THE DEVELOPMENT OF 5G DIGITAL INFRASTRUCTURE IN CHINA

Erik BAARK

EAI Background Brief No. 1645

Date of Publication: 13 April 2022

Executive Summary

1. In January 2022, China adopted the *Plan for the Development of the Digital Economy* following the release of the 14th Five-year Plan in 2021 and other initiatives to develop innovative high technology for digitalising the Chinese economy. The plan proposed constructing fifth generation (5G) mobile communications networks with high data speeds and quick response time (low latency).

2. The context for the development of the 5G infrastructure is related to the concept of new infrastructure launched at the Central Economic Work Conference in December 2018. As much as RMB17.5 trillion (about US$2.47 trillion) will be invested in new infrastructure from 2020 to 2025, from public and private capital.

3. China's government allocated licences for the 5G spectrum in the mid-band frequency range to three state-owned mobile operators in 2018 to prepare for 5G services launch in 2020. The Chinese market for 4G smartphones had saturated in 2019 and the launch of 5G services will persuade customers to upgrade their mobiles, with 266 million units of 5G mobile phones shipped at the end of 2021.

4. Thus, the rollout of 5G networks in China was already in full swing in 2019, and by end 2020, China boasted access to 690,000 5G base stations. By end December 2021, China had 1.43 million 5G base stations, or over 60% of the global total.

5. China hopes to integrate digital and real economies, including utilising the 5G network to develop applications of the industrial Internet of Things (IoT); in early 2021, the Ministry of Industry and Information Technology (MIIT) released an 2021-2023 action plan to build 30 "fully connected" 5G factories in 10 key industries.

6. China also hopes to move to the forefront of 5G and IoT applications the same way it will transition to the new Internet protocol version 6 (IPv6). The Cyberspace Administration of China has announced a plan for IPv6 to occupy 50% of Chinese

internet traffic in 2023, 70% in 2025 and in all industries and economic and social sectors by 2030.

7. Chinese telecommunications equipment producers have eagerly developed indigenous intellectual property related to 5G, led by Huawei with a declared 13.53% of global 5G patent families. The Standards-Essential Patents (SEP), where Huawei also occupies a leading position, has 23.18% of 5G technical contributions approved by the international standards-setting organisation 3GPP.

8. Under development globally is the 6th generation wireless systems, which embrace a wide range of systems, including integrating terrestrial wireless with satellite systems. In June 2019 the MIIT set up the IMT-2030 (6G) promotion group, bringing together all aspects of the industry, academia and research to fully deploy 6G requirements.

9. Much however depends on the development of innovative applications that can encourage mobile consumers to benefit from the new capabilities of 5G networks and in turn help industries introduce IoT hardware and software to enhance productivity and economic growth. As the cooperation of both public and private actors is needed, it is too early to tell if China will gain from its 5G infrastructure.

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Erik BAARK*

China's New Development Model for Informatisation and Promotion of a Digital Economy

1.1 In December 2021, a 14th Five-Year Plan (FYP) for National Informatisation was issued by China's Central Commission for Cybersecurity and Informatisation[1] as a follow-up to the 14th FYP for National Economic and Social Development of the People's Republic of China (PRC) approved in March 2021. The plan envisages a drive to use digital technologies to enter a new phase of accelerated digitised development and creating a digital China by 2025.

1.2 The National Informatisation plan was followed by the announcement on 12 January 2022 of a 14th FYP for the Development of the Digital Economy which outlined efforts to accelerate the construction of the information network infrastructure and a national-level integrated big data centre system coordinating computing power, algorithms, data and application resources.[2] Some of the achievements that this plan envisages for the development of the digital economy in China are highlighted in Table 1.

1.3 The shift in China's development model outlined in the plans for informatisation and the promotion of the digital economy had been highlighted by President Xi Jinping in a recent article in *Qiushi*, the official journal of the Chinese Communist

* Erik Baark is Professor Emeritus at the Hong Kong University of Science and Technology. In 2019, he was Visiting Research Professor at the East Asian Institute, NUS.

1 "Shisiwu guojia xinxihua guihua" (14th Five-Year Plan for National Informatisation) December 2021 http://www.gov.cn/xinwen/2021-12/28/5664873/files/1760823a103e4d75ac681564fe481af4.pdf. A translation is available at DigiChina, https://digichina.stanford.edu/work/translation-14th-five-year-plan-for-national-informatization-dec-2021/ (accessed 17 February 2022).

2 "Guowuyuan guanyu yinfa "shisiwu" shuzi jingji fazhan guihua de tongzhi" (The State Council on Printing and Distributing Notice of the "14th Five-Year" Digital Economy Development Plan), see http://www.gov.cn/zhengce/content/2022-01/12/content_5667817.htm (accessed 21 February 2022).

