From Self-Innovation to International Standardization: A Case Study of TD-SCDMA in China

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Time Division Synchronous Address (TD-SCDMA) is one of three 3G standards in China, the two others being Wideband Code Division Synchronous Address (WCDMA) from Europe and Code Division Synchronous Address (CDMA2000) from the US. TD-SCDMA is a Chinese-developed standard currently applied only in the Chinese market. From the very beginning, TD-SCDMA has caught tremendous attention. As a government-led standardization, it demands continuous technical progress, industry accumulation, and national confidence. At the time of its inception, China was not yet the second largest economy in the world; furthermore, as a developing country and technology latecomer, it faced many difficulties and challenges. Thus, it is interesting to note how the Chinese government reached the decision to apply standardization and prepare the relevant conditions to fully commercialize TD-SCDMA in China. After five years of TD-SCDMA application, more information has become available to help answer the questions above. Thus, in the current paper, we introduce the evolution of TD-SCDMA, from its very early stage technology to a standard approved by the International Telecommunication Union (ITU), until its first launch during the 2008 Beijing Olympic Games. The paper provides arguments and evidence to show that TD-SCDMA is a successful case because it has been selected by the ITU as one of the 3G standards for commercial application, even though it is a standard used only domestically in a country, which is considered a technology latecomer with low technological capabilities.

Keywords: Innovation, Standardization, China, Telecom industry

JEL Classification: O3, O32

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I. Introduction

TD-SCDMA is one of the three 3G standards in China, the two others being WCDMA from Europe and CDMA2000 from the US. TD-SCDMA is a Chinese-developed 3G standard currently applied only in the Chinese market. From the very beginning, TD-SCDMA has caught tremendous attention. As a government-led standardization, it demands continuous technical progress, industry accumulation, and national confidence. At the time of its inception, China was not yet the second largest economy in the world. Furthermore, China faced many difficulties and challenges as a developing country and technology latecomer at that time. Thus, it is interesting to note how the Chinese government reached the decision to apply the standardization as well as prepare the relevant conditions to fully commercialize TD-SCDMA in China. After five years of TD-SCDMA application, more information has become available to help answer the questions above. Thus, in the current paper, we introduce the evolution of TD-SCDMA, from its very early stage technology to a standard approved by the International Telecommunication Union (ITU), until its first launch during the 2008 Beijing Olympic Games. The paper provides arguments and evidence to show that TD-SCDMA is a successful case because it has been selected by ITU as one of the 3G standards for commercial application, even though it is a standard used only domestically in a country, which is considered a technology latecomer with low technological capabilities.

A brief description of the theories on standardization is presented in Chapter 2, after which the case of Korea's WiBro as a success story of an international standard developed by a newly emerging economy is discussed. In Chapter 3, we will focus on introducing the TD-SCDMA technology, from its origin, standard application, and industry chain building, to its transformation into a commercial product. In this process, we particularly emphasize the role of the government as the key decision maker and coordinator. Chapter 3 presents an analysis of the industry opportunity offered by the technology life cycle in the telecom industry and the technology accumulation in China. Several companies that developed during the process of the standard setting are then introduced. Finally, we draw conclusions based on the discussions.

II. Theories

A. Importance of Standards in the Telecommunication Industry

a) Network Economy

The telecommunications industry is a typical "network economy," in which consumers of computer and software programs, cellular phones, faxes, and Internet services all have more valuable products. As the use of a product increases, the total social value of that product also increases as it is shared with more consumers. Standardization is one of the crucial factors in a network economy. According to Farrell and Saloner (1986) "standardization" is a coordination process resulting in the production of goods that are interchangeable or compatible. Standards in telecommunications systems play a central role in maintaining service quality; such standards do not involve tradeoffs between service quality and variety, but rather integrate advanced telecom networks into a seamless web of interoperable technologies and services (David and Steinmueller 1996). Thus, the highest priority of standard setting is interoperability. However, they also stated that there are varied reasons as to why a construction is difficult to achieve. Technical compatibility standards do not flow "naturally" from the best engineering practice, but rather reflect the full range of strategic behaviors.

b) Dominant Design

A dominant design is often not the technologically superior one; it is typically the result of a complex interplay between technological factors and user demands as well as that among political, social, and economic factors. Different technological designs backed by different sponsors compete for the position of dominant design in a process wherein economic, technological, and socio-political factors are intertwined. Technology does not work in isolation, and coordination and compatibility with other products or systems are required. Generally, the more complex the product, the more actors are aligned to a technological design and the more complicated is the sponsoring role (Tushman and Rosenkopf 1992). What this means is that a complex system must focus on interfaces and negotiations with different users and producers of complementary products, through which it evolves from simple technological artifacts to more complex ones.

