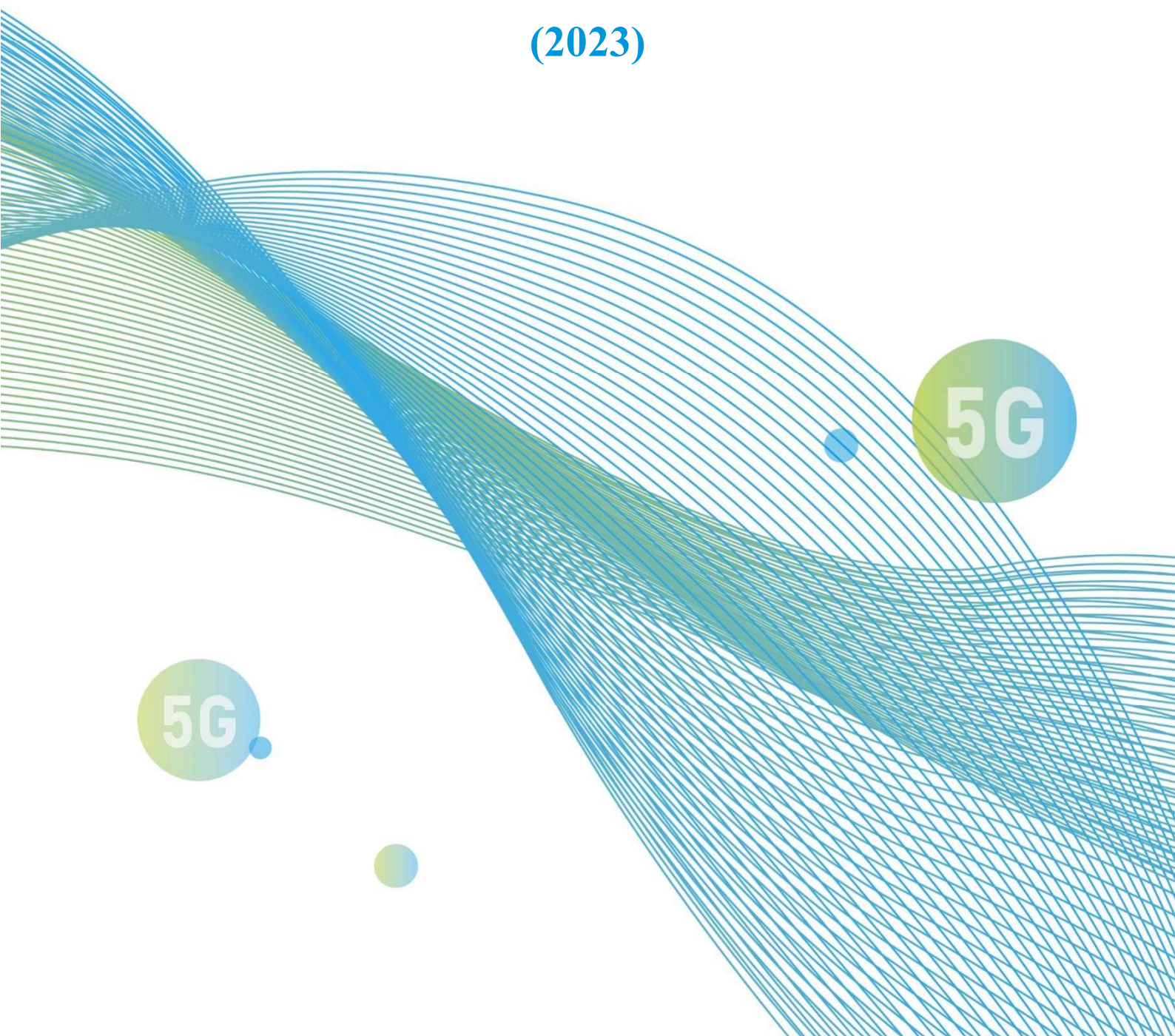# White Paper on Innovation and Development of 5G Business Model

(2023)

White Paper on Innovation and Development of 5G Business Model
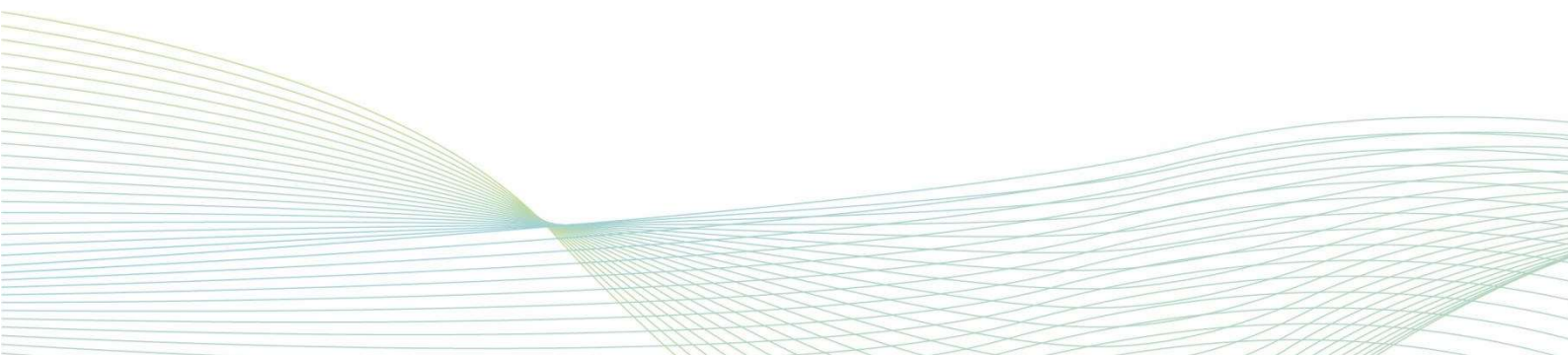
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5G Applications Industry Array (5G AIA)

GSMA 5G IN

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Copyright statement

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Executive Summary

Over the past few decades, the accelerated innovation in information and communication technologies (ICTs) has revolutionized the way the economy operates and the way people live. To effectively grab the historic opportunities presented by new technologies, as it has been found in this process, it is essential to consider how to reconstruct or establish new business models, in addition to continuous innovation in technologies and products in light of market feedbacks, thus unleashing the full commercial potential of new technologies and enabling the most effective value creation.

Since the commercialization of 5G officially kicked off in 2019, it has been developing rapidly worldwide. As of Q2 2023, 256 commercial 5G networks had been deployed globally, according to GSMA statistics. With the continuous expansion of 5G commercialization to less developed regions, 5G has basically spread all over the world. By 2030,5G adoption will be over 85% in the top 5G markets by 2030. In this context, participants in the industrial chain are much concerned about how to build a sustainable business model to more effectively unleash the commercial value of 5G technology and bring more growth opportunities for economic development.

Focusing on showing a picture of innovative development of 5G business models to all sectors of society and industry, the white paper reviews and summarizes the developments and characteristics of global business model exploration over the past four years since the commercialization of 5G, and objectively demonstrates the practice of business model innovation by enterprises in the 5G mass market and industry market through case studies. On this basis, the white paper analyzes the current problems facing 5G business model innovation, and puts forward some suggestions, with a view to offering the industry some insights into the systematic innovation and design of 5G business models.

The white paper has developed the following views on the development of 5G business models through intensive research and analysis:

First, the 5G business ecosystem continues to evolve over the past 4 years since the commercialization of 5G, and the market players involved have explored a number of new business models through innovation or referencing from others. At present, 5G business models are still in the stage of exploring value creation for customers, and participants in the industrial chain have contributed to business model evolution and innovation by tapping into new application scenarios, upgrading technological and service capabilities, improving product and service systems, and exploring new profit models. Meanwhile, the participation of enterprises has also injected new vitality into business model innovation.

Second, in the mass consumer market, telecom operators have come up with new business models based on pricing by speed, uplink capacity, low latency capability, and user profile through business model innovation built upon new network capabilities and application scenarios. In the industry's application market, telecom operators have not only actively explored business models such as private 5G networks, digital integration services and industry digital products on their own, but also cooperated with enterprises to explore new business models. Such cooperation has increased the complementarity and sharing of resources and strengths, expanded the value space of the 5G ecosystem, and opened up new routes for business model innovation.

Third, with the in-depth development of 5G industry applications, some enterprises have begun to explore the transformation of their own business systems based on 5G technology to establish new business models and open up more space for 5G value creation.

Fourth, the innovative development of 5G business models rests with a more mature technology product system and a more thriving business ecosystem. In the future, it is therefore necessary to further strengthen technology supply in the industry, enhance capacity building among enterprises, step up deep cooperation between the mobile communication industry and vertical industries, build a cross-industry, cross-cutting collaborative innovation ecosystem, and work together to promote iterative upgrading of 5G business models.

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Preface: 5G enables technology diffusion and starts a new wave of business model change

As mankind walks into the digital age from the industrial age, the importance of business model innovation has been increasing day by day, and a successful business model innovation can often rewrite an industry. Meanwhile, the innovation of business model is closely combined with technological progress, and every major technological breakthrough usually leads to the upgrading of business model. In the 4G era, the innovation of business model has shaped the glory of mobile Internet. In the 5G era, the rapid progress of technology will kick off a new round of business model changes.

(i) The business model is the operation mode of creating, transmitting and obtaining value

The term "business model" was put forward in 1950s, and gradually became a research hotspot with the development of Internet and network economy in 1990s.

This report defines the **"5G business model"** herein as **"building the transaction structure of stakeholders for business activities with 5G network service as the main business activity or with 5G network as the basic carrier, thus forming an operation model of creating, transmitting and obtaining value".** Meanwhile, this report defines **"innovation of 5G business model"** as **"realizing the maximum exploration of 5G business value by changing the traditional business model or creating a new business model, so as to promoting the prosperity of 5G applications".**

The analysis of 5G business model in this report draws lessons from the canvas analysis model of business model commonly used in academic circles. On the basis of combining the characteristics of the research object, a **four-element analysis framework** has been formed to carry out the whole report (see Figure 1). In this report, **Customer Positioning** refers to which customers enterprises choose to serve, what problems they plan to solve or what needs they meet. **Products and Services** refers to the products and services that need to be submitted to meet the aforementioned needs of customers. There are some complex products and services that need to be completed by multiple stakeholders, so it is necessary to consider the business cooperation relationship between different stakeholders [1] when providing products and services. **Critical Resources and Capabilities** refers to the resources[2] and capabilities [3] necessary to achieve supply and delivery. The **profit model** refers to the source and structure of income and expenditure, including income source, cost structure, income and expenditure mode and structure. Business model is an organic combination of a series of interrelated elements which coordinate and cooperate with each other and work together. It is essential to grasp the essence of the business model from these related elements in designing a business model.

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[1]When analyzed in great detail, stakeholders include both those outside an enterprise and those within the enterprise.
[2]Resources include financial, physical and human resources, information, intangible resources, customer relations, corporate networks, strategic real estate, etc.
[3]Capabilities include organizational, material, transaction and knowledge capabilities, among others.
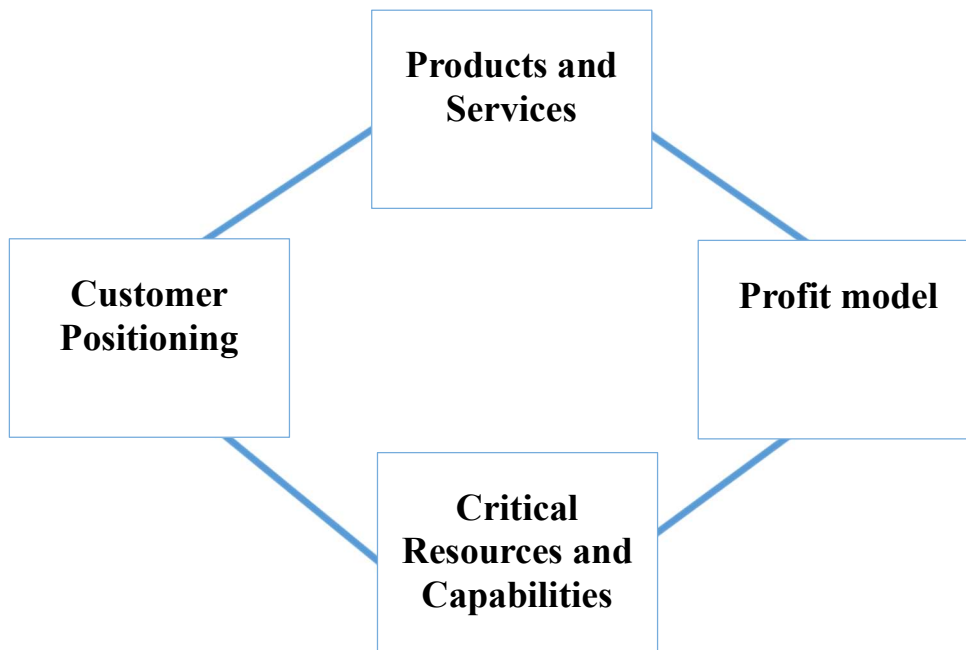
Source: "Research on Innovation of 5G Business Model" Project Research Group

Figure1Four-element business model analysis framework adopted in this report

The application of 5G and its related technologies can often change one or more elements of the traditional business model and bring a potential new value to customers. However, in order to turn this value into a commercial product acceptable to customers in reality, other related elements need to be changed to match it.