Party. Xi stressed making breakthroughs in core technologies in key fields, accelerating new infrastructure development, improving the digital economy governance and participating in international cooperation.[3]

TABLE 1 HIGHLIGHTS OF AIMS FOR DIGITAL ECONOMY DEVELOPMENT FROM 2020 TO 2025

Highlight of Aims	2020 Actual Figures	2025 Estimated Figures
Added value of core industries in the digital economy	7.8% of GDP	10% of GDP
Number of users of the Internet Protocol version 6 (IPv6)	460 million users	800 million users
Number of gigabit broadband users in China	6.4 million users	60 million users
Size of the software and information technology service sector	RMB8.16 trillion	RMB14 trillion
Penetration rate of industrial internet platform applications	14.7% of industry	45% of industry

Source: "Highlights of the blueprint for China's digital economy in 2021-2025", http://www.ezhejiang.gov.cn/wenzhou/2022-01/21/c_700769.htm (accessed 21 February 2022).

1.4 The new infrastructure that the Chinese leadership wishes to build comprises core facilities for collecting and sharing data, that is, fast and widely available communication such as fifth generation (5G) mobile communications networks, together with the means to store and analyse large collections of data using key technologies such as cloud computing and artificial intelligence (AI).

1.5 The technology of 5G mobile communications represents a radical departure from earlier generations of mobile telecommunications, from the initial stage of mobile communications (1G) when people called each other through analogue connections, and advancing to the digital communication possibilities of the smartphones (3G) offering basic internet access. The high speed systems (4G and 4G LTE) offered by most operators today feature all-IP Voice and Data services based on broadband internet connections at speeds of 150-1000 Megabits per second (Mbps).

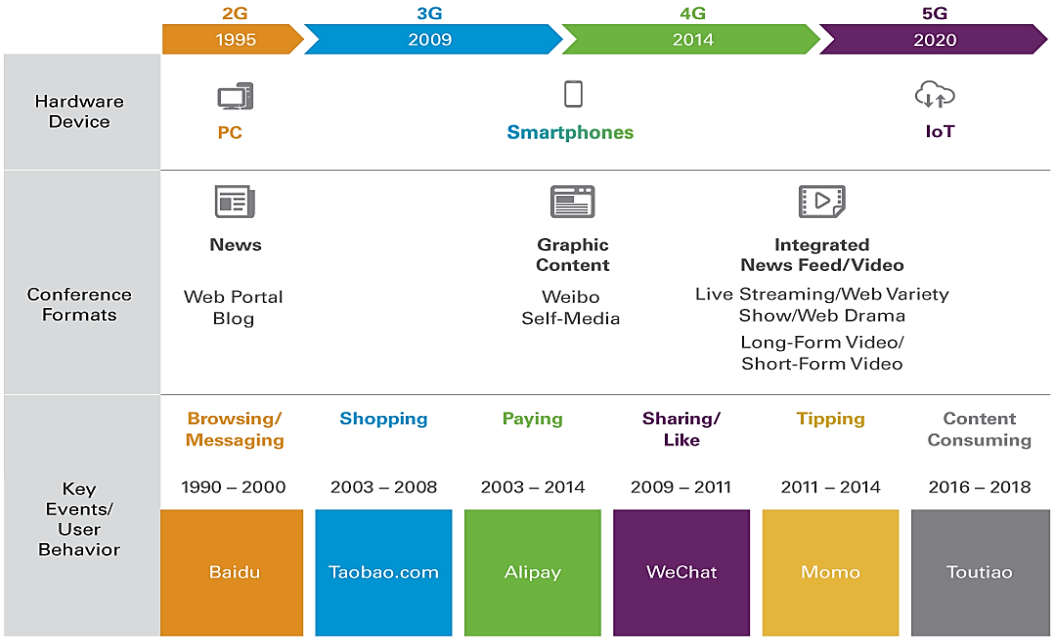
1.6 With the 5G technology of cellular wireless systems come data speed improvements of up to 10,000 Mbps and a quick response time (low latency) of one millisecond or

[3] "A New Economic Model Gains Prominence in the Information Age", China Focus, http://www.cnfocus.com/a-new-economic-model-gains-prominence-in-the-information-age/ (accessed 22 February 2022).

less, a feature that would become essential for providing real-time interactivity services such as control of self-driving cars. In addition, 5G systems could use broad channels in the radio frequency spectrum to transmit data, reducing the chance of overload at peak times and generating a capacity to connect a lot more devices and applications to each other.

1.7 With these features, 5G is expected to provide the digital infrastructure for the Internet of Things (IoT) where billions of physical devices around the world are connected to the internet, all collecting and sharing data. In the longer term, industrial and automotive equipment represents major opportunity of connected "things", with 5G supporting and expanding the current trends towards automation of industrial manufacturing and logistics. Figure 1 illustrates the evolution of wireless systems and the typical applications enabled in each generation.

FIGURE 1 THE EVOLUTION OF WIRELESS GENERATIONS AND MOBILE APPLICATIONS



Source: https://www.lazardassetmanagement.com/Images/RD0199-SEP2020-Ex01_Digital_tcm1148-460162.png (accessed 25 February 2022).

1.8 Consumers are likely to experience the adoption of IoT in the form of products like smart electricity metres or wearable devices in the near term. Ultimately, the technology promises to provide virtual reality capabilities for gaming and entertainment. It is likely that 5G applications that are being developed for industrial

and business use will generate the most significant social and economic impacts – and represent some of the most profitable new services offered by telecommunications services operators.