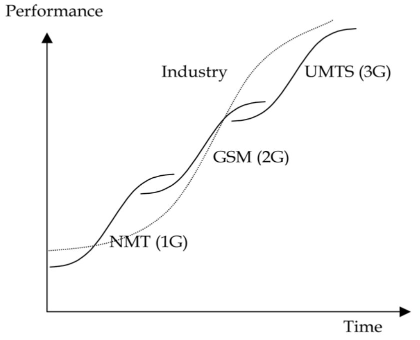
c) Network Effects

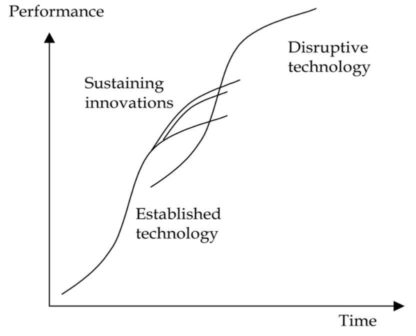
Network effects indicate that the utility derived by a consumer is affected by the total number of consumers subscribed to the same network. In other words, the demand or utility curve shifts upward with the increase in total users in the network. The adoption of a certain system is partially dependent on the number of other consumers purchasing similar systems. Network effects can be divided into direct and indirect effects. Direct effects are present when a new customer joins a network, and a new network connection is created for all members in the network. Direct effects depend on compatibility between system elements. For example, the utility of one user of an email system increases along with the increasing number of total users. Meanwhile, indirect network effects arise because of increased demand for complementary products or service, such as specialized training, after-sale support, and compatible software. Indirect network effects represent positive dependencies that evolve between the spread of a standard and the increasing demand for complementary goods. For example, the spread of an operating system plays an important part in determining the supply of compatible application software. Katz and Shapiro (1985) find that firms with good reputation or large existing networks tend to ignore compatibility, whereas those with small networks or weak reputation tend to favor compatibility. This is because large firms have market power to ignore compatibility when introducing new systems.

d) Technological Life Cycles in Mobile Communications

Numerous experiments are involved during the beginning of a product life cycle, particularly in terms of different designs and technologies, resulting in numerous innovations (Utterback 1994). In the early development stage, accelerated market dynamics and persistent uncertainties are also observed. As the technology evolves, the focus shifts slowly from product performance maximization to cost minimization (with the integration of market dynamics, standardization, incremental products, and process innovations) and to the prominent role of complementary assets. In the mature phase, innovation rate fades as the products become standardized and the market is manipulated by oligopolies. In the decline stage, the market contracts and technology exits.

The concept of technological life cycles can be applied to the evolution of mobile communication technologies. The transformation from first generation (1G) Nordic Mobile Telephony (NMT) technology to second generation GSM constitutes a shift in technological life cycles. The coexist-





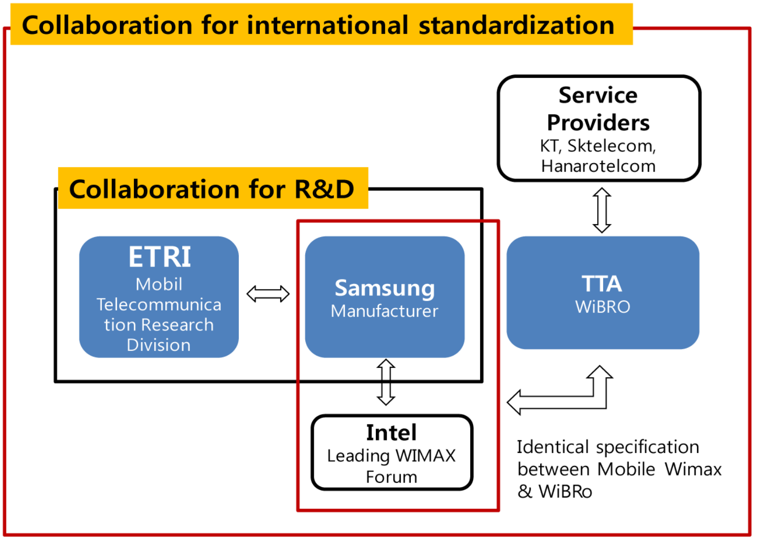
Source: Dalum *et al.* (2002).

FIGURE 1
S-CURVE TECHNOLOGY AND MOBILE TECHNOLOGY LIFE CYCLES

ence and shifts of different technological life cycles is not an S-curve, which is prone to disruption. The 1G mobile technology (*i.e.*, Nordic NMT) started from 1981 and consisted the first cycle. This technology achieved certain success within the European scope. The digital technology GSM entered into the market as a disruptive technology before NMT totally evacuated from the market; GSM then developed into the dominant technology replacing both NMT and even fixed telephones. With the further development of mobile technology, 3G and the next generation technology can be predicted according to the technology life cycle. However, the prediction would not be straightforward and would have to coexist with the GSM technology. Next generation technology would have to go with the evolution of other technologies (Dalum *et al.* 2002). The charts of S-curve technology and technology life cycles are illustrated below.

B. Major Capabilities Required for Successful Standardization

Korea has successfully raised its own technology, called the WiBro, to an international standard under various challenges and restrictions. After the Korean government decided to work on the standard WiBro, it simultaneously operated both networks for R&D and international standardization. As a member of the World Trade Order (WTO), the Korean government cannot interfere in choosing and supporting certain technologies; thus, it encouraged private companies to invest in R&D. As a result, Samsung was able to share the technologies and knowledge ETRI



Source: Park and Han (2011).

Figure 2
Collaboration for International Standardization

had built until that time, allowing it to collaborate with ETRI for further R&D. "R&D was not a type of collaboration among players under the government's control but a pure collaboration between a public institution and a company" (Park and Han 2011).