(ii) The multi-directional changes brought by 5G are expected to reshape the business ecosystem

Unlike 4G, which is more oriented to the consumer Internet, 5G technology innovation promotes the consumer Internet to the industrial Internet, expands the boundary of industrial ecological scope, and creates a broader space for business model innovation.

5G technology innovation drives the accelerating innovation of commercial applications. The technological breakthrough of 5G has brought about a qualitative leap in network performance. Compared with 4G networks, 5G is characterized by higher speed, greater connection, low latency, ultra reliability and network slicing, and can support more forms of application innovation.

The convergence of 5G with emerging digital technologies brings endless possibilities for innovation. 5G provides the underlying network support for such cutting-edge technologies as cloud computing, edge computing, AI (Artificial Intelligence) and blockchain, and the leap in network performance substantially improves the performance of upper-layer application technologies. The integration of 5G with cloud computing, edge computing and AI has formed an integrated production tool ranging from terminal to edge cloud and to central cloud in the digital age. The reliable network of 5G, the massive computing power of cloud computing and the application intelligence of AI cooperate with each other, which can go deep into various industries and support them to create new business experiences, new industry applications and new industrial layouts. Moreover, 5G has created a wider range of application scenarios for blockchain, quantum computing and other technologies, further expanding the depth and scope of industry application innovation. 5G is not only the evolution of communication technology, but also promotes the innovation and progress of emerging technologies in an all-round way. The integration of 5G and other emerging technologies will exert a positive effect of amplification, superposition, and multiplication, bringing about the "fusion" reaction of technology and the surge of capabilities, providing more fresh impetus to industry transformation, and offering new technological ecology and business models to all walks of life, thus changing the way people experience

the world.

The 5G era highlights the value of a more open and intelligent platform. At present, the traditional "vertically-linked value chain" is rapidly evolving into the structure of "loosely coupled and unbound value network". The interweaving and integration of 5G with emerging ICT technologies and general capabilities will give birth to an eco-level capability platform that is cross-disciplinary and cross-enterprise, supporting the rapid development and flexible deployment of applications upward, enabling agile innovation of businesses in various industries, realizing collaborative optimization of cloud computing, data pipeline and device through ubiquitous connections downward, and realizing deep integration between the physical world and the digital world, thus effectively amplifying the connection value. By relying on the openness of network and platform capabilities, gathering industrial chain partners, building a coordinated industrial ecology, and realizing the convergence of upstream and downstream resources and capabilities in the industrial chain, an industry-oriented end-to-end solution will be settled to serve the diversified needs of all walks of life.

Cross-border industrial cooperation promotes the innovation of 5G business model. The 5G era has witnessed redefined scope of competition and intensified cross-border penetration of competition. The industry development is no longer a single ecology, cross-border integration has become an important trend, and the industrial competition pattern has become unbounded, dynamic and ecological. 5G turns competitive relationship to be characterized by "openness, multiple linkage, symbiosis and co-creation". Both competitors and supply and requisitioning parties may become partners, sharing capabilities and channels, expanding market opportunities and jointly creating market value. Industries cross borders intensively and interact with external subjects such as upstream and downstream enterprises, governments, universities and scientific research institutions in the industrial chain, giving play to synergistic effect, integrating internal and external resources, improving the ability to serve customers and creating new business models.

I. Status quo of innovation and development of 5G business model

In the 4G era, the perfect combination of mobile communication technology and Internet technology has shaped a golden age for the development of consumer Internet, and the focus of business model innovation is on consumer Internet. The close integration of 5G technology and a new generation of digital technology promotes the consumer Internet to the industrial Internet, and business model innovation is more oriented to the industrial Internet. However, in the development of industrial Internet, the premise of business model innovation is the deep integration of 5G technology and industry knowledge, so the core of current 5G business model innovation is still in the stage of exploring how to use 5G to better create value for customers.

(i) The mass market has expanded the new value of network performance, and the industry market has explored new possibilities for application

Since its commercialization in 2019, the global 5G has developed rapidly. As of March 2023, the global 5G network has reached 30.2% of the population, and the population coverage rate of 53 countries/regions has exceeded 50%. 252 network operators in 92 countries/regions around the world announced that they began to provide 5G services (including fixed wireless and mobile services). The number of global 5G users reached 1.15 billion, with a penetration rate of 13.4%[4]. China, the United States, Japan and South Korea accounted for 81.5% of the total number of 5G users, of which China accounted for 58%[5].

The mass consumer market has continuously developed new applications, and the business model based on differentiated service experience has begun to be explored. Based on the characteristics of

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[4]Source of the figures: GSMA, https://www.gsmaintelligence.com/.
[5]Source: CAICT estimates.

large bandwidth and low latency of 5G, global telecom operators have been actively developing all kinds of new applications, such as 5G FWA (Fixed Wireless Access), 4K/8K HD video and cloud games to enhance users' audio-visual experience, 5G New Calling to enhance users' interactive experience, AR (Augmented Reality) viewing with immersive experience developed by new terminals, and cloud phones to provide flexible computing power and storage resources for entertainment and office isolation. Moreover, the uplink capability of 5G has also begun to empower more new scenarios. For example, in the emerging industry, the 5G live streaming card provides streamers with the ability to broadcast and sell goods anytime and anywhere, which has become the symbolic service of 5G innovation scenarios. Telecom operators have actively explored business models based on different network capabilities and products and services, and new charging models such as "traffic + products, content, rights and interests, differentiated services", charging by rate, charging by uplink traffic and charging by service guarantee priority have appeared in the market.

The industry application market has actively explored customer needs and application scenarios, and explored business models in multiple fields and multi-agents. The industry application market is a new blue ocean market for the expansion of 5G applications. In the past four years, different subjects in the industrial chain, such as telecom operators, communication equipment manufacturers and industrial enterprises, have carried out joint innovation and actively explored the demand and scenarios of 5G applications of industrial enterprises. Among them, the application of 5G industry in China has developed rapidly. According to the statistics released by China's "Bloom Cup" 5G Application Competition[6], nearly 50,000 5G application cases were collected from 2018 to 2022, and the integrated application of 5G in vertical industries such as mining, medical care and energy has been replicated on a large scale. In the industry application market, the main body of exploring business model innovation is telecom operators. However, with the continuous development of industry application, the leading force of 5G business model innovation is developing from telecom operators to multi-party participation and diversified leadership, and cases of industry enterprises relying on 5G to explore and innovate business models begin to emerge.

The needs of users in the 5G industry have the following characteristics: Firstly, diversified and personalized demand. Horizontally, industry users are complex, including various industries, while different industries and enterprises have different digital levels and development stages, and their demand for 5G is quite different. Vertically, from technology research and development to industrialization, there are many application links and long processes in the industry, which further intensified the personalized and diversified demand. **Secondly, hierarchical demand.** From the perspective of demand complexity, industry application demand presents the characteristics of gradient intensifying. From the network replacement application, to technology integration application[7], and then to the integration and transformation application, the customer demand is deeply expanded from the peripheral sectors to the core business sectors of the enterprise. **Specific to network requirements, there are the following characteristics: Firstly, the demand for 5G private networks and customized networks is prominent.** User network needs focus on data security isolation and protection, exclusive network resources, independent network operation and maintenance, etc. These generally need to build a 5G private network to ensure services. **Secondly, users with different volumes have their own characteristics.** Enterprises have different requirements for 5G networks and deployment modes. For example, distributed small and medium-sized enterprises (SMEs) mainly meet the interconnection needs and need general terminals and network products. Wide-area enterprises require SLA (Service

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[6]This is an event organized by the Ministry of Industry and Information Technology (MIIT), the competent authority in charge of the ICT industry in China to promote the development of 5G applications.

[7]Network replacement application: replacing the original information transmission channel (wired/Wi-Fi) with 5G to upgrade network capabilities and optimize part of the business process, without changing the original system and business logic or without significant transformation. Technology integration application: fully integrating with new generation information technologies such as big data, cloud computing, AI and IoT to give play to the role of new technology integration and innovation. Integration & transformation application: changing the original business logic and process, and bringing new models, new services and new business forms to create transformative value for the industry.

Level Agreement) guarantee of network delay bandwidth, and need to provide network slicing products that guarantee SLA. Large enterprises need to meet the needs of intelligent business production, and need to provide the overall solution of private network deployment and end-to-end cloud to application.

(ii) The technical and industrial service capabilities have been continuously enhanced, effectively supporting the exploration of new models

In order to effectively grasp new market opportunities, enterprises actively develop and build corresponding critical resources and capabilities. Among them, the two types of capabilities are the most prominent: the ability of the 5G technology service industry, and the service ability of telecom operators to industry enterprises.

The capabilities of the 5G technology service industry have been continuously improved. In the process of service industry, the original 5G technology industrial system for mass market is no longer applicable. After four years of development, the industry has gradually hatched and formed a 5G technology industry system for industry applications, which provides a good technology industry foundation for the innovative development of business models. **In the aspect of 5G technology,** eMBB's (Enhanced Mobile Broadband) large bandwidth technology product supply capability based on 3GPP (The 3rd Generation Partnership Project) R15 version has been formed, and 5G SA (Standalone) network has been deployed to support large bandwidth and low latency performance, and realize network capabilities such as network slicing and edge computing. Standards such as 3GPP R16 and R17 have been completed, and technologies such as lightweight RedCap (Reduced Capability) and 5G LAN (Local Area Network) are being tested and demonstrated. A variety of network and terminal products have been developed in the upstream and downstream of the industrial chain, which can meet the requirements of application scenarios for network performance such as low latency, high reliability, large bandwidth and high precision positioning. It is expected to have commercial conditions this year and reduce the cost of 5G products applied in the industry. **In terms of the integration of 5G and ICT technologies,** 5G and cloud computing, big data, AI and other technologies have achieved integration in core network, MEC (Mobile Edge Computing) and other 5G system equipment, machine vision, behavior recognition and other industrial applications. **In terms of the integration of 5G with industry technology,** the integration of 5G with automation control technology, mechanism modeling technology and robot technology has taken shape, which has driven the cloud transformation of core systems such as industrial PLC (Programmable Logic Controller).

Telecom operators' industry service capabilities have been continuously enhanced. The services provided by 5G for the industry are part of the digital services of the industry. The provision of 5G-based digital services to enterprises needs to be planned and designed according to their strategic goals, customer needs and business processes. It is necessary to master not only the relevant knowledge of 5G network, but also the industry knowledge, but the industry knowledge is generally possessed by industry enterprises or industry information automation service enterprises. Telecom operators have made up for this capability in many ways: **Firstly, mastered industry knowledge by cooperating with leading enterprises in the industry to develop applications.** At the beginning of entering the industry, telecom operators actively cooperated with industry leaders, which not only promoted application development, but also gradually accumulated industry knowledge. **Secondly, actively cooperated with information or automation service enterprises that have been deeply cultivated in the industry for a long time, and made up for the lack of their own industry knowledge by building a cooperative ecology.** For example, China Mobile has established an open ecosystem such as DICT (Data Information Communications Technology) integrated library, industry intelligent hardware library and industry application library, and cooperated with all parties in the industry to jointly explore the digital market of the industry. DICT integrated library has introduced more than 9,000 partners, and in 2022, the amount of cooperation based on the "three libraries" exceeded 36 billion RMB[8]. Another example is

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[8]https://zhengqi.10086.cn/partner/dictDetail.

China Unicom guiding its partners and customers to settle in the 5G Application Innovation Alliance and expanded its 5G ecological partners. At present, there are more than 3,000 members and more than 19,000 applications in the 5G industry[9]. **Thirdly, developed their own digital consultation, diagnosis and planning and design capabilities by purchasing training services.** For example, Chengdu Branch of China Telecom cooperated with ZTE Corporation, Aerospace Cloud Network and other enterprises with industry knowledge reserves through contract bidding, and improved its business capabilities through business training, team training and practical drills, so as to provide digital transformation services for more corporate customers and lay the foundation for future 5G business cooperation.

(iii) The product and service system has been continuously expanded and evolved, and ecological cooperation has injected innovation vitality

In the mass consumer market, telecom operators have explored new products and services. Cloud Phone is a brand-new computing terminal product launched by China Mobile on May 17th this year. This product is essentially a virtual phone that runs on the cloud. Compared with physical mobile phones, cloud phones put applications and operations in the cloud, and get rid of the constraints of hardware configuration such as processor and memory, so that users can easily operate through multiple terminals such as APP, H5 and applet, and enjoy the smooth cloud service brought by 5G network. As another new product created by telecom operators, 5G New Calling makes full use of the advantages of computing network technology, and adds AI algorithm and computing power in the call to upgrade the basic call, bringing users a new call experience with stable high definition, visual interaction, intelligence and efficiency, creating a platform product based on content management + AI ecology + interactive innovation, and making 5G New Calling a traffic portal based on mobile phone numbers.