The Push for New Infrastructure

2.1 The context for the development of the 5G infrastructure is related to the concept of new infrastructure launched at the Central Economic Work Conference in December 2018 where it was proposed to "strengthen the construction of new infrastructure such as artificial intelligence, industrial Internet and the Internet of Things". The policy to promote new infrastructure was then officially announced by Premier Li Keqiang in his report on the work of the government in 2020.[4]

2.2 On 20 April 2020, the National Development and Reform Commission (NDRC) provided new guidelines on the three components that defined new infrastructure, and which emphasised the role of digital infrastructure, the digitisation of existing industries, and infrastructure for research and development:[5]

(i) Information infrastructure. This includes 5G communication networks, IoT, industrial internet and satellite internet; it also covers new technology infrastructure represented by data centres, artificial intelligence, cloud computing and blockchain.

(ii) Integrated infrastructure. This mainly refers to the in-depth application of internet, big data, artificial intelligence and other technologies to support the transformation and upgrading of traditional infrastructure. The ambition is to combine digital services with existing physical services to create integrated infrastructure, such as intelligent transportation infrastructure and smart energy infrastructure.

(iii) Innovation infrastructure. Here the leadership envisages creating infrastructure that supports scientific research, technology development and product development, such as major facilities for scientific and technological research and industrial innovation.

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[4] "Zhengfu gongzuo baogao——2020 nian 5 yue 22 ri zai di shisan jie quanguo renmin daibiao dahui di san ci huiyi shang (Government Work Report - At the Third Session of the Thirteenth National People's Congress on May 22, 2020)", http://www.gov.cn/zhuanti/2020lhzfgzbg/index.htm (accessed 24 February 2022).

[5] "Guojia fagaiwei shouci mingque 'xin jijian' fanwei (For the first time, the National Development and Reform Commission has clarified the scope of "new infrastructure")", http://www.mofcom.gov.cn/article/i/jyjl/e/202004/20200402957398.shtml (accessed 2 March 2022).

2.3 One of the key factors considered by the leadership when embarking on the construction of new infrastructure was the emergence of the COVID-19 pandemic and its challenges for the Chinese economy.[6] This reflects the accelerated transition of the consumer market to online shopping and online services during lockdowns. At the time, digital services also included contract tracing apps that were widely employed to combat the spread of COVID-19 in China.

2.4 Moreover, the digitalisation of global value chains was an additional challenge for China, which remains thoroughly integrated with international networks and value chains.[7] Ultimately, it is clear that digitalisation remains the core instrument in creating the new infrastructure for tomorrow's economy, where traditional infrastructure integrates with digital technologies to form new entities such as "smart transport", "smart energy" or "smart cities".

2.5 As much as RMB17.5 trillion (about US$2.47 trillion) is expected to be invested in new infrastructure for the period 2020-2025, representing an annual growth rate of around 21.6%.[8] The funding model for new infrastructure launched by the central government represents some innovative features, emphasising the expectations that non-public sources of finance will become a major contribution to the construction of new infrastructure.

2.6 For example, the roll-out of 5G networks is financed through massive investments of more than RMB200 billion in capital expenditure during 2020 and 2021 by leading telecommunications operators China Mobile, China Telecom and China Unicom. By the end of 2021, China had launched 1.4 billion 5G base stations, reaching extensive coverage in major cities. The pace of 5G investments was also

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6 See, for example, Zhao Jiawei, Zhang Hua and Yi Xudong, "Xinxing jichu sheshi jianshe de qianli, tiaozhan yu zhengce jianyi (The potential, challenges and policy recommendations of new infrastructure construction)" *Xibu jingji guanli luntan (Western Economic Management Forum)* 37:6 (November 2020); and Caroline Meinhardt, "China bets on 'new infrastructure' to pull the economy out of post-Covid doldrums", *MERICS Short analysis* (4 June 2020), https://merics.org/en/short-analysis/china-bets-new-infrastructure-pull-economy-out-post-covid-doldrums (accessed 2 March 2022).

7 See Xiaolan Fu, "Digital transformation of global value chains and sustainable post-pandemic recovery", *Transnational Corporations,* Vol. 27, No 2 (31 August 2020), 157-66.

8 "New infrastructure spending may reach 17.5 trln yuan for 2020-2025: Analyst", *Xinhua*, 21 May 2020. http://www.xinhuanet.com/english/2020-05/21/c_139074719.htm (accessed 2 March 2022).

accelerated with the entry of a new 5G network operator, China Broadcasting Network, which is in alliance with China Mobile to expand the network.

2.7 With the Ministry of Finance's offering of RMB1.2 trillion worth of special-purpose bonds in December 2021, Beijing's policymakers have urged local authorities to issue those bonds as quickly as possible to fund construction projects and leverage private investment to yield results in the first quarter.[9] The central government has emphasised that these new fiscal resources should be devoted to promoting new infrastructure, rather than the traditional network infrastructure such as highways, railways and airports that were the focus of previous easing cycles.[10]

2.8 After the NDRC had clarified the scope of what was considered new infrastructure, local governments in 25 provinces launched their own plans (usually three years, covering 2020-2023). This included the Shanghai plan, which set the total investment target for the next three years at RMB270 billion, while Guangzhou approved 16 new digital infrastructure projects with a total investment of RMB56.6 billion. Zhejiang province, home to tech giant Alibaba, also committed to a new batch of projects – 61% of which are in the high-tech field, a 20% increase from the previous year.[11]