The Korean government also performed standardization activities by collaborating with IEEE802.16 under the government's support. In consideration of WTO restrictions on government interference, the Korean government gave funds to organizations formed around TTA meant for standardization activities, ensuring that Korean technology successfully becomes an international standard. The Korean government also postponed marketing activities to promote products after they had achieved successful international standardization because the latter already guaranteed penetration to the international market. Likewise, the Korean government worked actively with IEEE802.16 working groups; for example they allowed candidate firms to engage in business related to WiBro, with the requirement that their WiBro technology specifications have interoperability with IEEE802.16. The Korean government further emphasized that qualification is the most important factor for acquiring the rights for WiBro business (Park and Han 2011). This helped WiBro quickly become an international standard and a domestic standard. From these facts, it is obvious that the government played a crucial role in the entire process of applying and coordinating the standardization procedure. Standardization is not the harvest of one particular company, such as Samsung in this case, but is the triumph of the entire industry. More details on the efforts made by the Korean government in collaborating and allocating resources for the international standardization of WiBro are presented below. This story gives inspiration and reference for the TD-SCDMA in China, particularly when we read of the tremendous efforts and involvement from the origination of the technology to the commercialization of the standard by the Chinese government.

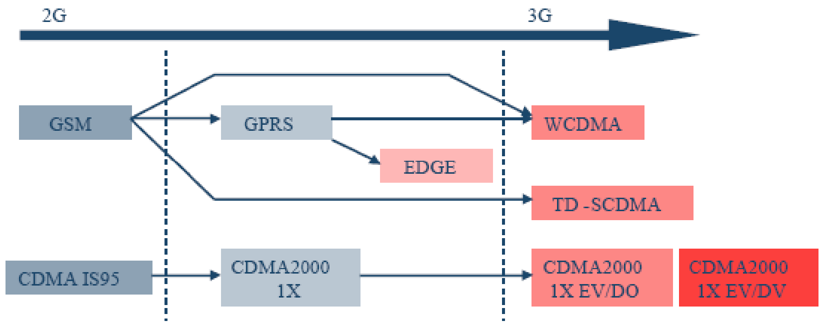
III. Standard-Setting Process

This chapter focuses on the three perspectives of TD-SCDMA, namely, the standardization battle, industrialization path, and commercialization challenge. We learn of the origin of the TD-SCDMA technology and the arduous process of patent application. In the industrialization path part, we introduce the important role of the Chinese government, which heavily pushed the progress of the technology's industrialization, and simultaneously acted as coordinator-in-general.

A. The Three Standards: WCDMA, CDMA2000, and TD-SCDMA

There are three 3G standards in China, namely, TD-SCDMA, WCDMA, and CDMA2000. WCDMA is upgrade from GSM. GSM is the 2^{nd} Generation (2G) technology that evolved from GSM, General Packet Radio Service (GPRS), and Enhanced Data Rate for GSM Evolution (EDGE), and WCDMA. WCDMA is the most extensively applied technology by users and the most mature technology and business application. The second is the CDMA2000 Evolution-Data Optimized or Evolution-Data (EV-DO), of which the EV-DO is an upgraded version of CDMA. Compared with GSM/WCDMA, CDMA/EV-DO deployment is much smaller, with fewer equipment manufacturers and terminal manufacturers. The last is Chinese TD-SCDMA. In May 2000, the ITU officially announced TD-SCDMA as the third 3G standard to be applied in China, after the European WCDMA and the CDMA2000 of the US. TD-SCDMA became commercially available in April, 2008.

Time Division-High Speed Downlink Packet Access (TD-HSDPA), which uses the Time-Division Duplex (TDD) mode, is the next step in evolu-



Source: China Electronics (2008).

Figure 3
Evolution of Three Standardizations

tional technology. After TD-HSDPA, TD-SCDMA must be upgraded to Time Division-High Speed Uplink Packet Access (TD-HSUPA) to achieve a 2.2 Mbps uplink rate, before finally evolving into LTE TDD. The application of TD-SCDMA could cover China. In addition, Myanmar and Africa has a small-scale test network, and test network and systems have been established in Korea, Hong Kong, Italy, Canada, Romania, and Ghana. There are about 337,000 users in China and in other countries. TD-HSDPA is operated by China Mobile and provided by Huawei, ZTE, and Datang. It is a Chinese technology backed by strong government support. There were 17,672 TD base stations by December 2008 and by June 2009, these increased to 25,842. The total number of stations from both stages one and two is 43,000 and will soon reach 145,000. In 2007, China Mobile invested RMB 26 billion to build the TD-SCDMA test network and 35.8 billion to construct GSM networks. The second phase of the TD-SCDMA investment reached RMB 30 billion, covering 10 cities; by the end of June 2009, 95% of the national-level cities were already covered. China Mobile also plans to develop Long Term Evolution, Time Division Duplex (LTE TDD) or Time Division-Long Term Evolution (TD-LTE) (China Telecom Industry Net 2007).

TD-SCDMA formally became a standard in 1998 and began its journey towards industrialization and commercialization. In 2009, it was launched in China within a testing network and a commercial network. We will analyze the process as a battle between different interest groups.

B. Map of the 3G Technologies in the World

On June 30, 1998, the China Telecom Science and Technology Research Institute (Datang Telecom Group's predecessor) submitted TD-SCDMA to the ITU the day after it called for 3G standard applications. On March 16, 2001, the TD-SCDMA technology was accepted as one of the standards by 3GPP. This is a great breakthrough in Chinese telecom history, given that ITU received 16 applications from the other countries, such as the Korea, US, Japan, and several European countries, with the submissions from the latter three accounting for the majority. Among these submissions, WCDMA and CDMA2000 were the main competitors. WCDMA, which naturally evolved from 2G mobile communication system, was initiated by European and Japanese manufacturers and by other standardization organizations. The European Telecommunications Standards Organization-European Telecommunications Standards Institute Special Mobile Unit (ETSI SMG) adopted WCDMA proposal as a standard on January 1998. Another competitor, CDMA2000, was the US-proposed air interface standard sponsored by Northern American and South Korean companies. Behind CDMA2000 are companies, including Qualcomm, SK Telecom, and other Korean companies. Hence, the fight between WCDMA/CDMA20000 and TD-SCDMA was highly unbalanced (Lu 2006).

