the possible new lifestyle in 5G era through interactive experiences such as smart guide and dinner-serve robots.

2.4 Embrace changes - enterprises actively participate in the ecological construction of 5G

As the leader of the new era, Chinese enterprises should also actively embrace the new era, participate in the formulation of international standards, conduct cross-border cooperation to

establish innovative business models, and use new technologies to enhance the efficiency of enterprise operations, which will be the new propositions in the 5G era.

- Active involvement in the international 5G standardization

5G is still growing. Chinese enterprises should get involved in the 5G standardization of ITU and 3GPP, to promote the evolution of the new version of 5G with high quality proposals and substantial technological innovation. In the process of defining technical rules, synchronous development and innovation are required so as to seize the market opportunity in the 5G era.

Advancing Qualcomm

In the standardization of 5G, Qualcomm has played a leading role in providing new creative and guiding directions for 3GPP, while investing heavily in the promotion of commercial use of 5G NR, including the introduction of a prototype system that complies with the 3GPP 5G NR specifications and interoperability testing with a wide range of system vendors and global operators.

Qualcomm is also one of the leading vendors in defining the 5G consistency testing framework, which is a critical factor in achieving pre-commercial use of 5G in 2019.

In the process of participating in standardization, Qualcomm has gained a great deal of voice and obtained an absolute first-mover advantage. Its Snapdragon X50 5G baseband has been selected by 20 terminal manufacturers around the world, and will be used to make the first batch of 5G equipment. And a number of mobile operators use Snapdragon X50 to carry out 5G new air interface moving of below 6GHz and millimeter wave band.

- Actively promote cross-border innovation and try new products

5G is the networking between enterprises. It is difficult for a single enterprise to independently drive the implementation of new product services at this stage, so it is required to find a partner with a consensus of 5G application scenarios to drive innovation in product services through cross-border collaboration, and the resulting new business model is the highest boiling point for 5G in the future economy.

- ## Upgrade 5G version of enterprise strategies to make adequate preparations for the new era

5G is not far off. With the arrival of 2019, the first year of 5G, 5G will bring about changes in the market environment and internal mode of operation for all enterprises.

Leading companies should think about their unique positioning in the 5G era, and quickly upgrade their corporate strategy, learn about 5G technology, develop 5G products and services, making full preparation for the arrival of 5G. They should know the impact of 5G, make full use of the advantages of 5G technology, carry out systematic upgrades of the whole chain covering enterprise management, R & D, production, operation, supply chain and sales, to enhance the overall efficiency of the enterprise and break the enterprise ceiling in the traditional environment.

III. New path - draw experience from partners and co-create pilot fields

3.1 5G vision of the world

With the steady evolution of 5G standard, governments and enterprises around the world are also developing 5G strategy and launching R&D programs to advance the progress of large scale commercialization of 5G technology. Around the world, besides China, South Korea, America, Japan and other countries are also forerunners in 5G commercialization.

In addition to small scale trial and intensive promotion, most governments and telecommunication operators will choose to demonstrate their 5G technologies at international events in the aim of boosting market confidence and showcasing national strength. During 2018 Pyeongchang Winter Olympics, Korea Telecom demonstrated 360° 5G virtual experience and holographic image broadcasting technology; in America, Verizon carried out a 180°remote 3D live broadcasting at the 2018 NFL Scores - Super Bowl event; Russia applied low latency Video Assistant Referee (VAR) and demonstrated VR and HD video broadcast at 2018 World Cup; in the 2020 Tokyo Olympic, it is expected that NTT Docomo will use 8K video stream of view 360° and implement face recognition with edge intelligence at venue entrance and other security scenarios.

Figure 7: 5G time line of different governments and telecommunication operators
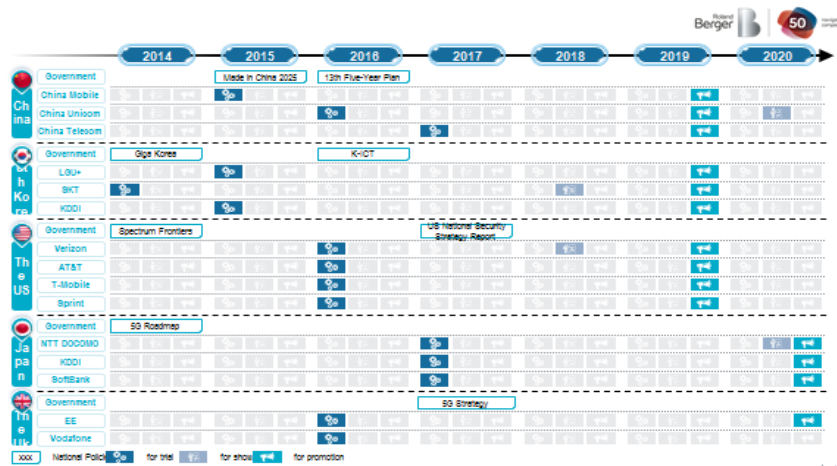
Source: case study; Roland Berger analysis