The Deployment of 5G Infrastructure

3.1 China had prepared for the development of 5G systems with an expansion of R&D even while the country was undertaking a massive expansion of 4G networks. In 2013, the central government established the IMT-2020 (5G) Promotion Group, based on the original IMT-Advanced Promotion Group. Subsequently, the Ministry of Industry and Information Technology (MIIT) officially launched research and

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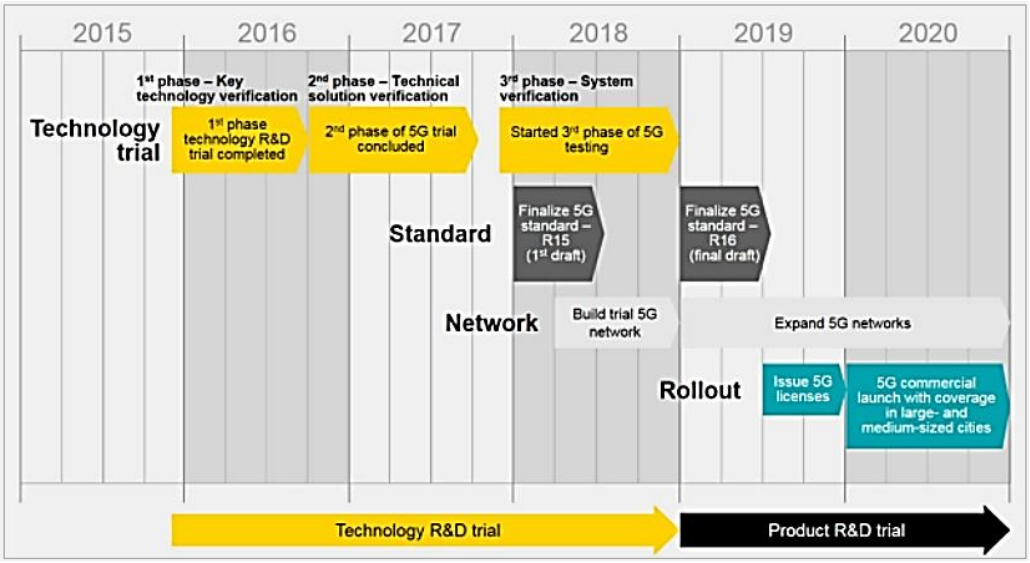
9 "China's infrastructure push to fast track 102 major projects as Omicron and economic risks loom large in 2022", https://www.intellasia.net/chinas-infrastructure-push-to-fast-track-102-major-projects-as-omicron-and-economic-risks-loom-large-in-2022-1007068 (accessed 21 February 2022).

10 Francoise.Huang and Ludovic.Subran, *Putting the Tiger on a Stronger Footing In 2022,* Allianz Research, 9 February 2022, https://www.allianz.com/content/dam/onemarketing/azcom/Allianz_com/economic-research/publications/specials/en/2022/february/2022_02_09_China_TigerStrongerFooting.pdf (accessed 21 February 2022).

11 "How Can Foreign Technology Investors Benefit from China's New Infrastructure Plan?" *China Briefing* 7 August 2020, https://www.china-briefing.com/news/how-foreign-technology-investors-benefit-from-chinas-new-infrastructure-plan/ (accessed 22 February 2022).

development tests for 5G technology in 2016, and in June 2019 the ministry issued 5G commercial licences to China Mobile, China Unicom, China Telecom, and China Radio and Television (see Figure 2).

FIGURE 2 TESTING AND EXPANDING THE 5G NETWORK IN CHINA, 2015-2020



Source: https://chinabizlawyers.com/2019/06/latest-updates-on-chinas-5g-spectrum-allocations/ (accessed 25 February 2022).

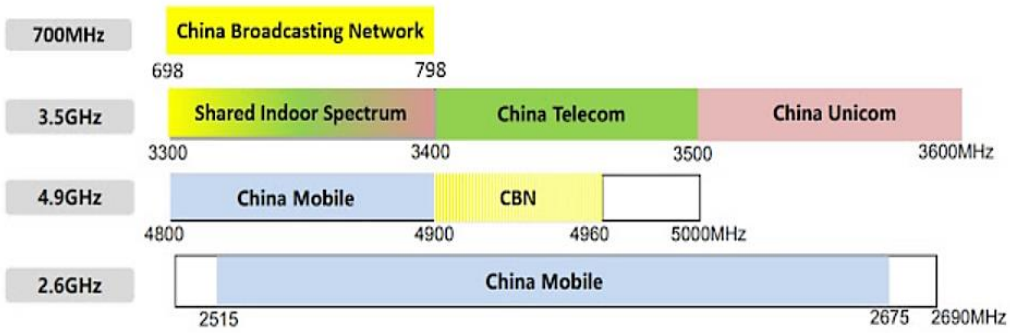
3.2 The Chinese market for 4G smartphones had reached saturation in 2019, and the launch of 5G services offered an opportunity for telco service providers to persuade customers to upgrade their mobiles. Apple was among the first to introduce its 5G-enabled phone in China, but domestic smartphone producers quickly caught up, accounting for 86.6% of mobile phone shipments in 2021. By end 2021, 266 million units of 5G mobile phones were shipped, at a year-on-year increase of 63.5%, or 75.9% of mobile phone shipments in the same period.[12]

3.3 China's government allocated licences for the 5G spectrum in the mid-band frequency range to three state-owned mobile operators in 2018 to prepare for the launch of commercial 5G services in 2020. Both China Telecom and China Unicom received 100MHz in the 3.5MHz band (also known as the C-band), while market leader China Mobile obtained 260MHz of spectrum in the 2.6GHz and 4.8GHz bands. China Broadcasting Network (CBN) received licences in the 4.9GHz and

12 https://www.chinainternetwatch.com/30902/mobile-phone-shipments/ (accessed 4 March 2022).