In the industry market, telecom operators have expanded and upgraded their products and services system. In this market, the innovation of 5G products and services has been closely integrated with industry application scenarios, and telecom operators have designed products and services in the direction of personalizing individuals and then differentiating market segments according to the target market, firstly meeting customized needs and then refining general needs, and their products and services have gradually expanded and evolved from traditional network products to digital transformation products. **At present, the industry products and services of telecom operators can be roughly divided into three categories according to their universality and digitalization: private network products, digital integrated services and industry digital products.** Among them, **private network products** not only meet the needs of enterprises such as universal connection and large bandwidth, but also provide differentiated and customized private network services according to SLA requirements such as enterprise scale and delay bandwidth guarantee. **Digital integration services** generally meet the personalized customization needs of enterprise customers, and provide a series of digital transformation solutions including top-level design, consulting and planning, ICT infrastructure construction, digital management and application around enterprise business strategies and digital transformation strategies. 5G is embedded as a part of the underlying network infrastructure. **Industry digital products** pay more attention to the general development needs of the industry, provide more general digital solutions for a certain type or several types of application scenarios in the industry, realize rapid online deployment of services through SaaS or platform-based service mode, reducing the application costs of industry customers. In the actual promotion process, the three types of products may be provided separately or jointly.

In terms of ecology, the participation of industry enterprises has injected new vitality into products and services and business model innovation. As 5G industry applications continue to expand in scale and extent, industry enterprises are increasingly paying more attention to and recognizing 5G applications. On the one hand, the participation of industry enterprises has greatly enriched and expanded the scope of innovation of products and services, and many new products and

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[9]Source: China Unicom.

services have obvious industry attributes, which will have a significant impact on vertical industries. For example, industrial giants such as Siemens, Schneider, and GE have launched 5G industrial terminal products, and industrial core equipment such as 5G valve islands and 5G PLCs have appeared, better realizing the adaptation of 5G and industrial communication protocols such as PROFINET, which will have a profound impact on the industrial 5G pattern. On the other hand, the participation of industry enterprises brings new industrial resource capabilities and more transaction partners and stakeholders, and based on the reconstruction of business processes and transaction structures, it is expected to form new value added and bring new possibilities for business model innovation.

(iv) The billing methods and charging modes are more diversified, and the space for commercial realization continues to expand

The mass consumer market has explored new 5G billing methods. On the basis of continuing the traditional traffic-based billing method of 4G, telecom operators have been exploring more diversified billing methods based on the new performance of 5G networks. **Firstly,** the method of rate billing. Starting from the Finnish market rate billing, Switzerland, Germany and Austria in Europe and the United Arab Emirates, etc. have adopted the 5G rate billing model. **Secondly,** billing based on the uplink rate or bandwidth. Compared with 4G, 5G features great uplink, which can provide better services for new application scenarios such as live streaming and securities trading. For example, China Unicom Guangdong Branch and 3HK have launched corresponding live streaming cards to provide users with better uplink network resource protection. **Thirdly,** more and more telecom operators bundle richer applications with 5G data services to explore new paths for 5G commercial monetization.

The charging model of the industry market is more diversified. At present, in this market, the mainstream charging model of telecom operators is to charge customers for pricing products and services according to the cost-plus pricing formula with reference to consumption value. **In terms of basic network resource products**, telecom operators charge resource usage fees and network operation and maintenance fees for private networks, traffic, cloud computing, edge computing and other resources according to the different capabilities of customers. For example, China Mobile has explored the multi-dimensional pricing model of the network for industrial applications, and on the basis of general network services, combined the value-added functions such as edge nodes, dedicated access, service acceleration, super uplink, network design, network operation and maintenance, thus forming the BAF business model (basic network + advanced value-added functions + flexible personalized services). **In terms of digital integration services**, in addition to providing customers with 5G network resources, telecom operators also provide them with rich digital solutions, and charge customized integration service fees for customers with different characteristics and various solutions, or charge for services in the form of SaaS according to the number of uses, or explore charging methods according to the use of the revenue share. For example, Huizhou Branch of China Unicom has promoted 5G+ energy consumption management applications by using both SaaS service charges and savings revenue sharing for enterprises in the cluster ecosystem to choose. In addition, with the participation of industry enterprises, the digital solutions and services provided based on 5G will be more diversified, and the charging model will be more diverse.

II. Practice of innovative development of the mass market 5G business model

(i) Exploring the business model of rated-based charging

Higher speed is a basic feature that distinguishes 5G from 4G. The highest speed of 4G can reach 100Mbit/s, while 5G can provide download speed as high as 1 Gbit/s, which greatly improves users' online experience and provides telecom operators with the possibility of differentiated pricing while ensuring users' basic network speed experience.

Case 1: Rate Experience Billing-Elisa in Finland, Sunrise in Switzerland, DU in United Arab Emirates[10]

In the 5G era, more and more operators have adopted the rate-based business model as the charging dimension. On the basis of Elisa billing by rate in Finland, more and more operators in Europe, the Middle East and other places have begun to adopt rate billing and experience monetization. Like Elisa in Finland[11], Sunrise in Switzerland[12] adopts unlimited data flow (limited to domestic or part of Europe) for the entire network, and no other packages with other billing models. On the basis of the existing global roaming traffic package model, DU[13] in United Arab Emirates has introduced a new rate grading package to provide users with unlimited local speed limit packages.

Elisa			
Package	300M package	600M package	1000M package
Monthly fee	31.99 euros/month	36.99 euros/month	49.99 euros/month
Voice calls and text messages	Unlimited	Unlimited	Unlimited
Data flow (within Northern Europe)	Unlimited	Unlimited	Unlimited
Data flow (within the EU)	32GB/ month	36GB/ month	45GB/ month

Sunrise			
Package	XL package	L package	M package
Monthly fee	44.50 Swiss francs/month	34.50 Swiss francs/month	29.50 Swiss francs/month

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[10] Use cases provided by Huawei Technologies Co., Ltd.
[11] https://elisa.fi/kauppa/puhelinliittymat
[12] https://www.sunrise.ch/en/mobile/mobile-subscription
[13] https://shop.du.ae/en/personal/s-du-postpaid-plans

Voice calls and text messages	Unlimited (within Europe)	Unlimited (within Europe)	Unlimited (Switzerland only)
Data flow	Unlimited (within Europe)	Unlimited (within Europe)	Unlimited (Switzerland only)
Maximum rate	2 Gbit/s	1 Gbit/s	500 Gbit/s

DU			
Package	Power Plan 500	Power Plan 300	Power Plan 250
Monthly fee	500 dirhams/month	300 dirhams/month	250 dirhams/month
Voice calls and text messages	1500 minutes	800 minutes	500 minutes
Data flow	Unlimited (maximum rate)	Unlimited (<10mbps)	Unlimited (<3mbps)
Maximum rate	Free of charge	Free of charge	Free under 35GB

(ii) Exploring the business models for new application scenarios

With the iterative evolution of mobile Internet applications, some application scenarios have new requirements for new performance such as uplink rate and latency of mobile communication networks, which provides the possibility for business model innovation based on the new capabilities of 5G networks. For example, under the influence of the Covid-19 epidemic, live streaming has become a tailwind for the development of the mobile Internet industry. E-commerce live streaming, game live streaming, reality TV live streaming, concert live streaming, and live sports events are all growing in users. Broadcasters need to rely on the large uplink bandwidth of mobile communication network to ensure good content production fluency, which provides new value release space for 5G networks' new capabilities - high uplink rates. For example, game and stock investment scenarios are sensitive to performance such as latency of mobile communication networks, which also provides new possibilities for 5G business model innovation.

Case 2: Guangdong China Unicom Launched a 5G Live Streaming Package[14]

In order to seize the huge potential of Guangdong's live broadcast market, Guangdong China Unicom innovated a 5G live streaming package[15]. Compared with ordinary 5G cards, 5G live streaming package can provide users who watch live broadcasts and perform broadcasts with more traffic (90-250G), ultra-high uplink speed (150-200Mbps), and network VVIP services (QCI level 6). The package price is divided into three tiers of 199/299/399 RMB, corresponding to different traffic packages and uplink rate ratings. Since its release at the end of October 2021, it has developed about 200,000 users.

Standard monthly rent	199 RMB	299 RMB	399 RMB
Local voice	500 minutes	500 minutes	500 minutes
Local data	90G	150G	250G
Over-package limit fee	Local voice 0.15 RMB/minute, SMS 1 MMS 0.1 RMB/article, local data 3 RMB/GB.		
Others	Local answering is free, including caller ID description, Unicom cloud disk, video color ring tone, missed message reminder and mobile email service.		
Downlink peak rate	1G		
Uplink peak rate	150M	150M	200M
Network service	VVIP has the priority service of live streaming network		

Case 3: Hong Kong Hutchison Offers 5G Packages With Latency Acceleration for Games and Stock Apps[16]

5G Game Acceleration Package for gamers and 5G Stock Pro Package for financial investors both use the ultra-low latency of 5G to provide users with 5G high-speed services. 5G Game Acceleration Package mainly provides game directional traffic and 5G acceleration services, ensuring the differentiated experience of game users through QCI (Quality of Service Class Identifier) priority improvement, such as signing a contract for 12 months and paying 59 Hong Kong dollars per month, not only allows users to play designated mobile games, but also rebates the monthly fee for APP Store and Google Play purchases, as well as the purchase of game credit cards (including MyCard, GASH and Razer Gold) [17]. 5G Stock Pro Package combines the etnet APP rights commonly used by investors with 5G high-speed services and targeted free traffic, and divides the package into two levels of 238/488 Hong Kong dollars according to the ET Net classification, further improving the user's ARPU (Average

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[14] Use cases provided by Huawei Technologies Co., Ltd.
[15] https://www.02010010.com/html/qiye/1657.html
[16] Use cases provided by Huawei Technologies Co., Ltd.
[17] https://www.supreme.vip/home/vas/gaming/index.html

Revenue Per User) [18].

5G Stock Pro Lite Monthly Plan	5G Stock Pro Monthly Plan
$238/month	$488/month
□ 30GB 5G local data per month □ etnet Streaming Stock Quote Mobile Service Level 1 (Applicable to etnet MQ Pro) □ Net+ up to 2x network speed service	□ 30GB 5G local data per month □ etnet Streaming Quotes Service Level 2 (including MQ Pro and TQ Pro) □ Enjoy TQ Pro Service and Real Time Broker Queue Service □ Net+ up to 2x network speed service

(iii) Exploring business model for a more accurate customer base

Business model innovation can be reflected in the accurate segmentation and portrait of customer groups, that is, based on customer characteristics, focusing on common needs and key pain points, providing customized products and services for specific customer groups through differentiated marketing combinations, and improving customer satisfaction while increasing sales.

Case 4: China Mobile's Filial Piety Card and Delivery Personnel Card[19]

China Mobile's Shenzhouxing Filial Piety Card and Shenzhouxing Delivery Personnel Card provide exclusive fees and rights for the elderly, takeaway delivery staff, deliveryman and other groups respectively. **Shenzhouxing Filial Piety Card[20]:** To meet the needs of "communication + health + safety + entertainment" for the elderly, it provides five major services: 1. support the family to pay for it, so that the elderly are not afraid of downtime, and the package also provides 40GB of data, so that the elderly can use the network safely and unworriedly; 2. provide professional and convenient online health consultation, so that the elderly can get professional health guidance at home; 3. provide cloud interception of high-frequency harassing calls, screen prompt of suspected fraudulent incoming calls, and anti-fraud insurance with a maximum claim of 10,000 RMB; 4. built-in Migu video diamond membership rights; 5. in addition to the huge traffic, family video V-network service is provided, and there is no charge for video calls, so that friends and relatives can be infinitely closer and chat freely. **Shenzhouxing Delivery Personnel Card[21]:** It focuses on employees in vertical markets such as express delivery, take-away, logistics, online car rental, and provides knight card users with smart helmets, preferential charging, delivery personnel insurance, entertainment and leisure, and directional traffic, etc., to meet their requirements of high call volumes and large traffic demand, while guarding their safe driving and insurance escort, which fully reflects the precise customization of package rights and interests design.

III. Practice of innovation and development of 5G business model in industry market

This chapter objectively shows some typical 5G business models in the industry application market, and introduces them respectively according to the core participants, namely the focus enterprises.

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[18] https://web.three.com.hk/plans/finsim/index2.html
[19] Use cases provided by Huawei Technologies Co., Ltd.
[20] https://dx.10086.cn/uPgdDA
[21] https://mp.weixin.qq.com/s/fwDJ5QtCCde8yzWk0v7bPw

(i) Exploring the business model of enterprises with telecom operators as the focus

1. Business model innovation of 5G private network products

The 5G industry private network is a flexible, customized, secure, controllable and exclusive 5G technology, network and service system for vertical industries.

Decisions about how to approach a private network deployment model will be governed by spectrum availability, OT (Operation Technology) requirements and cost. However, in general, very few industrial enterprises have the necessary expertise in managing and maintaining cellular wireless networks, which encompasses[22]:

•   Assessment of radio coverage on the areas of operations.

•   Maintaining the coverage.

•   Monitoring and maintaining the hardware and software upgrades.

•   Ensuring security against intrusion and other threats that do not require internal physical access.