3.2 South Korea - The first 5G country in the world

South Korea, a successful example of full 5G commercialization led by government, is making the first stride on behalf of the world in large scale 5G commercialization. Different from 4G, 5G in South Korea is initiated by enterprise and government. The three major operators in South Korea, namely, KT, SK telecom and LG U+ have successfully developed the first commercialized enterprise clients in December 2018 thus introducing the world the era of 5G. Close cooperation between government and enterprises has played a crucial role in this process.

The first commercialized 5G enterprise clients

The first clients of three major operators are all enterprises who will receive customized enterprise solutions.

The first 5G client of SK telecom is a auto parts supplier named Myunghwa Industry. Myunghwa Industry transfers image data (pictures/videos) of production line via 5G network to cloud server where images are analyzed by artificial intelligence to detect potential defects in products. The purpose of these is to improve the quality of production line.

The first client of KT is Lotte World Tower located at Seoul. Lotte World Tower, 123 floors, is a must-see sight for tour in Seoul and Lota, a tour service robot it configured adopts 5G technology. The 5G package Lota uses includes 10G network flow per month at a monthly flat rate of RMB 300 yuan.

"The reason we choose Lota as our first 5G client is that we want to highlight that 5G is not only about change of mobile network. It may serve as a platform that enables us to carry out innovations in our daily life and industries."

- *An Executive from KT*

To pioneer the development of "5G era" in the world, South Korea government begun to actively plan the incubation and implementation of 5G technology in South Korea as early as in 2013 when 5G standard is still at its early stage of development. Organizations and projects

led by the government such as GIGA Korea[1] and 5G Intelligent Factory Alliance [2]closely cooperate to promote the "convergence era" pioneered by 5G technology. The South Korea government made a clear definition of 5G ecology, development roadmap and guided the direction of innovation to encourage win-win cooperation. It also promotes the implementation of 5G service through configuring terminal applications. It is through steady promotion and detailed definition that make South Korea pioneer the development of 5G technology from which we may draw valuable experience.

- Definition of 5G ecology

The implementation of 5G projects involves the overall technology upgrade of multi aspects and multi industries from technology R&D, supply chain reform, infrastructure building to commercial operation and downstream application development. This immense and complicated system needs to be clarified at the early stage of development and allocated to corresponding agencies and enterprises so as to define the function and role of each enterprise and agency.

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[1] The key scientific research project of network communication led by Ministry of Science, ICT and Future Planning of South Korea is to create South Korea's 5G ecology system. It planned the whole industry ecology and production-research stages from AR/VR, multi-party high definition conference to holographic projection. The results have been applied in 360º 5G virtual experience and holographic image broadcasting in Pyeongchang Winter Olympics and also an important part of full 5G commercialization in 2019.

[2] Ministry of science and information technology, Ministry of trade, industry and commerce and Ministry of Small and Medium-sized Enterprises and Startups of South Korea jointly established intelligent factory alliance to promote the application standard of 5G in South Korea and explore new business models. Members of the alliance include ICT companies such as SK telecom, LG-Ericsson, Microsoft Korea, HYUNDAI BS&C, system technology developers such as Samsung Electronics, Siemens Korea, Omron Korea. In 2018, the enterprise members of the alliance reached 19 and are expected to build 30000 intelligent factories and 10 intelligent industry zones.

Function setup of Giga Korea

The core function of Giga Korea is to support network communication of extra-large data flow. The five types of CPND stakeholders are defined at the early stage, the boundary of ecology is specified and the way of interaction for this five stakeholders is also defined.