700MHz bands to enter the competition as a new operator. Figure 3 indicates a spectrum shared among the operators for indoor base stations.

FIGURE 3 5G SPECTRUM ALLOCATIONS IN CHINA BY FEBRUARY 2020



Source: https://www.operatorwatch.com/2020/02/china-allocates-shared-spectrum-for.html (accessed 25 February 2022).

3.4 Based on these resources, China Unicom and China Telecom have formed a strategic league, a 'One 5G Access Network' to share their spectrum resources while each continues to build its own 5G core network. On the other hand, China Mobile and CBN have been cooperating to share the spectrum resources of 700MHz (from CBN) and 2.6GHz (from China Mobile). Through these arrangements, the competition among wireless operators is likely to become more intense than with the 4G, where China Mobile had achieved a dominating position in the market.

3.5 Thus, the rollout of 5G networks in China was already in full swing in 2019, and by the end of 2020, China boasted access to 690,000 5G base stations. A year thereafter, at the end of December 2021, China had set up a total of 1.43 million 5G base stations, accounting for over 60% of the global total.[13] During 2022, Chinese carriers expect to deploy an additional 600,000 base stations and target more than 560 million 5G users by 2023.[14] The 5G base stations cover all cities and urban areas above prefecture level, more than 97% of counties and 50% of townships and towns.

[13] "China boasts over 1.4 mln 5G base stations", http://www.xinhuanet.com/english/20220209/e609eb1974294e60886e1721efaf534b/c.html (accessed 21 February 2022).

[14] "China expects deployments of 5G base stations to grow 42% in 2022", https://www.rcrwireless.com/20220301/network-infrastructure/china-expects-deployments-5g-base-stations-grow-42-2022 (accessed 3 March 2022).

3.6 These figures reveal the extent China's wireless operators will go to invest major capital assets in the expansion of the networks. Mobile operators in the China region will likely spend nearly $210 billion in their networks between 2020 and 2025, of which 90% will be dedicated to 5G.[15] Interestingly, a new study has found that government policy announcement relating to 5G in general affects telecommunication operators' stock returns negatively, a situation which is particularly pronounced if the announced policies have a higher level of interference.[16]

3.7 Meanwhile, major telecommunications service vendors had signed up a total of 730 million 5G subscriptions, adding and activating 396.5 million new 5G packages during 2021. This expansion of 5G package subscriptions was definitely boosted by the discounts offered by major Chinese services to attract new 5G consumers. Some 5G package subscription rates were available at ultra-low prices, with China Mobile's entry-level package around $12 a month.[17] However, without upgrading their phones, the around 100 million new customers who signed up for cheap 5G packages were in fact only using 4G devices.[18]

3.8 The rapid deployment of base stations in China has also been partly accelerated by operators employing the non-standalone architecture (NSA) option where 5G service is built over an existing 4G network during the initial phase. Increasingly, new facilities are added with standalone architecture (SA) that allows completely independent operation of a 5G service without any interaction with an existing 4G core.

3.9 A network built with such standalone architecture can improve the quality of connections for mobile consumers, but it is even more important for the

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15 GSMA, *The Mobile Economy China 2021*, https://www.gsma.com/mobileeconomy/china / (accessed 2 March 2022).

16 Chunmi Jeon, Seung Hun Han, Hyeong Joon Kim and Sangsoo Kim, "The effect of government 5G policies on telecommunication operators' firm value: Evidence from China", *Telecommunications Policy*, 46:2 (March 2022).

17 "Behind China's huge 5G numbers: Fast rollout and low prices", https://www.lightreading.com/asia/behind-chinas-huge-5g-numbers-fast-rollout-and-low-prices/d/d-id/773735 (accessed 2 March 2022).

18 "China 5G race taking its toll on operators", https://www.lightreading.com/asia/china-5g-race-taking-its-toll-on-operators/d/d-id/768369 (accessed 2 March 2022).

development of services for business.[19] 5G standalone architecture is a fully virtualised, cloud-native architecture that introduces new ways to develop, deploy and manage services and enables end to end slicing for unique, dedicated private networks. In this way, operators can effectively and efficiently launch new enterprise 5G services such as smart cities, smart factories and other applications for the IoT.

3.10 With a cloud-based standalone architecture the operators can greatly simplify services, dramatically reducing the cost of operation and speeding up the introduction of new revenue-generating services. For Chinese mobile service operators who have devoted large investments in the construction of the 4G networks, the prospect of marketing new 5G-based services with lower energy requirements and operating cost provides a strong profit incentive for them to make the transition to 5G.