Below are some options for deployment models:

Managed Services

Option A: An industrial enterprise specifies the service provider and vendors, and customized solutions based on its design requirements. A system integrator then builds the network. Maintenance may be negotiable among the integrator, the industrial enterprise and the communication service provider company.

Option B: An MNO (Mobile Network Operator) -managed private network. In this case, the industrial enterprise may specify its choice of spectrum, any special vendor needs, required QoS for the services, monitoring tools, APIs (Application Programming Interface) and SLA agreements for different levels of failures etc. Some countries make private licensed spectrum available to industrial enterprises at a nominal cost, but this might be a low-bandwidth spectrum and the enterprise might need more spectrum to scale its operations, while unlicensed spectrum is not reliable for critical operations. In the USA, CBRS (Citizen Broadband Radio Service) PAL (Priority Access Licence) is available in some regions. In other situations, when the industrial enterprise does not hold its own spectrum, it could potentially use MNO-provided mid-band or mm Wave spectrums and managed services from local service providers.

Enterprise-run full service

A large enterprise may decide to install its own 5G network and manage its premises. This is not straightforward, because it requires experience in radio coverage, running the cellular networks, managing vendors, training employees and upgrading the software and hardware as needed. The overall cost of maintaining the network may be higher than with an outsourced approach.

Neutral Host Model

This is a deployment model where the industrial enterprise may take advantage of two di¡erent service providers to run its networks. For example, one service provider may manage the private networks and the other provider can take care of the PNI-NPN (Public Integrated Non-Public Networks) portion of the facility. The following table (Table 1) maps the ownership models of private network deployment among industrial operators, service providers and their ownership of the network components.

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[22] The private network deployment model (including table 1) is quoted from *Private 5G Industrial Networks - An analysis of Use Cases and Deployment (GSMA, June 2023, https://www.gsma.com/iot/resources/private-5g-industrial-networks-2023/)*

Type of private networks/ ownership	Industrial enterprise roles	Service provider type and offerings	Service provider roles
Standalone non-public networks (SNPNs)			
Enterprise-managed SNPN	Provides requirements, vendors, device choices and networking space. May provide spectrum in some regions or ask for spectrum from a MNO	Not applicable	Not applicable
SNPN delivered as a managed service by an MNO	Provides requirements to the MNO	An MNO is hired by the enterprise to install, design and support the 5G SNPN. The MNO may need to provide spectrum and the deployment may use RAN sharing.	Managed service and provision of spectrum, as needed
SNPN delivered as a managed service by a third party, such as an equipment vendor, software or cloud vendors or an MNO	The enterprise may use spectrum it has licensed itself locally or it may use unlicensed spectrum, such as CBRS General Access	The third party provides software and hardware, radio and management of 5G SNPN, but it does not provide licensed spectrum	Managed service without licensed spectrum
Public integrated non-public networks (PNI-NPN)			
Managed by MNO	The industrial enterprise is responsible for providing requirements and space for on-premises servers and equipment. The enterprise may use RAN sharing from a MNO	The MNO and industrial enterprise decide the requirements and the MNO installs 5G components in PLMN or inside the enterprise premises as per an SLA. The MNO may provide RAN sharing feature and/or use network slicing (see	MNO fully managed or partially managed service for the 5G Network. MNO selects its vendors/partners

		deployment models section)	
Or jointly by MNO and enterprise as per SLA	The enterprise and MNO may split the device management roles	An MNO might also provide edge services or other compute services through its partners/vendors	The enterprise and MNO may split the device management roles
Neutral host network (NHN)			
Hosted by an enterprise or MNO	The enterprise makes a decision on multiple operators or multiple types of private networks	MNO provides the 5G networks as requested by the enterprise. An MNO may allow other network operators to provide the network service using the MNO's physical resources	Managed service for the requested portion of the network

Source: GSMA Digital Industries

Table 1 | Private network deployment models

For enterprises, 5G private network has the advantages of higher reliability, low latency, higher security, stronger customization ability and freer operation and maintenance mode. To expand the market, 5G private network needs to tap the needs of customer segmentation more effectively, fully amplify the technical advantages of 5G private networks, especially the advantages combined with 5G wide-area network and 5G network slicing technology, and evolve from 5G traffic card to private network products that match industry attributes such as campuses, education and government affairs, so as to achieve 5G product extension and create greater and newer value for customers.

Case 5: China Unicom and Huawei Jointly Launched 5G Private Network for Multiple Campuses Solution[23]

[Background] The 5G Private Network for Multiple Campuses can be customized for industry customers (especially those with regional dedicated network requirements) to provide different degrees of "purpose-based construction, exclusive use, private network operation, dedicated maintenance", allocate end-to-end network resources for industry users and achieve network isolation.

[Customer Positioning] In the initial stage of marketing of the 5G Private Network for Multiple Campuses, operators targeted customer positioning in the industrial Internet industry which has the need to build smart applications and smart factories, and there are many large-scale enterprise groups with factories across cities and campuses in China.

[Products and Services] In view of the pain points of long construction period, low maintenance efficiency and slow innovation promotion in multiple campuses network construction of large enterprise groups across cities, China Unicom, Huawei and other industrial partners launched the 5G Private Network for Multiple Campuses solution, realized the unified construction and unified operation and

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[23]Case information provided by China Unicom Beijing Branch, Huawei Technologies Co., Ltd..

maintenance of private network for multiple campuses, and based on the value-added capabilities of private networks such as 5G positioning and 5G LAN, realized the innovation pilot in one place and nationwide replication and promotion, and helped multiple-campus enterprises quickly achieve the landing of 5G applications and accelerate the digital transformation of enterprises by relying on the network architecture of 5G CtoB and the top-level design of the group, forming an integrated network construction scheme, running the script to load the baseline configuration of a single campus private network to help customers build a national network.

The products and services provided specifically include: realizing data isolation and improving user business security; providing self-maintenance, self-operation and self-management services; realizing the separate operation between the public network and the campus business, and ensure the campus business unaffected by the interrupted public network; realizing the unified management and operation and maintenance of multiple campuses; the deployed 5G private network can support large-bandwidth uplink and low-latency factory application scenarios, and can be smoothly upgraded to provide value-added network capabilities such as slicing, 5G LAN, positioning.

[Profit model] Operators provide customers with a subscription mode involving area, flexible and value-added. Firstly, package all the network services in the customer's production area and issue a quotation according to the area; secondly, in some complex scenes, according to different wireless coverage models, different construction cost quotations can be flexibly given; finally, corresponding quotations are also provided for value-added services such as 5G LAN, uplink and downlink time slot matching, and CPK enhancement package. The unified signing mode at the group level has been realized, and the ordering efficiency has been improved.

[Critical Resources and Capabilities] 5G Private Network for Multiple Campuses service requires operators to have comprehensive knowledge and technology, including professional 5G network solution capability, network management operation capability, 5G network fault repair capability, 5G terminal debugging operation capability, as well as a professional human resources team that masters these knowledge and skills. Moreover, because its main customers are those in the industrial Internet industry, operators also need the corresponding 5G smart factory application service capabilities.

Case 6: Business Model Innovation of 5G Education Private Network[24]

[Background] There are some problems in VPN (Virtual Private Network) access under public network environment, such as leaked usernames and passwords to access other accounts, high risk of VPN security, poor user access experience, and high cost of network maintenance. China Unicom Guangdong Branch and Guangdong Education and Research Network (GDERNET) have jointly built a large-scale, multi-site and continuous coverage 5G network, connected with the core nodes of GDERNET through moving UPF (User Plane Function) downwards to build a shared 5G private network for schools, realized the rapid access of intranet resources of colleges and universities in the region through 5G private network, and intelligently diverted the business of schools through DNN (Data Network Name)+ULCL (Uplink Classifier), and provided high bandwidth, low latency or massive access guarantee for different business scenarios on campus by combining network slicing technology, effectively solving the problems of high risk, poor experience and difficult management of traditional VPN accessing intranet.

[Customer Positioning] In the initial stage of marketing the 5G education private network, telecom operators mainly targeted the two groups of customers, accessing the major colleges and universities of GDERNET and the faculties and students in the colleges and universities that have active the 5G education private network service, and further expanding to enterprises with government affairs and

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[24]Case information provided by China Unicom Guangdong Branch, South China University of Technology

network security requirements.

[Products and Services] Based on the network foundation of GDERNET and China Unicom's 5G public network, the 5G campus private network with low cost, greenness and safety can be constructed by deploying a set of UPF equipment exclusive to GDERNET in its core computer room, reusing the existing lines of the education network and sharing the 5G private network equipment deployed in GDERNET. The products and services provided specifically include: Firstly, the source control of the schools' access rights to users' intranet can block and trace network attacks at the end-to-end level and eliminate security risks such as password leakage. Secondly, contracted users can realize the non-perceptional switching access between campus intranet resources and Internet resources. Thirdly, schools can purchase private network access services with different bandwidth levels according to their own business scenarios, complete the rapid access of resources to the 5G education private network, and reduce the investment in private network construction and maintenance.

[Profit model] Telecom operators provide two payment models for colleges or faculties and students. **Firstly, colleges and universities purchase services**, and they can choose different bandwidths according to the number of users and business volume on campus, buy different levels of streaming bandwidth fees or network rental fees, and pay them every time or on a periodic basis (month/year). **Secondly, faculties and students in colleges and universities purchase services**, and they can pay the related functional service fees on a periodic basis (month/year) by purchasing the function overlay package of 5G education private network or the campus intranet traffic fee.

[Critical Resources and Capabilities] Telecom operators have comprehensive knowledge and technology to provide 5G education private network services, including professional 5G network service capability, AAA security authentication capability, 4/5G core network element interoperability capability, and end-to-end service debugging capability. In addition, given that its main customers are those in the education industry, it also needs the corresponding marketing ability and service ability of large customers.

[Innovation] There are three main innovations in the business model of the 5G education private network: Firstly, the cooperation between telecom operators and GDERNET has promoted the deep integration between GDERNET and 5G private network, and schools accessing GDERNET can directly open 5G private network services to realize resource sharing. Secondly, colleges and universities accessing the 5G education private network can simplify the access process, improve the security protection capability and increase roaming access only by purchasing the diversion service package. Thirdly, faculties and students in colleges and universities that have activated the 5G education private network service can voluntarily purchase the function overlay package of the 5G education private network or the campus intranet traffic, realizing safe and non-perceptional access to campus resources. In addition, the business model has also been successfully promoted in government affairs and other fields. For example, China Mobile has also adopted a similar business model in the government affairs network project. In addition to the charging mode of 5G traffic package for toC users, China Mobile has also adopted the charging mode of 5G private network traffic resource pool for the toB Bureau. Through the charging mode of public network and government private network traffic separately, the role of operators has evolved from simply providing traffic cards to providing secure government network products, thus realizing the non-perceptional security authentication and business diversion of government private networks.

2. Business model innovation of digital integrated services

In the process of digital transformation, industry customers often need end-to-end digital solutions both for 5G networks and for how to realize the digitalization of services based on 5G networks. In the process of providing 5G network services to industry customers, telecom operators gradually understand the deep-seated digital needs of enterprises, and begin to provide customized digital integration services for industry customers by developing their own critical resources and capabilities such as digital planning and consulting design, terminal equipment integration and digital ecological aggregation, and achieved

their own expansion in the industrial value chain by bringing more activities in the digital transformation service value chain into their own business scope.

Case 7: Innovation of Industrial Value Chain Extensible Business Model of JISCO[25]

[Background] Xigou Mine of Jiuquan Iron & Steel Group Limited Company (JISCO) has a harsh working environment, and the equipment in the mining area is huge and bulky, with many blind spots, which is prone to on-site accidents, resulting in difficulties in recruiting workers and high safety risks. Therefore, JISCO proposed that production needs to develop in an intelligent, unmanned and flexible-manpower manner, and the personnel production environment can be transferred from the harsh mining area to comfortable spaces. JISCO raised the demand for 5G network in order to support its transformation and upgrading. Gansu Branch of China Mobile found that customers of JISCO not only need the 5G network solution, but also need to deepen the overall solution of the digital transformation of JISCO's intelligent mine, develop new integrated resource capabilities, and realize the digital transformation business of intelligent mine, such as unmanned production, 5G video surveillance, active equipment maintenance, and comprehensive management and control of mining equipment and business.

[Customer Positioning] Customers are mainly mining enterprises working in open-pit mines, underground mines, the production departments serving for mining enterprises, especially those involved in intelligent transformation. The model provides customers with digital solutions from interconnected terminals, networks, platforms to applications, meets the production needs of intelligent, unmanned and flexible-manpower transformation, reduces mine production costs while improving efficiency. On the basis of the mining industry, it can be further extended to manufacturing, steel, petrochemical and other industrial enterprises.

[Products and Services] Provide integrated services for 5G networks and related applications. The cooperation mode of integrated service is that telecom operators conduct general integration and integrate the products and capabilities of communication equipment manufacturers, mining equipment manufacturers and other software service companies, specifically including the integration scheme of "planning, construction, maintenance and optimizing".