Compared with the two other competitors, three points demonstrate the enormous gap in technology accumulation and industrialization base between the two "competitors." First, the technologies proposed by other countries have been established for over a decade, and key technologies have already completed verification. Thus, the companies can provide demonstration or test of commercial systems, technical regulations, and patent protection (Tang 2009). Second, the TD-SCDMA proposal was independently created by the Chinese Academy of Telecom (CAT), although it enjoyed collective support from the Chinese government and operators. In comparison, the competitor technologies were backed by strong alliances among operators, manufacturers, and governments (Lu 2006). Third, the two other standards both relied on the global 2G industry and network operation, which endowed them the best selling point as being "smoothly evolved." Fourth, both standards can establish completed industry chains. At the time, there were more than 100 companies with over 10,000 researchers conducting R&D for WCDMA, to which some of the main equipment producers invested more than USD 1 billion. In comparison, TD-SCDMA only had dozens of researchers, and R&D investments only reached an estimated RMB 2 million annually (Tang 2009).

C. SCDMA: Prototype of the TD-SCDMA

In 1994, the smart antenna represented a very advanced technology in terms of subscriber capacity, coverage distance, and cost savings; however, it was still difficult to apply in civil communication. Two Chinese researchers, Chen Wei and Xu Guanha, jointly developed a smart antenna in wireless communications. They established a technology start-up company Cwill, which stood for "China wireless access." To develop the new system, Chen and Xu developed another core technology called uplink synchronization, and the resulting technology was named SCDMA (the largest sources later referred to as Synchronous CDMA) (Lu 2006).

Li Shihe, vice president of the Telecom Science and Technology Research Institute, thought that SCDMA wireless was a promising technology, and recommended it to Zhou Huan,[1] then director of the Science and Technology Department of the Ministry of Post and Telecommunications. Zhou responded positively and decided to promote the application of SCDMA in China. Thus, in 1995, Zhou Huan spearheaded a joint venture called "Xinwei"[2] company between the Post and Telecommunications Research Institute and Cwill. The company focused on the development of smart antennas and synchronous uplinking of SCDMA wireless access to the core technology system. SCDMA originally provided wireless accession between fixed networks and fixed terminals, and acquired profits from installation fees of fixed telephones (Zheng and Tao 2006). Then, SCDMA was selected in the "9^{th} Five-Year" research programs and received funding of RMB 15 million, of which RMB 10 million came from the State Development Planning Commission. The SCDMA thus became the prototype of TD-SCDMA (Lu 2006).

D. Process of Application

a) Hesitation and Lack of Confidence

In 1997, when the ITU solicited for the 3G mobile communications standards, the Post and Telecommunications Research Institute wanted to try to promote SCDMA to an international level. In April 1997, the ITU called for 3G standard applications based on the established IMT-

[1] He is now a Director of the Board of Datang.

[2] Li was appointed as DB and Chen as the General Manager.

2000 standard and a detailed RTT IMT-2000 timetable and procedure. It also set a deadline of June 30, 1998. At first the Chinese government was hesitant to join, as it had no prior experience to propose standards. Finally, it decided to set up a China 3G wireless technology assessment group to handle the standardization setting procedures and gain relevant experience (Lu 2006).

b) Motivation to Apply Based on Foreign Interest

By the end of July 1997, the 3G wireless technology assessment coordination team, consisting of Chinese wireless communications authoritative experts officially registered with ITU and became the 11^{th} international assessment team. A rather meaningful scene emerged as all factions from Europe, Japan, and the US took the opportunity to show good will to China because of the prospect of enjoying the huge Chinese market. Every faction was trying to persuade China to join them. At that time, China started to consider its own strategy and decided to hold a meeting to discuss the opportunity (Lu 2006).

c) Xiangshan Meeting: The Essential Goals of Standardization

In January 1998, only a few months before the deadline set by the ITU, the Ministries of Post and Telecommunications and Science and Technology organized the 3-day Xiangshan Meeting based on the suggestions of the assessment coordination team. After heated discussions, the meeting reached two essential goals regarding the 3G standard issue: to present a completed set of standard proposal or to include Datang's technology into WCDMA and Siemens' proposal. Although most parties felt the second goal was more realistic, the group finally decided to adopt the first one (Lu 2006).

d) Datang Submits the Application

Despite the fact that the group had already decided on a goal, time was running out, and only a few months were left until the deadline set by the ITU. Furthermore, the group had no previous experience and SCDMA was only borrowed from Xinwei. Worse, Cwill quit their participation in the development of TD-SCDMA, as Datang took over the research team in Xinwei and continued the R&D. To establish a standard within the shortest time, Datang attempted to "inoculate" to other standard, while maintaining the core smart antenna technology. After comparing the technologies of Ericsson, Nokia, and Siemens, Datang chose Siemens, which also applied the TDD standard. This approach hastened the development of TD-SCDMA. The standard proposal was finally submitted by CATT and MPT (Lu 2006).