Expanding 5G Network Applications and Services

4.1 Evidently, the Chinese government is very eager to promote the integration of digital and real economies, including utilising the expanding 5G network to develop applications of the industrial IoT.[20] In early 2021, the MIIT released an action plan for 2021-2023 that envisions building 30 "fully connected" 5G factories in 10 key industries; this requires upgrading the industrial internet platforms and doubling the number of industrial devices and systems connected to the internet in 2023, compared to those of 2020. Moreover, the action plan envisages building five new national pilot zones for the industrial internet industry and 10 pioneer zones based on 5G and the industrial internet by 2023.[21]

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[19] "Standalone (SA) and Non-Standalone (NSA) 5G Architectures: The various paths to 5G revenues and profitability", https://www.affirmednetworks.com/sa-and-nsa-5g-architectures-the-path-to-profitability/ (accessed 2 March 2022).

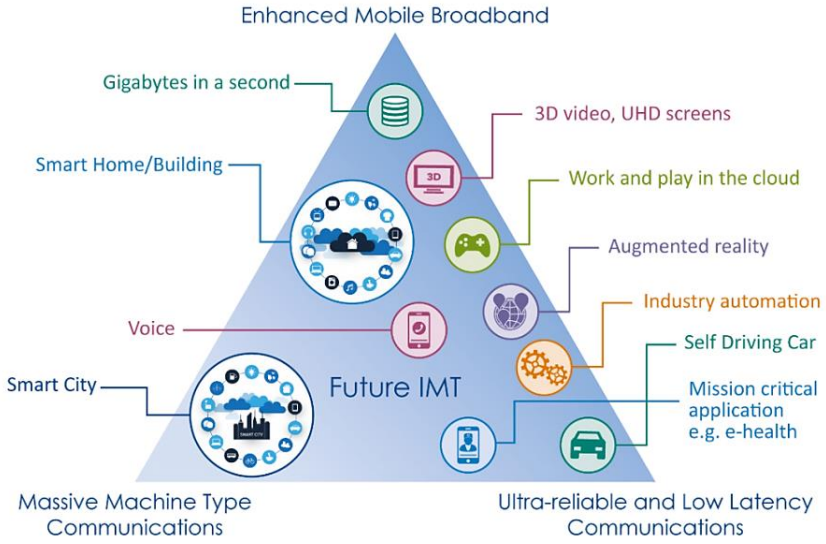
[20] "Five-year plan to speed up integration of digital, real economies", https://english.www.gov.cn/statecouncil/ministries/202112/01/content_WS61a6d009c6d0df57f98e5da0.html (accessed 24 February 2022).

[21] "China releases three-year action plan on industrial internet construction", http://www.wuzhenwic.org/2021-03/04/c_598459.htm (accessed 25 February 2022).

4.2 This Chinese government vision of the dissemination of industrial IoT is also amplified in the "Set Sail" Action Plan for 5G Applications (2021-2023) issued by the MIIT in July 2021.[22] In this plan, the state hopes to mobilise markets and industry verticals in order to attain 5G application penetration rate to over 35% for large industrial enterprises. In electric power, mining and other such fields, 5G applications will be disseminated on a large scale. Furthermore, the ambition is to expand the scope of 5G + Internet of Vehicles (IoV) pilot projects.

4.3 The Chinese initiatives are made feasible by the way 5G networks have been defined by the 3rd Generation Partnership Project (3GPP) which is an international alliance for setting standards that provides a complete system description for mobile telecommunications, lately focusing on 5G systems.[23] The 5G design allows services to be structured along three dimensions, as depicted in Figure 4.

FIGURE 4 THE THREE DIMENSIONS OF USAGE OPTIONS FOR 5G



Source: https://www.testandverification.com/5g-usage-scenarios-nsa-sa (accessed 2 March 2022).

4.4 For many consumers, the key facility is enhanced mobile broadband, which improves access to uses such as cloud storage and augmented reality; massive

[22] "5G yingyong "yangfan" xingdong jihua (2021-2023 nian) 'Set Sail' Action Plan for 5G Applications (2021-2023)", http://www.gov.cn/zhengce/zhengceku/2021-07/13/content_5624610.htm (accessed 2 March 2022). See also the draft translation offered by CSET: https://cset.georgetown.edu/publication/set-sail-action-plan-for-5g-applications-2021-2023-draft-for-comments/ (accessed 2 March 2022).

[23] For more details on the work of this organisation, see https://www.3gpp.org/about-3gpp (accessed 2 March 2022).

machine type communications can facilitate smart home or smart city applications, while applications built on ultra-reliable and low-latency communications may be developed primarily to operate systems for self-driving cars and industry automation.

4.5 China's goal is ultimately to lead the world in the evolution of IoT systems; to achieve this goal, the country will have to promote advanced capabilities in the development of IoT application standards and key technologies such as AI, edge computing and production of high-end chips. In September 2021 these ambitions were spelled out in the Three-Year Action Plan for New IoT Infrastructure Construction (2021-2023).[24]

4.6 The plan envisages that, by the end of 2023, new IoT infrastructure will be preliminarily established in major domestic cities, with higher technological level and market competitiveness for key technologies such as high-end sensors, IoT chips, IoT operating systems and short-range communications. Furthermore, the government will promote 10 IoT enterprises to grow into leading enterprises with output values of over RMB10 billion and create an ecosystem for the development of small and medium-sized enterprises.