[Profit model] For the enterprise-side 5G network, the service fee is charged annually. The integration of unmanned/remote control applications such as shovel drills adopts the mode of charging one-time integration service fee, and the subsequent services such as operation and maintenance optimization will adopt the mode of charging service fee on an annual basis as the applications are gradually launched. For the interface between equipment vendors and operators, end-side and network equipment apply a one-time charge. The business integration services provided by equipment vendors also apply a one-time charge. The maintenance and optimization parts are charged on an annual basis.

[Critical Resources and Capabilities] In order to provide digital integrated services, in addition to 5G basic network resources, telecom operators also need to have several critical resources and capabilities: 5G private network integrated service capabilities, i.e., planning, construction, maintenance and optimization; end-to-end integration ability of terminal equipment and applications, business insight, consulting design and marketing ability for major customers such as mining enterprises, and ability to understand industry business processes and business pain points; having stable and reliable partner and partner management ability.

[Innovation] Through the expansion of customers, from the original network deployment with the IT department of JISCO, innovative expansion to in-depth docking with the production department, on the basis of this innovative mine achieving unmanned mining surface, obtaining safety, efficiency and

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[25] Case information provided by Gansu Xigou Mining Co., Ltd., Jiayuguan Branch (Gansu) of China Mobile, Huawei Technologies Co., Ltd.

economic benefits improvement, telecom operators have achieved value chain extension, from the value link of providing 5G network upward, to the value link of the upper layer of integration services.

Case 8: Wuyi Mountain 5G Smart Tea Mountain Model[26]

[Background] Wuyi Mountain tea industry has entered a new stage of brand development, but there are also some problems in the tea industry, such as scattered management, low degree of organization, short of enterprise standards, full of counterfeits, uneven quality, incomplete service system, high industrial economy and operating costs. In order to solve the industrial pain points, Wuyishan Branch (Fujian) of China Telecom focused on improving the big data platform of the tea industry, building a smart demonstration tea garden, upgrading the blockchain traceability platform of recognizing the label and purchasing tea, and comprehensively helped the government to promote the high-quality development of the tea industry.

[Customer Positioning] The target customers of this project are mainly the government. The model can provide the government with a platform for tea industry data management and tea enterprise supervision, provide tea enterprises with smart tea mountain services, help sales transformation, improve planting efficiency and quality, provide credit and financial services for the upstream and downstream of the industrial chain, and solve the problems of difficult and expensive financing.

[Products and Services] Through the tea industry platform, the local government can browse the situation of the tea industry in the whole region, and take tea mountain as a link to relate to various tea industry data information such as tea enterprises and tea workers, so as to grasp the development of the industry; standardize the supervision and monitoring of tea farmers in tea enterprises from all aspects of tea planting, picking and landing, production and processing, quality inspection, warehousing, logistics and sales. Local tea enterprises can also build an "ecological tea garden" demonstration by deploying IoT (Internet of Things) equipment such as Smart Tea Mountain and Smart Tea Factory, so as to enhance the influence and image publicity of enterprises. Online and offline services provide scientific guidance for tea farmers in tea enterprises to grow tea and increase tea output. With the official rating certification, tea enterprises can provide unified publicity and sales channels, which improves the standardized management of tea enterprises by the government. In addition, based on the big data platform of tea industry, the financial system builds a risk analysis and evaluation model of tea industry, which can provide financial services such as valuation and pricing, risk assessment and financing credit to tea enterprises and farmers.

[Profit model] This project adopts the ICT project integration model, and the payment is made according to the business quotation and the project schedule. The project agreement shall be valid and remain in force for a period of three years. The investment cost of operators adopts capital expenditure mode, including equipment expenditure and service expenditure, of which service expenditure accounts for about 90%. The direct benefit of this project is significant, the direct rate of return on investment is 15-20% (calculated according to business quotation and capital expenditure), and the internal rate of return is about 11%.

[Critical Resources and Capabilities] Based on its own networking resources, China Telecom collects tea mountain data through 5G base station deployment, 5G VR (Virtual Reality) panoramic live broadcast and Internet of Things (IoT) probe equipment and sends it back to the platform for AI analysis in real time, realizing a comprehensive, rapid and accurate grasp of the data and spatial layout of various resources in the tea industry, and enhancing the supervision and service capabilities to promote the

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[26]Case information provided by Wuyishan Branch (Fujian) of China Telecom, Nanping Branch of China Telecom Fufu Information Technology Co., Ltd.

development of the tea industry. CTFF Information Technology Co., Ltd. customized and developed a visual integrated management platform to match the actual needs of the owners, collected fragmented and decentralized data resources of the whole chain of tea industry, and realized information gathering and sharing. In addition, financial services cooperated with the banking system to connect the big data platform of tea industry with financial data through the financial private network, and applied key technical resources such as MEC and 5G network slicing encryption.

[Innovation] The innovation of this project lies in the integrated mode of digital transformation of tea industry ecological chain. 1. Established a tea data collection and planting management platform, integrated the technical advantages of 5G+AI, UAV (Unmanned aerial vehicle) +GIS (Geographic Information System) aerial photography modeling, BSN (Boundary Sensitive Network) winding, etc., monitored and evaluated the tea growth status and pest information in real time, and displayed the data of microelements, PH value, air and water in the tea garden soil through the IoT sensing technology, so as to realize the functions of environmental monitoring and video monitoring, remote control and management of the tea garden, and broadcast the ecological features of the tea garden in real time with 5G+VR. 2. Established a comprehensive, perfect and traceable intelligent tea industry ecosystem. Relevant government departments can monitor and record tea planting and production processes, and use blockchain, distributed storage and peer-to-peer transmission to realize information gathering and sharing, and upload information such as planting, production, warehousing and sales, enable China National Intellectual Property Administration's new geographical indication and official special mark certification, improve the workflow system of "recognizing labels and purchasing tea", and trace back the whole process of tea from tea garden to teacups through government endorsement. 3. Solved the demand of capital circulation; cooperated with Wuyi Mountain Rural Commercial Bank to build an innovative guarantee lending service integrating production, sales and credit, and connected the data of tea planting environment and production collected by 5G+ IoT equipment, as well as the data of tea product sales and transactions to the 5G financial private network, with leading enterprises in the tea industry as the core, supplemented by public data such as credit investigation, business and private issuance; and applied MEC edge computing and 5G network slice encryption channel for credit verification to provide financial services for suppliers and distributors in the upstream and downstream of the industrial chain and improve the credit risk control level of banks to tea enterprises. 4. Helped the transformation of sales model; integrated 5G with AI, big data, cloud and other technologies to create a self-service scenarios of the commercial street in the meta-universe. In the virtual commercial street and "air tea house" in the meta-universe, each customer has an independent personal avatar, roaming, communicating and consuming in the virtual 3D scene, and can interact with tea enterprises and tea merchants to view the real-time situation of tea hills, tea factories, tea warehouses and tea shops, enjoying "immersive consumption".

3. Business model innovation for digital products in the industry

While customized digital integration services can further fit the needs of customers in the industry and secure a leap in value, they cannot be replicated and applied on a large scale as customized products entail high personnel and time costs. To solve the dilemma, telecom operators have attempted to put their eyes on differentiated market segments of the industry, developing highly standardized products and services based on a summary of the common needs of customers in the industry and then expanding to the wider industry or scenarios.

Business model innovation for digital products in the industry needs to focus on three areas: firstly, the identification of new customer needs. It is necessary to investigate and identify the user pain points that may occur at present and in the future and the new customer needs for digital transformation in the industry according to the development trends of the industry. On this basis, the common demand scenarios of different enterprises can be explored and used as the basis for 5G-based innovation in digital products and services in the industry. Secondly, the introduction of new functions into products and services. In the design of digital product solutions in the industry, it is essential to continuously add new

optional function modules to products or services and test and verify them to examine whether they can meet the new needs of enterprises in the industry. Thirdly, the exploration of new profit models. It is important to design and create a new profit model for products and services according to the current situation and affordability of different types of enterprises in the industry, and develop a flexible and effective charging model, so that the new charging method for products is easily accepted by customers in the industry.

Case 9: 5G+Beidou Production Safety Management Innovation for Chemical Enterprises[27]

[Background] The real-time management of personnel and vehicles carrying dangerous chemicals in production areas by chemical enterprises remains a problem for daily production safety management. On the one hand, there are a large number of staff members of both an enterprise and its contractor(s) working at the same time in the production area, and it is necessary to collect real-time location data for thousands of people during peak hours; on the other hand, vehicles carrying dangerous chemicals are constantly moving in the factory premises and in-vehicle camera video data needs to be transmitted in real time to facilitate the effective management of vehicle locations and driver behaviors such as fatigue driving and dangerous driving. Currently, most chemical enterprises still resort to manual statistics for on-duty personnel and vehicle operation data, which cannot meet the requirements of real-time safety management. In this case, 5G+Beidou, Bluetooth and video surveillance and analysis technologies are used to enable real-time location supervision and personnel trajectory tracking, high-precision positioning and data analysis of vehicles carrying dangerous chemicals, as well as real-time management and real-time warning of such vehicles in all processes within production areas, effectively ensuring the safety of operating personnel and transport vehicles.

[Customer Positioning] The telecom operator has mainly considered applying these products to harsh workplaces with high temperature, high pressure, combustibles and explosives, and places vulnerable to accidents triggered by various dangerous chemicals. Target customers include enterprises and public institutions that produce, store and sell chemical products. The project is committed to delivering integrated personnel and vehicle positioning management services that are safe, convenient, efficient and low-cost to customers.

[Products and Services] The 5G+Beidou personnel and vehicle positioning system is mainly composed of personnel positioning work cards, vehicle-mounted positioning terminals and a positioning management platform. In terms of personnel management, personnel in production areas are equipped with positioning cards to enable high-precision positioning and trajectory tracking of such personnel through 5G+Beidou+Bluetooth. For open outdoor areas and some production areas, the 5G+Beidou positioning technology is used. For office buildings, semi-open outdoor areas, closed production areas and some areas where satellite signals are seriously blocked, Bluetooth beacons are used to assist positioning, with personnel information and trajectories displayed precisely on a 2.5D map. In addition, personnel are warned immediately through the loudspeaker on their positioning cards of behaviors against regulations based on 5G mobile control balls and AI analysis of public area surveillance video. The relevant violations of regulations are then pushed via the background to HSE (Health Safety and Environment) managers and corrected in a timely manner. Meanwhile, the positioning work cards are integrated with the SOS function, and personnel can send the current location data by pressing the SOS button to facilitate rescue efforts when they are in danger. In terms of vehicle management, 5G+Beidou intelligent positioning terminals are installed onto enterprise vehicles, contractor vehicles and vehicles carrying dangerous chemicals to enable intelligent positioning management of ordinary vehicles and vehicles carrying dangerous chemicals across the factory premises. Moreover, AI behavioral analysis is conducted based on vehicle-mounted mobile video and public area video surveillance to check the compliance of the driving behavior of vehicles in the factory premises and increase the level of safety

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[27]Case information provided by China Unicom Jiangsu Branch, Sinopec Yangzi Petrochemical Co., Ltd., Jiangsu Xinta Internet of Things Research Institute Co., Ltd.

management. The system also conducts basic information query, trajectory tracking and playback for vehicles carrying dangerous vehicles, provides timely overspeed, deviation, illegal parking, overstaying and other warnings, and obtains real-time field information to prevent major incidents and accidents.

[Profit Model] China Unicom delivers a package of 5G network access services, device terminals and system background, and provides its customers with a variety of charging models. **Firstly, the rental model.** China Unicom offers to its customers personnel positioning work cards, vehicle-mounted positioning terminals, vehicle-mounted mobile control balls and an SaaS (Software-as-a-Service) cloud platform for the personnel and vehicle positioning system. Personnel and vehicle location data and video surveillance data is transmitted back through 5G networks, and a monthly fee is charged for the traffic generated and for the use of the rental devices and platform, and can be paid by customers on a monthly basis. This model is geared to the needs of temporary or short-term personnel and vehicle management projects, and costs lower than separate purchasing. **Secondly, the devices + platform purchasing model.** In this model, enterprises directly purchase personnel positioning work cards, vehicle-mounted positioning terminals, vehicle-mounted mobile control balls and a personnel and vehicle positioning system platform from China Unicom, and pay for 5G traffic, the devices and platform as a package or on a yearly basis.

[Critical Resources and Capabilities] China Unicom has to possess comprehensive know-how and expertise in delivering 5G+Beidou personnel and vehicle positioning services, including professional skills to develop and use high-precision, low-power 5G+Beidou special explosion-proof devices and personnel & vehicle positioning management platforms, the capability of AI intelligent video analysis using MEC, and service capabilities of 5G networks and Beidou-enhanced ground base stations.

Case 10: 5G+Beidou Integration with Digital Twin to Fuel Water Conservancy and Flood Control Innovation[28]

[Background] At present, reservoir safety is threatened by problems such as a large number of dilapidated reservoirs, insufficient flood discharge capacity of some reservoirs, incomplete safety monitoring facilities, and unreasonable management systems and mechanisms, as well as inaccurate forecasting of extreme rainstorms in some areas, low precision of flash flood warnings, obstructed channels for the issuance of warnings, impeded transmission of information, insufficient coverage of early warnings, inadequate simulation of flood control dispatching and poor simulation checking function.