Contents generator/service provider

Responsibilities: create contents of Giga level (such as VR film) and provide relevant service (such as multi-party HD meeting)

Relevant enterprises: in addition to traditional media like films and television, sports and news, it also includes emerging content providers like holographic projection and ARVR

Platform operator

Responsibilities: improve the compatibility of cloud storage and overall computing power

Relevant enterprises: cloud platform and big data

Network operator

Responsibilities: improve mobile network speed

Relevant enterprises: telecommunication operator, telecommunication equipment provider

Device manufacturer

Responsibilities: promote devices that may create, transfer and receive contents of Giga level

Relevant enterprises: including 3D display device, multi-screen device, mobile 3D device and holographic projection device manufacturers

● Route planning

In early 2014, there were still many problems in 5G technology such as ambiguous standard and responsible persons. Therefore, it is pretty important to define clear phased achievements and annual aim at the early stage of the project and clearly specify when and what work relevant responsible persons must complete as well as set measurable phased aims in order to help relevant enterprises and organizations steadily achieve the long term aim.

Table 1: Example of three phase development plan of Giga Korea (South Korea)

	Phase 1 2013-2015	Phase 2 2016-2017	Phase 3 2018-2020
Network	The network speed may reach tens of Mbps – The download time for 3D Avatar is about 3 hours	The network speed may reach 500 Mbps – The download time for 3D Avatar is about 7 minutes	The network speed may reach 1 Gbps – The download time for 3D Avatar is about 3 minutes
Device	Intelligent hand-held device	Naked eye 3D device	Holographic apparatus
Platform	Computing power of 1,000 PCs Single cloud terminal	Computing power of 100,000 PCs Interaction of same cloud terminals	Computing power of 10,000,000 PCs Interaction of different cloud terminals
Content	Support transfer of 3D contents	Support transfer of five-sense experience	Support transfer of holographic image

● Guide the innovation

At the early stage of 5G development, South Korea has clearly defined the six development directions of priority, namely, automatic drive, robots, disaster relief, AR/VR, smart city and smart factory. In this way, it may avoid aimless terminal service development and optimize the R&D and manufacturing resources around the country.

● Win-win cooperation

To ensure the efficient implementation of 5G technology at a national strategy level, the Ministry of Science and Information Technology of South Korea has made a lot of communication and negotiation.

Valuable lessons from 4G development drive cooperation in 5G

Dated back to 2011 when 4G LTE was introduced in South Korea, the three major operators fiercely competed for the title of "The first 4G LTE service operator" with huge investment. They even fight for users through alleged accusation which caused serious resource waste.

Therefore, in April 2018, the South Korea government guided three major operators to reach an agreement to jointly build, share[3] and simultaneously launch 5G service with tax preference policy and maintenance service. While eliminating the interest conflicts among operators to the maximum extent, the government also strives to reduce repetitive investment and building caused by cut-throat competition. It is predicted that South Korea may save USD 935 million in ten years.

- Terminal applications planning

As one of the 5G clients, the government shall also purchase government projects while promoting the development of 5G industry to drive the development of government terminal services.

Intelligent Transport System Program of Seoul

The municipal government of Seoul has invested USD 23 million to build intelligent transport system with SK telecom in Seoul. SK telecom will install 5G sensors manufactured by Samsung Electronics on the main roads in Seoul and provide public buses and taxis with 5G telecommunication terminal devices. SK telecom will also establish a control center to collect data and provide safety related information. Public buses and taxis mounted with 5G devices will coordinate communication between bus stations and traffic lights and send messages to public buses and taxis in case of any dangers. This service may also serve non-5G regular buses through T Map navigation application from SK telecom to reduce accident risks. Meanwhile, the government of Seoul may also conduct real-time big data analysis to provide information required by optimization of traffic system.

This program has been under test since January 2019, and 2000 road sensors have been mounted by far which will be delivered by the end of 2020 and cover 121km's urban highway.

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[3] The three major operators will cooperate to build and share 5G base stations as well as all transfer and network access infrastructure.

3.3 China - the ideal test field of 5G

China, with a large population base and high population density, has a comprehensive industry structure and strong innovation power. Thus it is a ideal place for 5G technology R&D and implementation.

- High population density

According to the latest data in 2018 Statistical Bulletin of Communication Industry by Ministry of Industry and Information Technology, the mobile network users of China has reached 1.31 billion. In terms of communication infrastructure, China has constructed the largest 4G network in the world. In 2018, the total number of 4G base stations has reached 3.72 million with the newly built 439 thousand stations. The dual support by high population density and well-established infrastructure may maximize the scale effect of 5G industry and reduce operator's cost per bit which both contribute to more economical 5G products and applications.

- Diversified industry structure

5G industry is at a stage of evolution and formation. Therefore, development and application of new technology as well as the integration and cooperation with other industries have become extremely important.