4.7 Another feature that can help China move to the forefront of 5G and IoT applications will be the country's transition to the new Internet protocol version 6 (IPv6). The IPv6 standard was adopted in 1998 to address the shortage of available IP version 4 (IPv4) addresses. This is likely to become a serious problem in China when the number of connected units under IoT will increase the requirement of IP addresses exponentially. In 2021, the Cyberspace Administration of China announced its plan to accelerate the adoption and application of the IPv6 protocol over the next 5 to 10 years. The plan envisages that IPv6 will occupy 50% of Chinese internet traffic in 2023, 70% in 2025, and integrated in all industries and economic and social sectors by 2030.[25]

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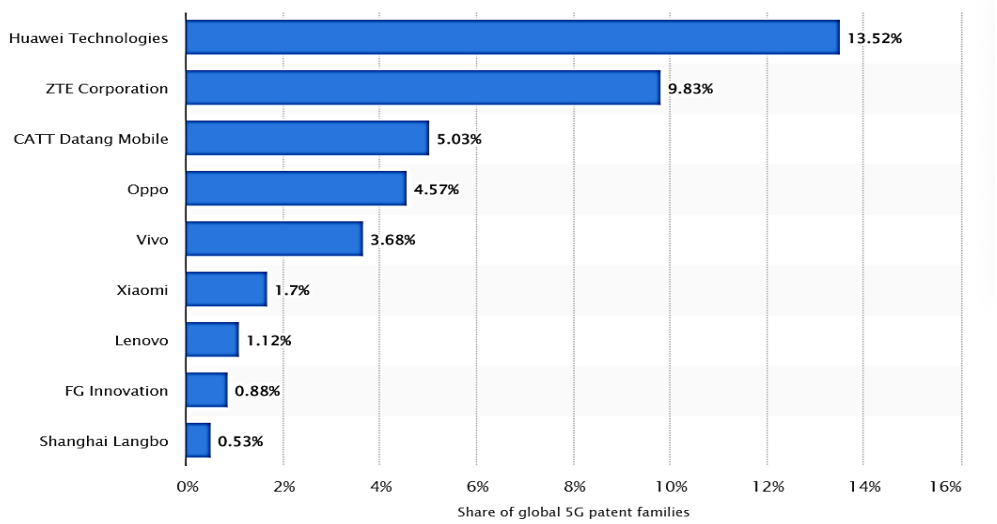
[24] "Wulianwang xinxing jichu sheshi jianshe san nian xingdong jihua (2021-2023 nian) (Three-Year Action Plan for New IoT Infrastructure Construction (2021-2023))", http://www.gov.cn/zhengce/zhengceku/2021-09/29/content_5640204.htm (accessed 2 March 2022).

[25] "Guanyu jiakuai tuijin hulianwang xieyi di liu ban (IPv6) guimo bushu he yingyong gongzuo de tongzhi (Notice on Accelerating the Large-scale Deployment and Application of Internet Protocol Version 6

Supporting the Future: Patents, Standards and the 6th Generation

5.1 It is part and parcel of the Chinese leadership's endeavour to transition society to a digital future to support the supremacy of Chinese producers in the domestic 5G technology ecosystem and ultimately occupy a leading position on the world markets. For this purpose, Chinese telecommunications equipment producers have eagerly developed indigenous intellectual property related to 5G, with Huawei ahead of most companies having a declared share of 13.53% of global 5G patent families as shown in Figure 5. The other major telecommunications equipment producer ZTE is second with 9.83%, while 5G handset producers OPPO and VIVO are number four and five with 4.57% and 3.68% shares.

FIGURE 5 SHARE OF GLOBAL 5G PATENT FAMILIES OF CHINESE COMPANIES, 2021



Source: https://www.statista.com/statistics/1290165/china-share-of-global-5g-patent-families-by-company/ (accessed 4 March 2022).

5.2 Even more significant is the share of Standards-Essential Patents (SEP), patents containing intellectual property that have contributed to defining 5G standards. This is because all firms that utilise technologies based on such 5G standards will have to pay royalty fees to the patent owner. Here, Huawei also occupies a leading position, with 23.18% of 5G approved technical 3GPP contributions. The Swedish

(IPv6))" http://www.cac.gov.cn/2021-07/23/c_1628629122784001.htm (accessed 2 March 2022). See also "China's plan to accelerate IPv6 adoption over the next 5-10 years", https://www.stackscale.com/blog/china-plan-ipv6-adoption/ (accessed 2 March 2022).

telecommunications firm Ericsson is second globally with 18.83%, while the Finnish Nokia is third with 14,61% and the US-based QUALCOMM is a distant fourth with 6,44% of contributions to 3GPP approved 5G standards.[26]

5.3 Huawei has recently started to charge royalty fees for its 5G technology to smartphone producers such as Apple. However, it has announced that it will cap its licence fees at US$2.50 per unit; this is less than equivalent fees by Nokia at 3 Euro (US$3.58) or Ericsson that will charge between $2.50 and $5 per device.[27] It is likely that the income from 5G royalty licensing fees will increase substantially when the millions of 5G related devices are diffused as part of the expansion of IoT in industries such as automotive, power, mining and other industries.