By integrating features such as Beidou, satellite remote sensing, radar, drones and unmanned ships with 4G/5G networks, China Unicom has built a provincial digital twin reservoir platform and space-air-ground integrated ubiquitous sensing network to enable automatic measurement and forecasting of rainfall, water levels and project operations, digital management of reservoir information, rainwater-holding capacity analysis and simulation of joint flood control dispatching in a river basin. The aim is to provide timely and accurate information for the safe operation of reservoirs and flood control dispatching, ensure effective management of reservoir safety and safeguard the healthy operation of reservoirs. Moreover, the 5G+MEC technology and intelligent algorithm model are used to achieve unified management of water conservancy models and intelligent algorithms for forecasting and flood control dispatching, develop refined flood forecasting models, and realize intelligent flood control dispatching for large reservoirs.

[Customer Positioning] Target customers initially include units in charge of water projects at all levels across Shandong Province. The customer base will then be extended to units in charge of the more than 98,000 water projects across China, including reservoirs, channels, sluices and dams, in particular those

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[28]Case information provided by China Unicom Shandong Branch

plagued by safety hazards and therefore badly in need of sensing devices and digital monitoring measures.

[Products and Services] The digital twin reservoir platform for flood control command and dispatching is a whole-process, visual and digital flood control command management and dispatching platform that combines pre-flood monitoring, flood regulation, post-flood summary and evaluation, contingency plan management and simulation. It features capabilities to make forecasts, issue early warnings, conduct simulations and draft contingency plans for upper-layer services of water conservancy departments at all levels and reservoirs, including flood prevention, water resources management and allocation, construction and operation of water projects, and can provide the following standardized services:

1. The 5G+Beidou+IoT service mainly includes safe displacement detection at reservoir sections, and collection and analysis of water quality, water level, osmotic pressure and other data. GNSS (Global Navigation Satellite System), water meter and osmometer are installed to a reservoir to obtain real-time data on the reservoir, analyze the data and then issue early warnings.

2. The 5G intelligent safety inspection service issues early warnings about any crack or floating object in a reservoir based on the reservoir photos and underwater photos taken by 5G-enabled unmanned ships and drones.

3. The 5G+video analysis platform issues alarms and warnings about illegal intrusion of floating objects, personnel and vehicles by using cameras around a reservoir and AI analysis technology; at the same time, video matching and stitching is done through 5G+MEC+RTK (Real-time kinematic) to track such illegal intrusion.

Based on standardized products and services, a "digital twin reservoir" can provide rainfall forecasting models, flood forecasting models, flood control dispatching models based on customized AI algorithms, as well as high-performance and intelligent hydrological, hydrodynamic, water project scheduling and related algorithms according to the needs of different scenarios, thus delivering "computing power" to reservoir disaster prevention and decision-making about joint flood control dispatching and promoting intelligent flood control dispatching for large reservoirs.

[Profit Model] A variety of models are available to customers. **Firstly, the service purchase model.** Customers directly use a full package of services offered by the telecom operator, and pay for the services on a periodic basis (monthly/yearly). In this model, customers do not have to bear the cost of device purchase and platform maintenance. **Secondly, the rental model.** In this model, the telecom operator provides customers with sensing devices or platform rental services, and the rest is left to customers themselves. **Thirdly, the device purchase model.** In this model, customers directly purchase sensing devices and platforms from the telecom operator.

[Critical Resources and Capabilities] **Firstly, the operator has independently developed terminals and operation & maintenance management systems; secondly, the operator has established an ecosystem cooperation alliance by pooling resources from all parties concerned.** Focusing on building an ecosystem cooperation alliance for the water sector, China Unicom has created a space-air-ground integrated sensing network for water resources management by expanding the scope of real-time online monitoring through multiple monitoring means such as satellites, drones, video, remote sensing and robots. **Thirdly, ecosystem partners have contributed technologies such as space remote sensing, oblique photography and BIM (Building Information Modeling)** to the construction of large and medium-sized reservoirs, digital water projects in key river and lake basins, and related standardized management application systems.

Case 11: The Lightweight Service Model for the Business of Huangni'ao Mining Co., Ltd. in Hunan[29]

[Background] As one of the first innovation-based small enterprises piloting green mines in Hunan Province, Chenzhou Huangni'ao Mining Co., Ltd. has been committed to the construction of automatic and intelligent mines in recent years. In the deployment of 5G intelligent applications, small and medium-sized mining enterprises are under great pressure as the adoption of private 5G networks and customized deployment of local operations require heavy initial investment. China Mobile, together with Huawei, has enabled Huangni'ao Mining Co., Ltd. to achieve lightweight deployment through business model innovation of cloud-based light apps, so that smart apps are ready to use out of the box. This leads to the establishment of the standards for the construction of low-cost light apps featuring continuous innovation and subscription as needed, which promotes the digital transformation of SMEs.

[Customer Positioning] The lightweight service model is mainly geared to the needs of small and medium-sized mining enterprises, and meets connection management and other general needs through standardized products and lightweight services. This service model can be extended to manufacturing, petrochemical and other industries, and is mainly geared to the needs of enterprises with integrated business management needs and budget constraints. It can visualize and monitor the conditions of industrial parks and meet the needs of integrated management and stable production.

[Products and Services] The lightweight service model delivers business upgrading services to meet standardized general business needs, including:

1. Private 5G networks, providing private networks or shared networks for enterprises.

2. Intelligent transformation of existing systems and devices, enabling 5G connections through the transformation of terminals and devices.

3. Lightweight business services, including features of standardized services, such as video, PLC, data acquisition and other devices monitoring, video surveillance, and business connection/campus network topology visualization, to support standardized services access for long-tail enterprises.

[Profit Model] Lightweight services are mainly geared to the needs of numerous mining enterprises, and Hunan Branch of China Mobile has realized business model innovation by changing the cost structure. The original deployment model adopts private 5G networks and customized apps, and enterprises need to invest heavily in IT application. To reduce enterprises' costs, lightweight service innovation is conducted to place private networks under the private or shared network service model and apps under the cloud-based deployment model, thus forming the cost structure service model of "fixed costs of network services + terminal & device transformation costs + low marginal costs of apps", and linking the app service costs to the number of connections. Therefore, the rapid scale replication of the lightweight service model can be achieved by reducing the initial investment by enterprises in the case of a small number of connections.

1. Private network services: Customized private networks adopt a monthly rent model, while shared networks adopt a billing model based on connection traffic.

2. Intelligent transformation services: Enterprise equipment such as mining trucks, data acquisition devices and video cameras are transformed for 5G purposes, and 5G terminal and module expenses and nonrecurring expenses for transformation and integration are charged.

3. Lightweight services: Through cloud-based deployment of general standardized apps, apps can be subscribed as needed and adopt a license-based billing model. They are gradually rolled out according

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[29]Case information provided by Huangni'ao Mining Co., Ltd. in Suxian District, Chenzhou City, Chenzhou Branch (Hunan) of China Mobile, Huawei Technologies Co., Ltd.

to business needs to reduce enterprises' one-time costs and enable rapid business deployment.

[Critical Resources and Capabilities] To deliver a lightweight service model, the operator should possess the following critical resources and capabilities, apart from 5G network capabilities:

1. Terminal & device integration, upgrading and transformation capabilities, completing 5G intelligent transformation of terminals and devices by embedding 5G modules, network connection design and transformation of devices and other modes.

2. Ecosystem aggregation capabilities, enabling the aggregation of standard general connections, monitoring and management apps through ecosystem integration of independent software vendors (ISVs) to deliver standardized app services to SMEs.

3. Public/private cloud service capabilities. Cloud-based deployment of apps to deliver general cloud service capabilities such as topology visualization, connection monitoring, device monitoring and fault demarcation.

[Innovation] With the continuous advancement of digital transformation of enterprises and industries, mining subsystems, platforms and apps have been integrated through the lightweight service model to realize the sharing of resources and capabilities. Business that is highly general and can be deployed on the cloud, such as connection management and AI video analysis, has undergone standardized lightweight deployment to change the enterprise's cost structure for digital transformation, so that the enterprise could quickly bring its business online at a low cost, upgrade its business and improve management efficiency.

(ii) Exploring business models featuring cooperation between telecom operators and enterprises in the industry

With the acceleration of digital transformation, it is of great significance to enhance value creation capacity through collaborative innovation. Telecom operators enjoy formidable network and technology platform resources, a broad user base and complete service systems, and can provide a full range of technical support and services for the digital transformation of enterprises in the industry. Enterprises in the industry, on the other hand, boast a wealth of know-how, professional skills and diversified ecosystem resources. By enhancing resource complementarity and advantage sharing, the collaboration innovation by the two sides may expand the value space of the ecosystem, promote technology and business innovation, bring in more trade objects to improve trading efficiency, and create value for more stakeholders, thereby driving the development of the entire industry.

Case 12: Business Model Innovation by the Gree-Led 5G Large Appliance Industrial Cluster[30]

[Background] As the leader of the large appliance industrial cluster, Gree Electric Appliances, Inc. of Zhuhai (hereinafter referred to as Gree), in partnership with Guangdong Branch of China Unicom, has developed a 5G industrial chain digitalization platform to address the core pain points of enterprises in the industrial cluster, such as inefficient supply and demand matching in the supply chain, difficulty in closed-loop control of business quality in the industrial chain, inefficient reconciliation of funds in the industrial chain and great pressure on cost reduction. The platform incubates digital apps for research and development (R&D) and design, production and manufacturing, operation management and market services. Based on multi-campus network coordination in the industrial cluster, the platform enables plan-coordinated real-time monitoring, plan-shared inventory reduction, continuous process optimization and intelligent settlement optimization, as well as ecosystem capability sharing among enterprises in the industrial cluster. In addition, a trustworthy data mechanism and unified standard system have been established. Gree has taken the lead in building a model 5G industrial cluster in

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[30]Case information provided by China Unicom Guangdong Branch, Zhuhai Gree Electric Co., Ltd.

Zhuhai's home appliance agglomeration area.

[Customer Positioning] In order to enhance its overall brand capacity, Gree has launched 5G network transformation and digital transformation of the production environment of more than 1,000 upstream enterprises in the industrial cluster to empower the upgrading of the vertical sectors of home appliances, satisfy the needs of systematic cost reduction and quality improvement across the industry, and improve the efficiency of industrial chain coordination.

[Products and Services] Gree and Guangdong Branch of China Unicom have formed an alliance (hereinafter referred to as the alliance), as the initiator of the capacity upgrading of the large appliance industrial cluster, to build a "5G industrial chain digitalization platform" and bring Gree's upstream and downstream enterprises in the chain onto the cloud and platform. The aim is to enable capabilities such as ecosystem capability sharing, resource pool sharing, industrial chain coordination system sharing, business process coordination, data space coordination, and the establishment of a unified standard system, a unified architecture system and a trustworthy data mechanism.

Focusing on the 5G industrial chain digitalization platform, the two parties to the alliance deliver different services:

1. Guangdong Branch of China Unicom:

(1) Capability of 5G transformation of enterprise intranets: for large enterprises with higher requirements for network capabilities and information security in the industrial cluster, providing them with the capability of 5G transformation of intranets through moving hybrid private 5G networks downwards and private deployment, and at the same time carrying out systematic coordination via the 5G industrial chain digitalization platform. For SMEs that value cost-effectiveness, providing them with integrated edge solutions, shared virtual private networks and SaaS apps based on the 5G industrial chain digitalization platform to enable more deployment modes, thus reducing the cost of digital transformation and digitalizing their production. (2) Cloud capabilities: China Unicom Cloud has built a cloud base for the large appliance industry to help enterprises bring their service onto the cloud and establish a security capability system. (3) Fixed-network capabilities: providing enterprises in the industrial cluster with basic IT service capabilities, and ensuring the confidentiality and reliability of business information transmission between enterprises through private network communication. (4) Big data capabilities: ensuring the consistency of collaboration data through the blockchain technology.

2. Gree:

(1) Platform services: undertaking the development, operation and maintenance of the 5G industrial chain digitalization platform. (2) Collaborative standard setting: based on the exploration of its own digital transformation, developing a standard system and an architecture system for enterprises in the industrial chain to ensure consistent coordination among the enterprises and ultimately promote lean, automated and digital development. (3) Industrial application services: based on its own sci-tech service capabilities, providing standard products such as smart factories and AI+intelligent manufacturing for enterprises in the industrial chain, and delivering customized development services to meet individual needs. (4) Data+financial services: by establishing a supply chain financial ecosystem based on industrial chain data accumulation, building a credit system for enterprises in the industrial chain, and providing the enterprises with blockchain-based financial services for the flow of capital funds.

[Profit Model]

Guangdong Branch of China Unicom: delivering basic network capabilities to enterprises in the industrial chain to facilitate their digital transformation and connection to the cloud and the 5G industrial chain digitalization platform. To better serve the enterprises, the company has shifted its billing model from traffic billing to value supply, and delivers slicing, connection, 5G LAN, cloud and various other capabilities to meet different corporate needs.