In 1998, on behalf of China, Datang submitted the proposed Chinese 3G standard (later named TD-SCDMA) to the ITU. On the other hand, to promote a uniform standard WCDMA in Europe, the Siemens-proposed TD-CDMA[3] was sacrificed, driving Siemens to support the Chinese TD-SCDMA. From late 1998 to 1999, WCDMA and CDMA2000 began a harsh battle that provided TD-SCDMA with new opportunities. In 1999, TD-SCDMA emerged from all 16 3G standard proposals received by the ITU and in May 2000, it was finally approved as one of the standards (Zheng and Tao 2006). In March 2001, TD-SCDMA joined the standardization organization 3GPP, and became the potential commercial standard. Finally, in May 2005, TD-SCDMA became an international standard (Zheng and Tao 2006).

E. The Path of Industrialization

a) Datang as a Core Contributor

The industrialization route of TD-SCDMA was more difficult than its standardization route — an R&D engineer even admitted that achieving industrialization can take three years. There were simply too many unexpected problems and difficulties. Conducting research on standardization is really a "firing money" enterprise. From station, system, terminal, and chip, all tasks fell on Datang, and the company was confronted with serious financial pressure. The 500 million RMB loan from banks was quickly used up on TD-SCDMA projects. Given that the international information industry was in significant recession, investors were not interested in 3G; in other words, Datang was in big financial trouble. At the same time, MNCs began making public their negative views on TD-SCDMA. Having just embarked on the industrialization path, TD-SCDMA thus faced capital and technology challenges while enduring speculations and doubts from both the media and the industry (Lu 2006).

Datang Telecom then decided to use loans to support the capital for R&D in order to survive in difficult times. In July 14, 2005, Datang Telecom announced that its subsidiary would apply for loan guarantees of RMB 110 million, and use its properties and patents that were worth over RMB 300 million as mortgage asset. Other loans of about RMB 1.1

[3] It is different from TD-SCDMA; here TD-SCDMA is Time Division-Code Division Multiple Address.

billion were from Datang's sub companies. The liability ratio in terms of Datang's net assets was as high as 69.78%, greatly exceeding the limitation of 50% for all publicly listed companies. By February 8, 2002, Datang Mobile was officially established based on Datang Academy and Shanghai Datang, In order to facilitate financing, China Bank International was instructed to raise private funds overseas. However, the project's progress was not smooth because few were convinced TD-SCDMA was any good (Lu 2006).

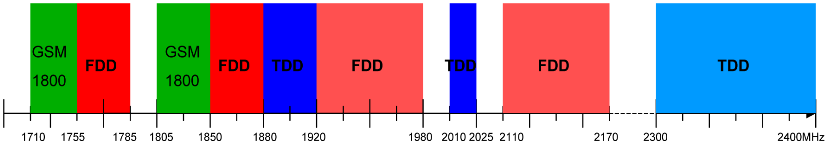
After an unsuccessful demonstration of TD-SCDMA delivered a serious blow to its developers, and days before Datang Mobile's official establishment, Datang and Siemens decided to hold the first TD-SCDMA live demonstration in Beijing with the purpose of raising public attention for Datang Mobile's establishment and gaining more support from the government. However, the demonstration did not achieve the goal. According to records, when the TD-SCDMA test vehicle started to move, the site received non-continuous sounds and pictures with mosaic images from time to time. The sound was also very weak. When the driving speed reached 70 km, the entire screen was covered by mosaic and then the screen froze. Most of the experts commented that, although some breakthroughs were achieved, the demonstration was mostly a failure and the technology was far from industrialization. The unsuccessful demonstration of TD-SCDMA lowered public confidence in the technology and research on TD-SCDMA reached a plateau (Lu 2006).

Researchers in Datang had to develop their own testing devices and continue to improve the system, leading Datang to rely on equity fundraising to support R&D investment. Datang Mobile in Shanghai was also looking for support from domestic capital, because various investments and even shareholders were coming in and out of Datang, either providing or withdrawing support for the project (Lu 2006).

b) Government Support

• Budget Support

In the face of rising problems that challenged the technology, the government came to the rescue and resolved the problem. The Ministry of Information Industry (MII) lent vigorous support to TD-SCDMA development and arranged special funds from the mobile projects and electronic development budget. The MII and the Ministry of Science and Technology, together with other governmental departments, invested RMB 1 billion (USD 120 million) from the late 1990s, involving nearly 3,000 scientists and engineers across the country. A total of 10,000 techni-



Source: Siemens White Paper (2002).

FIGURE 4
FREQUENCY DISTRIBUTION

cians and researchers were involved in the R&D and market promotion in 3G mobile services. In 2002, MII established the TD-SCDMA industry alliance with other ministries and supported theoretical research on TD-SCDMA, including design and R&D in crucial chips, systems, antennas, terminals, network plans, testing, and construction. MII invited an increasing number of Chinese and foreign manufacturers to join the alliance. To date, there are over 50 manufacturers engaged in the development of TD-SCDMA. The members of the industry alliance have increased from 8 to 47 (Liu 2005).