5.4 The next step in the digital revolution is the 6th generation wireless systems that are under development globally, which embrace a wide range of systems, including coverage by integrating terrestrial wireless networks with satellite systems. Thus, 6G will go beyond mobile internet and support ubiquitous AI services from the core to the end devices of the network.[28]

5.5 In June 2019 the MIIT led the establishment of the IMT-2030 (6G) promotion group, bringing together all aspects of the industry, academia and research to fully deploy the 6G vision requirements. This group released a White Paper in July 2021 that presented a vision of China's R&D activities, technical development and other preparations for a commercial launch of 6G systems in 2030.[29] The White Paper discussed Chine's 6G vision, the driving forces of 6G development and candidate use cases of 6G, focusing on 10 candidate 6G technologies.

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26 "Who leads the 5G patent race as 2021 draws to the end?" https://www.iam-media.com/who-leads-the-5g-patent-race-2021-draws-the-end (accessed 4 March 2022).

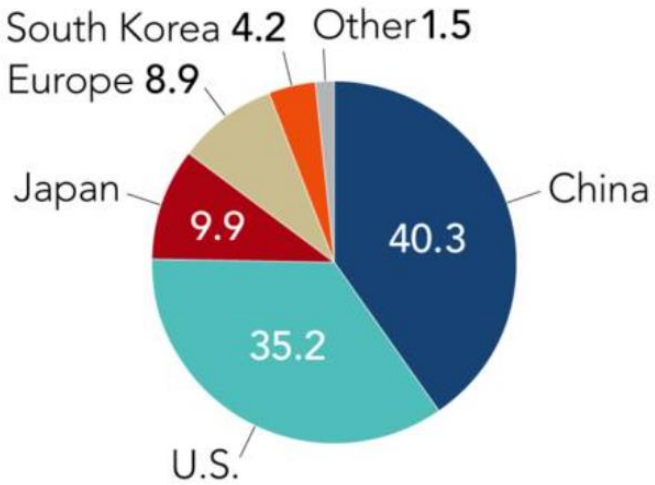
27 "Huawei to start charging royalties to smartphone makers using its patented 5G tech".

28 Khaled B Letaief, Wei Chen, Yuanming Shi, Jun Zhang and Ying-Jun Angela Zhang, "The Roadmap to 6G – AI Empowered Wireless Networks", *IEEE Communications Magazine*, vol. 57, no. 8, pp. 84-90, August 2019, doi: 10.1109/MCOM.2019.1900271.

29 *White paper on 6G Vision and Candidate Technologies*, http://www.caict.ac.cn/english/news/202106/P020210608349616163475.pdf (accessed 5 March 2022).

5.6 With such initiatives, China has mobilised research in potential 6G technologies by scientific institutions and leading firms. China is estimated to own 40% of global patent applications relating to nine core areas of 6G technologies, as shown in Figure 6. Huawei started to invest in R&D for 6G systems in 2017 and has been accelerating its drive for 6G related patents lately.[30] Moreover, the company published a white paper titled *6G: The Next Horizon* in 2021, arguing that 6G represents a paradigm shift towards connected intelligence and outlining a roadmap to 2030.[31]

FIGURE 6 6G PATENT APPLICATIONS BY COUNTRY/REGION, AUGUST 2021



Source: https://www.electronicsweekly.com/news/business/china-leads-6g-patents-2021-09/ (accessed 4 March 2022).

5.7 Research and development for 6G technologies is also conducted extensively in the United States and Europe, and the core standards that will govern the international framework for 6G is still under development by 3GPP. Due to the increased complexity of 6G, such standardisation negotiations are expected to continue until the networks are ready to be launched in 2030 and international organisations are eager to reach globally accepted core standards.[32]

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30 "Huawei leads China to dominate 6G race against US & Japan", https://techwireasia.com/2021/09/huawei-is-charged-to-have-china-at-the-forefront-of-the-6g-race-against-us-japan/ (accessed 4 March 2022).

31 See *6G: The Next Horizon*, https://www-file.huawei.com/-/media/corp2020/pdf/tech-insights/1/6g-white-paper-en.pdf?la=en (accessed 5 March 2022).

32 https://www.6gworld.com/exclusives/standards-towards-6g-everything-is-at-an-inflection/ (accessed 5 March 2022).

Powering a Digital Future

6.1 The Chinese leadership is committed to transitioning to a digital economy with the help of new infrastructure, notably the expansion of 5G networks and services for consumers as well as industry. It has successfully mobilised major firms to provide essential equipment and persuaded big telecommunication service operators largely owned by the state to devote major investments in 5G in the immediate future. At the same time, the government and key actors are preparing for a future launch of 6G networks.

6.2 Once the networks are in place, the next phase will require a boost to the development of new and innovative applications that will encourage mobile consumers to benefit from the new capabilities of 5G networks, and help industries introduce IoT hardware and software to enhance productivity and economic growth. The government is deeply engaged in promoting such applications, but since it requires cooperation from a wide range of both public and private actors, it is probably too early to predict what benefits China will achieve with its 5G infrastructure.

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