Gree: for industrial apps, the platform provides SaaS (Soft as a Service) services and charges for these services according to the operating costs of the module functions used, and at the same time offers customized industrial apps according to individual needs of enterprises. It also delivers financial services to solve financing difficulties facing enterprises in the industrial chain, while charging a fair fee for these services.

[Critical Resources and Capabilities]

Based on its own practice of digital transformation, Gree, in partnership with Guangdong Branch of China Unicom, has incubated a 5G industrial chain collaboration platform and developed a variety of industry solutions that are more targeted and can quickly match the production sites of all units in the industrial cluster. Based on its own cloud network capability, Guangdong Branch of China Unicom has accumulated mature underlying network capabilities for the home appliance industry in the process of serving Gree's transformation, and delivers one-stop 5G network service capabilities, as well as atomic capabilities such as AI intelligent analysis platforms and device IoT platforms.

[Innovation] Based on the industrial chain collaboration platform, capabilities such as enterprise portrait data and industrial mechanisms are shared, and enterprises are provided with platform services and digital transformation design for free to reduce the cost of platform use for enterprises and improve the efficiency of supply-demand matchmaking. So far, more than 1,000 upstream and downstream enterprises of Gree have joined the platform.

On the premise of coordination and efficient matching of industrial chain business, the problem of inefficient reconciliation has been solved for enterprises, driving a reduction of RMB 60 million in internal management costs for inter-business reconciliation for more than 1,000 enterprises.

Slow-moving inventory in enterprises has been reduced through strong supply chain coordination, driving a reduction of over RMB 900 million in raw materials costs and warehouse management costs for more than 1,000 enterprises in the industrial chain.

Case 13: Business Model Innovation of 5G+MEC Application in Smart Rice Farming by Tramy Group[31]

[Background] Shanghai Tramy Green Food (Group) Co., Ltd. (hereinafter referred to as Tramy Group) is dedicated to the R&D, planting, production and sales of fresh food. Planting bases are critical fresh food infrastructure, and self-built bases can stand immune from external uncertainties such as weather and emergencies, and ensure stable basic supply of agricultural and processed products. Currently, 4G transmission fails to enable real-time monitoring of crop growth or inform scientific decision-making through data analysis due to problems such as slow and delayed uploading. Additionally, the traditional farming model of "going it alone" among downstream farmers often leads to the problem of blind production. Tramy Group has built a rice farming demonstration zone in Shanghai, hoping to digitalize the cultivation of rice crops by resorting to 5G technology with advantages such as high bandwidth, low latency and wide connectivity. Based on the 5G+MEC (Mobile Edge Computing) technology and by combining it with AI intelligent analysis apps, China Telecom has helped Tramy Group achieve the real-time digitalization of rice and vegetable planting processes. Through intelligent data interpretation, modeling and decision-making, a regional big data cloud platform that integrates data acquisition, transmission, interpretation, simulation and decision-making has been developed for the construction of smart agriculture management platforms.

[Customer Positioning] Large leading agricultural enterprises can be provided with customized

[31]Case information provided by Shanghai Branch of China Telecom.

agricultural application models and platform development and data services according to the characteristics of these enterprises as well as soil, weather and other factors. Cooperatives, family farms and other customers affiliated to these leading enterprises can be provided with IoT data acquisition plans and platform interfaces, such as those based on 5G agricultural intelligent poles. Data on agricultural products is automatically uploaded to the background to generate analysis results and solutions. Individual customers can directly provide pictures data through mobile phone photos and then be directly provided with agricultural production suggestions after background analysis.

[Products and Services] Based on China Telecom's MEC platform, Wuhan University's AI analysis technology and Tramy Group's test base, the parties concerned have jointly built a fully intelligent digital rice planting demonstration project based on 5G+MEC, and established a smart agriculture management system featuring intelligent acquisition, transmission, interpretation, simulation and decisioning, which is composed of an AI visual system, a management platform, a farmland digital twin system and a mobile APP.

1. Sensing IoT of 5G plus multi-source observation data acquisition, which collects agricultural data such as weather, soil moisture and crop growth through ubiquitous sensing devices installed across Tramy Group's agricultural base, such as ground sensors, intelligent monitoring poles and multispectral video from drones, and transmits the data back through a 5G network.

2. 5G+AI system autonomous analysis, which, based on 5G+AI technology, automatically stores, extracts and interprets the massive data acquired at the front end, and therefore enables features such as intelligent counting, growth diagnosis, nutrient level assessment, intelligent identification of pests and diseases, and intelligent yield measurement.

3. Agricultural digital twins, which display the indoor digital twin of the demonstration zone in real time by using the digital twin technology and taking advantage of 5G features such as large bandwidth and low latency, combine data with the realities to ensure timely prediction of water, fertilizer and pesticide demand and remote control.

[Profit Model] The telecom operator provides customers with a PaaS/SaaS service purchase model in the form of platform capability output, and enjoys greater room for the expansion of PaaS/SaaS services and for the promotion of other telecom services in the future.

[Innovation] The project has explored the promotion model for 5G large bandwidth services and DICT integration. The operator has moved the core network components downward to the user side, and adopts a multidimensional service model of non-traffic billing. The provision of services is strongly bonded with application scenarios such as planting production, management and origin tracing, which has not only solved problems such user data security and latency, but also addressed user concerns about billing. The project has brought significant economic benefits to Tramy Group. Precise water and fertilizer management through intelligent identification based on big data analysis has reduced the waste of fertilizers, improved the quality of crops, and cut the cost of agricultural products, while ensuring the traceability of farming and the quality and safety of agricultural products. The project is expected to save water by 10%-35%, nitrogen fertilizer application by 10%-30%, increase yield by 5%-20% and reduce the number of farmland managers per 10,000 mu of farmland, and enjoys the prospect of large-scale application, including the further expansion among customers and the promotion to other regions.

[Critical Resources and Capabilities] The project adopts a model of joint development by China Telecom, Wuhan University and Tramy Group.

The operator has provided information infrastructure such as 5G networks, cloud and edge cloud and related operation and maintenance management, and opened a dedicated 5G slicing network for agricultural purposes for Tramy; while Wuhan University has delivered AI technology capabilities in the intelligent management of farmland.

Tramy Group has provided a test base, which consists of an 8,000-mu agricultural planting base and a

nearly 500,000-mu extended base. It maintains stable relations with upstream and downstream enterprises in the industrial chain, and has created its own production, processing, logistics and retail platforms.

(iii) Exploring business models focusing on enterprises in the industry

With the gradual understanding of the performance of 5G technology, some enterprises in the industry have begun to innovate based on "5G+DICT" technology, and re-engineer the business model by reconfiguring their original business systems or changing one of the business activities or links. The re-engineering of business model brings new space for value creation, and may also have a huge impact on the original transaction roles, transaction structure and transaction value in the industry. The development of 5G technology is providing a new technological support environment for business model innovation in some industries.

Case 14: Business Model Innovation of Virtual Power Plants by Guangzhou Power Supply Bureau[32]

[Background] In recent years, China has attached great importance to the development of virtual power plants in the context of the "dual carbon" goals of carbon peaking and carbon neutrality by actively exploring business models such as smart energy and virtual power plants. The country has proposed to support user-side adjustable resources such as user-side energy storage, electric vehicle charging facilities and distributed power generation, and encourage load aggregators, virtual power plant operators and integrated energy service providers to participate in power market transactions and system operation and regulation.

[Business Activity System] The business activity system of a virtual power plant is mainly composed of a power grid company, aggregators and a telecom operator.

The power grid company has systematic planning for power development, investment, construction, operation and management, and the stakeholders of a virtual power plant needs to accept the unified supervision and management of the power grid company. The power grid company is able to independently undertake the research and development of a cloud dispatching center and a control platform for the virtual power plant. To be specific, the cloud dispatching center lies at the core of the entire virtual power plant control system, and is capable of centralized management and dispatching of various distributed resources such as controllable loads and storage & discharge equipment. As main players on the power demand side, aggregators are in control of massive loads, such as workshops, office parks, large shopping malls and charging pile operators, and can respond to the power grid company's preset or real-time dispatching during peak hours to achieve "peak shaving and valley filling" and then improve the reliability and operating efficiency of the power grid as a whole. By responding to the grid dispatching requirements for "peak shaving and valley filling", aggregators can receive a certain amount of subsidy or tariff credit from the power grid company. Some smaller aggregators may choose to be directly connected to the power grid company's control platform, while some large ones may opt to independently develop a control platform that collects, aggregates and reports information on the operating parameters of electric equipment scattered everywhere, and receives and responds to the various commands from the cloud dispatching center to enable precise control of electric equipment in their control.

In a virtual power plant project, the telecom operator delivers network products and services to the power grid company and aggregators, and charges for network construction and equipment transformation. Apart from providing network resources (e.g., 5G, optical fiber private networks, virtual private

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[32]Case information provided by Guangzhou Power Supply Bureau of Guangdong Power Grid Co., Ltd., Guangzhou Branch (Guangdong) of China Mobile, ZTE Corporation

networks, the Internet) for the cloud dispatching center and control platform, the telecom operator also undertakes the retrofitting and transformation of devices such as 5G CPE (Customer Premise Equipment) and IoT cards to the production lines, charging piles and other load terminals controlled by the aggregators, thus ensuring the load terminals' access to the network. This requires the telecom operator not only to possess relatively comprehensive network technologies, but also to meet the special requirements of electric power scenarios for the network environment.

On the whole, it takes only a small subsidy and a platform & network construction fee for a power grid company to significantly reduce the cost of infrastructure construction; it takes only a small network traffic and equipment upgrading fee for an aggregator to effectively cut down on the overall cost of electricity; and a telecom operator could also gain benefits by selling network products and services to power grid companies, aggregators and other players, while further expanding the customer market. In this way, the virtual power plant model succeeds in bringing win-win results to the three parties in terms of commercial interests, and forming an effective positive feedback loop.

[Innovation] Firstly, distributed resources in power systems are regulated in real time through advanced ICTs and software technologies, breaking the old prior notice model and at the same time allowing relatively decentralized power-consuming enterprises to participate extensively in the power market and the daily management of power grid operations. Secondly, a profit model of multi-stakeholder participation and win-win cooperation has been formed. In the project, the power grid company, aggregators and the telecom operator could, for their own interests, work together to advance the scale application of virtual power plants.

Case 15: TWMG's 5G Cloud XR-Driven Cultural & Artworks Metaverse[33]

[Background] In recent years, riding the wave of digitalization of industries, cultural industries have been making full use of technologies such as 5G, XR (extended reality), blockchain and AI to accelerate the digital transformation and upgrading of traditional cultural industries and create a new business form of digital culture. The digital cultural industry has grown fast in the creation, exhibition and trading of cultural artworks, and features a combination of virtuality and reality, and online and offline forms. Tang West Market Group (TWMG) has joined hands with units including Shaanxi Branch of China Mobile and ZTE Corporation to spearhead the exploration of cultural digital innovation.

[Customer Positioning] Target customers of TWMG's cultural & artworks metaverse mainly include non-state-owned and state-owned museums that own resources of cultural relics and cultural artworks, institutions, organizations and individuals engaged in the collection, exhibition and trading of digital collections and cultural artworks, as well as commercial entities, museums, hotels and scenic areas within the Tang West Market Cultural Scenic Attraction.

[Products and Services] Based on the cultural & artwork metaverse platform, TWMG advances the development of its products and services. Firstly, an art realm platform is created for the construction of metaverse museums to enable interaction with online exhibitions of digital artifacts and cultural artworks and to expand consumer business both online and offline. The platform can deliver services such as digital artifact construction, online 5G digital museum construction, 5G+AR artifact appreciation, 5G+AR digital landscape and 5G+AR navigation. It can provide non-state-owned and state-owned museums with metaverse museum construction services, build personalized metaverse art galleries for institutions and individuals, and attract visitors to the scenic attraction to pull consumption. Secondly, a digital artwork trading platform is created to enable online exhibition and trading of cultural artworks.

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[33]Case information provided by Tang West Market Group, Shaanxi Branch of China Mobile, ZTE Corporation.

[Profit Model] The cultural & artworks metaverse platform of TWMG adopts the following charging models: firstly, the digital modeling fee for artifacts and artworks. The platform charges museums and individuals for 3D data collection and modeling of their collections and artworks. Secondly, the fee for bringing metaverse museums onto the platform. The platform charges non-state-owned and state-owned museums that have settled on the platform for platform services during the mature period. Thirdly, the platform charges institutions and organizations for platform services when they hold temporary exhibitions, special exhibitions and launches of digital collections and artworks. Fourthly, the service fee for digital museum exhibitions. When institutions and organizations build digital museums, they are charged for digital collection construction, point cloud 3D reconstruction and AR/VR display services on a case-by-case basis, and for platform services. Fifth, the rent for institutions and individuals to settle in metaverse art galleries. Institutions are charged for the use of the space of metaverse art galleries according to the duration of such rental and the size of the rental space. Sixth, the service fee for metaverse digital assets trading. Institutions are charged for the trading of digital artworks exhibited in metaverse art galleries. Seventh, the service fee for the release of digital artworks. Institutions are charged for the release of digital artworks on the platform.