• Spectrum Support

Radio spectrum is an enormously valuable and scarce natural resource. According to an MII document, the WCDMA standard has a core frequency band of 60 MHz and an expansion frequency band of 60 MHz, and the CDMA2000 standard has the same. In comparison, the TD-SCDMA standard obtains a core frequency band of 55 MHz and an expansion frequency band of 100 MHz, ranging from 1880 MHz to 1920 MHz,[4] 2010 MHz to 2025 MHz, and from 2300 MHz to 2400 MHz.[5] Although the allocated frequencies to the three standards are all located in the core frequency according to the ITU regulations, the 2300 MHz to 2400 MHz frequency allocated to TD-SCDMA was carefully planned by the government. Since this specific frequency band used to have a military-related purpose, the government specially cleaned up the frequency in the interest of TD-SCDMA. However, the view of most foreign countries pertaining to TD-SCDMA was not positive. Many had already allocated core frequencies to the two mainstream standards, which made it difficult for TD-SCDMA to roam in other countries. However, if China can successfully commercialize TD-SCDMA in these two expanded frequencies, it would be possible to influence neighboring countries and even pene-

[4] This band is no longer available for TD-SCDMA because of PHS, for example.
[5] All current TD-SCDMA phones are now operating only on this 15 MHz band.

trate the world market, because the 2300 MHZ to 2400 MHZ is not occupied in most countries (Ren 2005).

In general, TD is assigned to the 35 M spectrum and the two others are assigned to 30 M, indicating the preferential policy towards TD. China Mobile TD-SCDMA newly obtained 1880 to 1900 MHz; a total of 20 M, including the previous TD-SCDMA's 2010 MHz to 2025 MHz spectrum, with a total of 35 MHz. China Telecom obtained 1920 MHz to 1935 MHz (uplink) and 2110 MHz to 2125 MHz (downlink), whereas China Unicom is assigned 1940 to 1955 MHz (uplink) and 2130 MHz to 2145 MHz (downlink).[6] Both get 30 M and do not interfere with each other. Although TD only has an additional 5 M than the other two, its unsymmetrical nature means that its use efficiency is much higher than the other two technologies. The frequency obtained by TD has lower system signal than the other two; however, the lower the frequency, the lower the energy consumed by the terminal. China Telecom and China Unicom are quite satisfied with their allocation, because 15 M is enough for them to operate their business (Ren 2005).

- Frequency-Division Duplex (FDD)
  - 1920 MHz to 1980 MHz/2110 MHz to 2170 MHz (core)
  - 1755 MHz to 1785 MHz/1850 MHz to 1880 MHz (complement)
  - All 2G used spectrum (GSM and CDMA) on 800, 900, and 1800 MHz are 3G FDD extended spectrum
  - Total: 2 × 90 MHz
- Time-Division Duplex (TDD)
  - 1880 MHz to 1920 MHz/2010 MHz to 2025 MHz (core)
- 2300 MHz to 2400 MHz (complement, shared band with Wireless Location Based service)
  - Total: 155 MHz
- Satellite Component (same as International's)
  - 1980 MHz to 2010 MHz/2170 MHz to 2200 MHz

This situation obviously reflected the Chinese government's support, and the isolated situation previously faced by Datang changed dramatically. In fact, Siemens in Shanghai expressed that it would continue investing Euro 50 million in the R&D of TD-SCDMA. On October 30, 2002, Datang successfully convinced Huawei, ZTE, and eight other domestic companies to join TD-SCDMA alliance. Datang's strategy was to

[6] http://zhidao.baidu.com/question/91231422.

share some IPR within the alliance to survive in the competition against WCDMA and CDMA2000.

• Supporting the Alliance

Although these domestic companies all responded positively to the invitation to join the alliance, there was no essential progress in the early stage after its establishment. According to the alliance's agreement, TD-SCDMA technology can be licensed among alliance members, but the initiator of the alliance should invest so that funds are available for the R&D, production, and manufacture of TD-SCDMA. Companies such as Huawei and ZTE had already invested huge amounts of capital into WCDMA and CDMA2000. Therefore, they had to face capital pressure if they decided to invest in TD-SCDMA. Furthermore, the grant of RMB 700 million by the Chinese government to the alliance substantially resulted in a fundamental change in the situation (Lu 2006).

In the beginning of 2003, the TD-SCDMA alliance organized a "summit" and invited top executives of various companies. The summit discussed IPR sharing, capital investment, and market foreground, arriving an internal agreement. The summit became the turning point of the development of the TD-SCDMA alliance, and industrialization entered a new stage. By the end of 2003, TD-SCDMA alliance had expanded to 14 members. In early 2006, the alliance expanded to 26 members, covering systems, and terminals, core networks to access other networks, and chips to software. MNCs were also interested in gaining access into the alliance.

• Postponing 3G

The Chinese government also postponed the launch of 3G. It was first tested in the 2008 Olympic Games, and was formally launched in 2009, about five years later than European countries and a decade later than South Korea. Obviously, the Chinese government wanted to seize the opportunity of delivering its own standard especially since the 3G was taking off at that time. The government then implements an industrial policy to improve the competitive position of Chinese firms, especially for the standard of TD-SCDMA to become more mature and commercialized. From the view of short-term benefits, the Chinese standard policy is designed to decrease dependence on foreign expertise by developing domestically controlled technology, which can reduce burdensome royalty payments running to hundreds of millions of dollars each year, by domestic producers of high-tech goods.