China, as the second largest economy[4,] the largest industrial[5] and agricultural country[6], as well as the second largest country of service industry[7] and the largest trading country[8], has

[4] The largest economy: based on 2017 GDP ranking by International Monetary Fund (IMF)

[5] The largest industrial country: based on 2017 *The World Factbook* industry ranking by Central Intelligence Agency

[6] The largest agricultural country: based on 2017 *The World Factbook* agriculture ranking by Central Intelligence Agency

[7] The second largest country of service industry: based on 2017 *The World Factbook* agriculture service industry ranking by Central Intelligence Agency

[8] The largest trading country: based on Global merchandise exports ranking by WTO

grown up as the largest and most diversified economy in the world. 5G innovation of each industry or cross field may find the best commercial environment and industry ecology here.

- Strong innovation power

Besides strong industrial power, China also has the world-leading innovation basis. Mature enterprises in China now are able to compete against leading companies in America such as Baidu vs Google, Alibaba vs Amazon, WeChat vs Facebook and Huawei vs Apple. Startups in China are also catching up. From artificial intelligence to financial technology, from virtual reality and shared economy to E-commerce, these companies are making revolutionary progress in a variety of technology fields. "Copy China" is on the rise and China is the best trial field for 5G technology.

Figure 8: international experts comment on the possibilities of 5G development in China

50% of the mobile network coverage in China is based on 4G networks, which is very impressive. For the upcoming 5G era, China is leading the development of 5G networks, and fosters various innovative business models, which is a very smart move. This is a very smart thing.
Mats Granryd, GSMA Director General

In the future of 5G era, Ericsson plans a large-scale deployment in China in the first place. Ericsson is investing heavily to be a technology player in the 5G market in China. The strategy here is to root in and seize the market.
Hans Vestberg, CEO of Verizon Communications, Former President of Ericsson

China is a key market for EU companies in 5G era. China may become a major player in the development of 5G technology, with great potential to become the world's largest market for 5G technology, products and service. At the same time, China will also play an important role in the establishment of global standards for 5G technology.
Jean-Claude Juncker, President of the European Commission

3.4 Inspiration from China

China, as a powerhouse of economy and culture, shall make encouraging policies to promote the construction of 5G infrastructure and facilitate the implementation of government purchase programs. More importantly, it shall embrace all participants around the world in an open and collaborating way.

- Environment: promote the construction of 5G infrastructure

By virtue of the advantage of high population density and well-established network, develop the infrastructure development road map from 4G to 5G. In specific, gradually expand from urban center to area of low population density, and promote the upgrade and improvement of 5G infrastructure step by step. Swiftly promote the commercialization of 5G mobile network from trail to demonstration and introduction through the three major operators.

- Wellbeing: promote the 5G upgrade of government service program with people oriented

Drive changes to people's life and work brought by 5G technology with the concept of improving people's livelihood through government purchase program. Facilitate the development of 5G industry chain in China and promote the penetration of 5G applications in consumers, enterprises and governments.

- People: promote win-win cooperation among different stakeholders

Define the main innovation direction and invest resources to drive the product R&D and model innovation of such application in 5G environment. Launch R&D programs, establish industry association, guide enterprise cooperation, promote the concept of win-win cooperation and create efficient and intensive industry environment.

- Cooperation: seek cooperation in international competition and achieve win-win

Actively participate in the development of international standard and encourage foreign

enterprises to test 5G products and services in China. Integrate into international 5G industry chain, create international industry convergence platform and promote the implementation of international cooperation. Create open business environment and promote the vision of collaborative innovation and joint development.

IV. Conclusion

Throughout the world, 5G is a great opportunity for this era, an important driving power of economy development and social progress and also a chapter that shall be composed by global community of common future.

Looking at China, Chinese nation is well known for its openness, cooperation and inclusion. They are the pillar stone of the ever-lasting Chinese culture which brings up the 5000 years civilization that make the world salute. This cultural foundation has facilitated the cooperation of China with other economies since the introduction of reform and open-up policy and has been a guidance through the building of open global economy. The profound creativity and spirit of reform and innovation have made China one of the important members that drives the global economy development.

Adhering to the principle of cooperation, openness and innovation, China will become the main driver of progress, innovation and breakthrough in the global 5G market. Both politicians that steer the direction of national development and entrepreneurs that promote the prosperity of economy shall fully understand and actively embrace the emerging 5G technology and explore an new road of openness and innovation.