[Critical Resources and Capabilities] TWMG possesses cultural artwork resources and capabilities of digital creation, virtual display and trading & circulation of cultural artworks. Firstly, the company has the ability to build and operate the cultural & artworks metaverse platform, and has in place the foundation for supporting the creation, display and trading of digital cultural artworks. Secondly, it has abundant customer resources and the ability to bring together and communicate with institutions of digital collections and lovers of cultural artworks. Thirdly, it has the ability to trade and circulate digital cultural artworks, and is qualified for trading at Hainan International Culture and Artworks Exchange (HNICAE). Fourthly, it has the ability to operate a cultural industrial park.

[Innovation] By constructing a cultural & artwork metaverse platform and a trading platform, TWMG has enabled the expansion from traditional cultural industries to the realm of digital culture. Firstly, the project has promoted the development of exhibition of and interaction with digital artifacts and cultural artworks. Based on technologies such as 5G, XR and cloud computing, a platform for exhibition of and interaction with digital artifacts and cultural artworks is created, which is known as "Art Realm", to promote the expansion of cultural and art entities to digital space applications, and support services and applications such as metaverse museums, metaverse art galleries and 5G digital culture parks. Secondly, the project has boosted online and offline transactions of digital artifacts and cultural artworks. Based on technologies such as 5G, blockchain and cloud computing, an artwork trading platform is created to deliver cultural artwork release and trading services to institutions and individuals.

Case 16: Business Model Innovation of an Ecoverse 5G Smart Commercial Complex by Anhui Wanda with the Help of Anhui Branch of China Telecom[34]

[Background] The concept of smart commerce was first put forward in the 1950s. With the development of emerging technologies such as cloud computing, IoT and AI, and continuous consumption upgrading, 5G smart commerce is a perfect combination of online and offline consumption that allows consumers to enjoy an "immersive" shopping experience. The 5G smart commercial complex solution, based on the technology base of a digital capability platform, integrates 5G cloud network, virtual reality (VR), indoor positioning and digital twin technologies to meet the needs of core scenarios such as indoor navigation, virtual and real interactive experience, coupon pushing, and smart diversion of customers and shopping guide.

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[34]Case information provided by Anhui Branch of China Telecom.

[Customer Positioning] The solution is mainly promoted to business management companies of commercial complexes such as large supermarkets, department stores, pre-installed home furnishing malls and shopping malls, and serves customers of all sizes including general consumers, complex tenants and business management companies of complexes. It offers a digital retail solution featuring deep integration of online and offline consumption to business management companies, retailers and consumers, thus satisfying users demand for digital, immersive shopping and consumption, and constantly improving consumer recognition.

[Products and Services] By leveraging the capabilities of a customized 5G network, such as high bandwidth, low latency and ubiquitousness, the smart commercial complex delivers a range of core application products of smart commerce, such as AR navigation car locating, AR landscape gaming, AR treasure box card collecting, and XR entertainment space, through the technology middle platform, the data middle platform and the business middle platform. AR navigation services enable real-time positioning, path planning and full-time AR navigation at any place of a department store, and provide random AR treasury box coupons; the AR imaging technology allows consumers to immerse themselves in cool and colorful AR landscape, experience the perfect fusion of virtuality and reality; the "5G cloud XR entertainment space" offers consumers a fascinating, immersive interactive experience.

[Profit Model] Based on business partnerships of mutual benefit, bundling and win-win cooperation, the Ecoverse 5G smart commercial complex solution generates revenues through lump-sum payment, store replacement and resource exchange according to the realities of different business management companies.

[Critical Resources and Capabilities]

Digital construction capabilities: by leveraging its premium 5G networks and technologies such as VR, UHD, slow live broadcasting, China Telecom contributes to the digital and intelligent upgrading of the media industry on all fronts, including filming, production and transmission.

Digital service capabilities: the digital platform adopts a microservice model and is deployed at China Telecom Cloud in a centralized manner to provide services for complex tenants and public users. The digital capability base carries public applications, and features high performance, high availability and good scalability.

Resource input: in the entire solution, Anhui Branch of China Telecom needs to invest cost resources such as development, function realization and manpower resources; in the early stage of joint promotion of the Ecoverse platform, it needs to cooperate with business management companies to engage complex tenants and customers in the whole process and invest the manpower needed. Commercial complexes have advantages such as unified management of tenants, department store membership and intensive planning of activities, and could invest resources through direct payment, store replacement, resource exchange or revenue sharing.

[Innovation] Customers can enjoy a story-telling immersive experience of real and virtual business activities, with their interest quickly satisfied, which leads to a purchase. Tenants can share the big data on the XR cloud platform to adjust their revenue generation strategies. The connection among consumers, tenants and stores is reconfigured via spatial information. User information is collected and analyzed to guide the development of offline commerce, improve the efficiency of business operation and create new points of profit growth.

IV. Recommendations for the development of 5G business model innovation

Over the four years since the commercialization of 5G, 5G business model innovation has given initial results, and the mining of new application scenarios, the upgrading of technologies and the industry's service capabilities, the improvement of the product and service system and the exploration of new profit models have all contributed to the evolution and revolution of business models. 5G business model innovation is still restricted by problems such as slow application of new technology products, an immature industry of related technologies[35], a fragmented industrial application market, and insufficient cross-industry collaboration. With the gradual deepening of 5G applications, it is important to address these problems by enhancing the supply of the technology industry at a faster pace, building a cross-industry and cross-cutting collaborative innovation ecosystem, gradually improving the 5G business environment, promoting iterative upgrading of 5G business models, and boosting the scaling up and effective quality improvement of 5G applications, thus driving digital, intelligent and green economic and social development and making 5G a genuine strong engine of China's high-quality economic and social development.

(i) Stimulating the vitality of innovation to diversify the supply of technology products

Following the principle of demand-based and innovation-driven development, we should promote the commercialization of urgently-needed new technology products as soon as possible and accelerate breakthroughs in the R&D of key and difficult technologies, thus laying the technological and industrial foundation for 5G business model innovation. **Firstly, innovation in new terminal technologies should be promoted.** We should accelerate breakthroughs in core and key technologies, and step up the industrialization of lightweight and portable consumer AR/VR terminals. We should speed up the wider application of new terminals such as foldable screens, UHD mobile phones and 3D naked-eye mobile phones. **Secondly, the supply capacity for industry-oriented generic 5G-Advanced technology products should be enhanced.** We should continue to improve the resilience of 5G intermediate frequency and millimeter wave industries, strengthen joint research on 5G-Advanced technology products, intensify the R&D of 5G technology products such as 5G uRLLC (Ultra-Reliable and Low Latency Communications), TSN (Time-Sensitive Networking) and high-precision positioning, and enhance the supply capacity for universal 5G gateways and terminals to meet the common needs of vertical industries. We should strengthen the development of international standards on 5G-Advanced, develop new technology products such as AI and Integrated Sensing and Communication (ISAC), extend support to drones, AR/VR and other new fields, and expand the generic supply capacity. **Thirdly, a product system that integrates 5G into industrial systems and equipment should be established faster.** We should accelerate the integration of 5G into large industrial machinery and control systems such as industrial robots, CNC (Computer Numerical Control) machine tools and coal mine machinery, establish a product system that integrates 5G applications, networks and terminals, which can be promoted on a large scale, and accelerate the fostering of an independently controllable terminal operating system for 5G IoT.

(ii) Innovating cooperation models to create a new industrial ecosystem

Following the principle of coordinated and integrated development, we should encourage mobile communication enterprises to explore diversified sustainable cooperation models together with enterprises in vertical industries, upstream and downstream enterprises in the industrial chain, and small, medium-sized and large enterprises, increase connectivity and coordination to form a "team race" model. Apart from the establishment of various innovation consortiums such as industry alliances and open laboratories, more new models can be explored. **Firstly, a mobile network capability open platform should be built to bring more developers into the 5G application innovation ecosystem.** In February 2023, GSMA proposed at the MWC Barcelona to launch the GSMA Open Gateway initiative, in a bid

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[35]Specifically, such technologies refer to new digital technology products, new consumer terminals, industry terminals and industry information software that create value for customers in synergy with 5G technology.

to foster a new connectivity framework that opens mobile network capabilities to the global application development ecosystem through unified and open Application Programmable Interfaces (APIs). Open Gateway provides app developers with cloud-based universal access to mobile communication networks, allowing them to invoke mobile communication network capabilities in an interoperable, intuitive and programmable way and implant these capabilities into a wide range of industrial innovation applications. It provides a brand new technological means for ecosystem partners such as industrial customers, cloud service providers and developers to innovate their business models and create new business value. So far, nearly 30 leading mobile operators around the world have joined the initiative, covering about 60% of the world's mobile users. With more ecosystem partners participating in the initiative, 5G business models are expected to usher in a new wave of innovation. **Secondly, the power of capital should be exerted to develop and expand the 5G industrial ecosystem.** To effectively make up for the deficiency of industrial expertise and ecosystem resources, we may explore the possibility of building an integrated investment, merger and acquisition (M&A) and incubation platform through capital operation activities such as strategic investment, M&As and establishment of joint ventures to accelerate the expansion of 5G+ new models and business forms. **Thirdly, cooperation with enterprises dominating the industrial chain and leading enterprises in industrial clusters should be strengthened to create the advantage of scale.** We may cooperate with these enterprises to develop and deliver distinctive 5G products, and provide services for extensive SMEs in the industrial chain and in industrial clusters.

(iii) Enhancing capacity building to raise the level of innovation among enterprises

We should drive enterprises to adapt to new markets, new demands and new applications, develop new resources and capabilities, and help explore business model innovation. **Firstly, the capability of understanding customers' core value needs should be enhanced.** To meet the integrated, diversified and comprehensive needs of customers in vertical industries, enterprises have to stand in customers' shoes and incorporate digital transformation into all production and operation processes of customers, including R&D, production, manufacturing and sales. Enterprises should not only provide customers in the industry with dedicated high-quality network services, but also offer systematic and integrated services of "private networks + platforms + applications" to customers in vertical industries by giving play to the advantage of cloud-network integration (CNI). **Secondly, the capability of ecosystem operation should be improved.** Enterprises should be good at organizing a variety of ecosystem resources and play a leading role in enhancing core capabilities of technology innovation, standard setting, resource integration, marketing and promotion, application and incubation, and risk management to drive common progress of alliance enterprises and achieve win-win results. Efforts should be made to actively explore diversified cooperation models, build an open and win-win 5G industrial ecosystem based on core capabilities, and accelerate the expansion of 5G+ new models and new business forms. **Thirdly, the capability of designing diversified sustainable profit models should be improved.** On the one hand, enterprises can charge customers accordingly for the products and services they deliver. For example, based on private network services, they may charge customers for network connection, traffic, card numbers, and application scenarios based on private networks; based on the provision of integrated solutions, they may charge customers for consultation and planning, ICT projects, network maintenance, and rental of base stations and other network devices; based on 5G digital platforms, they may charge customers for platform development and operation, monetization through platform opening, and value-added application services on the platforms. On the other hand, enterprises can construct a profit model by using a variety of revenue and cost allocation mechanisms, where profit may come from third parties or other stakeholders, and cost may be borne by other stakeholders, thus diversifying the profit model. **Fourthly, the organizational structure should be adjusted to reshape the internal stakeholder transaction relationship.** The advancement of new business activities involves multiple departments within an enterprise, where the business collaboration process, personnel coordination relationship, business settlement relationship and even performance evaluation mechanism are generally set based on old business activities. The new business environment puts forward higher requirements for an enterprise's internal organizational structure, and major adjustments and reforms should be undertaken in technology R&D, business departments, the

collaboration mechanism, project management, talent utilization and ways of performance assessment and management to align the organizational structure to the changes in business and ensure fruitful corporate innovation.

(iv) Enhancing cross-industry cooperation to foster a favorable business environment

Pushing 5G toward industrial Internet requires closer and deeper cooperation between the mobile communication industry and vertical industries in the fields of formulation of industry integration standards and security collaboration, thus creating a favorable ecosystem cooperation environment for innovation in 5G technology applications and business models. **Firstly, a cross-industry and cross-cutting innovation center system should be established.** Telecom operators and leading enterprises in vertical industries should be guided to set up a cross-industry and cross-cutting 5G integration application innovation center, and be encouraged to open technology capabilities and offer training services to different industries and SMEs, improve the level and capacity of services of the innovation center, and promote innovation in integration technologies and applications. **Secondly, the establishment of a system of cross-industry integration standards should be accelerated.** We should systematically advance the research on 5G integration application standards for key industries and make clear the key direction of standardization. We should enhance cross-sector, cross-industry and cross-cutting coordination of important standardization matters, establish a sound cooperation mechanism for the relevant standardization organizations to realize interworking between various protocols and mutual recognition of standards, and accelerate the formulation of integration application standards. We should expedite the implementation of key standards in the industry, establish a standard implementation system of "standard setting + laboratory-based technical verification + field adaptation verification", and propel the implementation of 5G integration technologies and their industrialization. **Thirdly, cross-industry mutual trust and recognition of security capabilities should be promoted.** We should enhance cross-sector, cross-industry and cross-cutting coordination to ensure 5G security, accelerate the development of a system of 5G integration application security standards, and release a cross-industry management system and guideline for 5G integration application security.

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