A long-term goal is to help leading Chinese firms secure technological leverage through the procurement of standard setting policy in order to

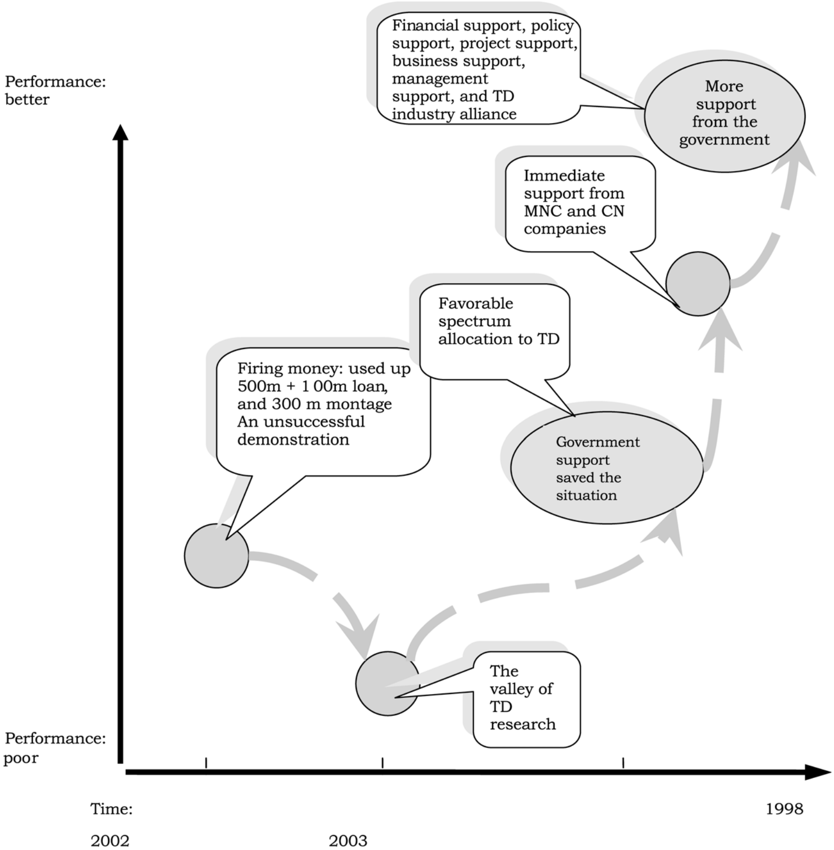


FIGURE 5
CHINESE GOVERNMENT SUPPORT FOR THE DEVELOPMENT OF TD-SCDMA

close the gap with more advanced countries over the next decade. The impact on global standards can be expected to increase. During the process of opening telecom markets and introducing foreign technology, China fostered several telecom manufacturers (Huawei, Datang, and ZTE) with excellent reputation worldwide and have aggressively increased their global market share. These enterprises have the capability to catch up through the procurement of standardization and eventually drive telecom and relevant industries to a higher technical level. In this case, China is pursuing the domestic development and application of intellectual property rights in a determined manner.

Government support for TD-SCDMA can be illustrated in Figure 5.

c) The TD Alliance: Its Emergence and Current Role

TD-SCDMA is a national strategic innovation industry, which requires strong governmental support. The huge number of stakeholders means that nobody else can undertake the mission. A challenge for the government then is find ways by which to work as a coordinator effectively. The mobile communication industry is characterized as a long and large-scale industry chain, and thus, even some huge companies cannot undertake the task. The task calls for a capable agent who can actively deliver information as well as coordinate organizations and marketing programs. The successful case of the telecom industry in other countries has shown that this can be achieved. To maintain its dominant position in the telecom industry, EU initiated GSMA in 1987.[7] GSMA focused on the promotion of GSM and WCDMA on a global scale, including the following: organizing roaming negotiation; funding projects in the areas of regulation policy, billing, and Internet; promoting industry development and establishing working groups; and creating a development foundation to promote WCDMA in newly emerging markets. Through the extensive efforts of the EU, GSM, and WCDMA became the most widely used technology standards. GSMA is responsible for most of the daily work in international promotion, with the EU becoming involved only on crucial decisions. To compete with European players, the US government promoted the establishment of the CDG (CDMA Development Group) in 1993 in order to facilitate the development of CDMA and CDMA internationally in 2000 (MII 2009).

Generously supported by the Chinese government (*i.e.*, National Development and Reform Committee, Ministry of Science and Technology, and Ministry of Information Industry), Datang, Huawei, Holly,[8] and ZTE, China Electronics Corporation (CEC) initiated the TD-SCDMA alliance in October 2002. The alliance has played an active role in industrializing the TD-SCDMA technology. According to different developmental stages, the alliance focused on those crucial enterprises and products in the industry chain to provide various means of support. The margin for the development of TD-SCDMA depended on the maturity of the industry chain. The alliance designed an industry chain chart to identify capable

[7] The GSM Association (GSMA) is an association of mobile operators and related companies devoted to supporting the standardization, deployment, and promotion of the GSM mobile telephone system. It claims nearly 800 mobile operators and more than 200 related companies as members.

[8] The Holley Group is a multi-industry cooperation with Holley Group Co., Ltd. as the parent company and pharmaceuticals as its core business.

and potential companies that can join the chain. In addition, the alliance coordinates the research calendar. For example, it usually adopts a linear research process in terms of technology, system development, chip, and terminal. TD-SCDMA applied the multi-linear type, when the system was under development and also promoted chip development; thus, when the chip was introduced, it promoted terminal development (MII 2009).

IV. Analysis

A. The Potential of the Telecom Industry

Two factors make the TD-SCDMA a candidate of standardization. One is the nature of the telecom industry in China. Information technology is the highland of state-of-art technology in the world. Among them, mobile communications is the most important and fastest-growing field of technology. Whether in the area of CPU or other technology areas, China may still experience difficulty in achieving a breakthrough in the near future. For example, in the area of consumer products, because of the Chinese being relatively weak in R&D and the fast-changing international standards, Chinese enterprises find it difficult to challenge the industry standard. By contrast, the R&D level in telecommunications is stronger than that of other areas, and the cycle of establishing and eliminating a standard in telecommunications is longer than that in other industries. The 3G generation of mobile communication can be predicted based on the technology life cycle of the mobile industry (Dalum *et al.* 2002). Thus, Chinese enterprises have sufficient time to challenge the current standard. This situation also creates the best opportunity for the Chinese industry to catch up. In the beginning of the product life cycle, researchers experiment with different designs and technologies, which result in many innovations (Utterback 1994). Then, in the early development stage, accelerated market dynamics and persisting uncertainty are observed. Based on 1G and 2G history, one generation of mobile communication spans approximately 20 years; however, the technology evolves every three years to five years. Thus, if China missed the 3G opportunity, they might need to wait another 10 years or even longer. In this way, 3G becomes the best choice to achieve a breakthrough. The emergence of TD-SCDMA has enabled the Chinese government to seize such an opportunity.

Another factor originates from the expectation in increased overall innovation capability. According to the forecast of the State Council Development Research Center (Chen 2006), "the overall input of the Chinese 3G mobile communications network in the beginning 6 years will reach 75 billion USD, of which more than one billion (are spent) annually." As Niosi *et al.* (1993) indicates, the government expects that the standardization can provide social value as well as market value by significantly enhancing national confidence, such as by promoting the technology as the flagship of innovation in China. Innovation can expand from an individual firm to the environment and industry, in which that firm operates and finally to the national system of regulations, institutions, human capital, and government programs. TD-SCDMA has been regarded not only as the model of indigenous innovation in the field of telecommunications, but also as an important practice of indigenous innovation based on enterprises. After the Datang Group submitted its application to the ITU, a TD-SCDMA industrial alliance was rapidly established under the active guidance of the Ministry of Information Industry. This action means that the Chinese government expects the TD-SCDMA standardization to drive the development of the entire industry value chain. The development of a self-developed TD industry promotes the development of the entire industry value chain and helps improve the national science and technology as well as national economy. The 3G market scale is estimated to reach RMB 1000 billion, and TD-SCDMA's contribution to GDP would reach RMB 1.8 billion (Tang 2010). The Chinese government expects that the involvement of standardization can help Chinese companies and the national economy move toward a higher level.

B. The Emerging Side: Technology Accumulation

a) The Acquisition of Further Experience among Operators

The possibility is also enabled by the accumulation of technology and experience. After more than a decade of operating and developing the telecom systems, China began to acquire the basic confidence of developing its own technology or system. Along with the fast development of the market, operators had also undergone significant reform and restructuring. China Unicom was established in 1994 to cope with the market development. In 1997, China Mobile's Guangdong and Zhejiang branches were listed in the New York and Hong Kong stock market. The GSM network was operated in more than 15 provinces, and subscribers reached 20 million in August of 1998. All these developments brought rich knowledge and experience to the Chinese operators, who were relatively late entrants to the market economy. The operators became increasingly mature and powerful, and the accumulation of knowledge and experience also helped the Chinese government become confident that the growing domestic operators would have sufficient ability to support a Chinese-led standardization.

b) Dragon's Breakthrough

Three manufacturers, Dragon, Huawei, and ZTE, have contributed to increasing public confidence in implementing a Chinese standardization. Dragon became the first contributor when it independently developed HJD04, the biggest breakthrough in the Chinese telecom history at that time. HJD04 took over most of the market because of its low cost. However, the company gradually disappeared from the scene beginning in 1998. Although Dragon is almost inexistent now, the ten-year development experience of Dragon leaves a significant amount to inherit for the telecom sector. The success of HJD04 greatly motivated the confidence of Chinese engineers in their own R&D capabilities; the research staff from Dragon then turned to work in other companies, also spreading the knowledge and experience they gained from Dragon. Thus, from many perspectives, Dragon is the pioneer self-developer company in the Chinese telecom industry (Sun 2008).

c) The Emergence of Huawei and ZTE

Two companies, namely, Huawei and ZTE, were also emerging stars of the telecom industry in China during that time. In 1992, Huawei successfully opened the rural market by the self-developed product C&C08, thereby beginning its "rural to urban" strategy. The company's revenue reached RMB 1.5 billion in 1995, and all of these came from the rural market. Huawei entered the urban market in 1997. In the same year, Huawei began to develop GSM. Meanwhile, the company also established a joint laboratory with many international companies, including Texas Instruments, Motorola, IBM, Intel, Agere Systems, Sun Microsystems, Altera, Qualcomm, Infineon, and Microsoft. By 1998, Huawei was developed as a company, acquiring a certain name recognition and market share in the domestic market by its self-developed products. Another emerging star, ZTE, also successfully presented the ZX500 exchange in 1990, and by 1995, it was successfully listed in the Shenzhen stock market. By 1998, ZTE established three research centers in the U.S. and also gained the exchange turnkey projects of Bangladesh and Pakistan, which was the biggest overseas project for a Chinese telecom company at that time, thus increasing the industry's confidence in undertaking similar projects. When the Chinese government decided to adopt the standardization, the Chinese telecom companies were experiencing faster development than ever, acquiring significant amounts of knowledge, experience, technology, and skills. Therefore, the Chinese government gained higher ambition and sufficient reason to accept more challenges for the Chinese telecom industry (Sun 2008). The above mentioned provides Huawei and ZTE the industrial condition to go further to support their own standard. Then the second point is, both Huawei and ZTE's R&D capabilities have largely improved by hiring a large number of newly graduate students and launching university cooperated research. As Eun (2009) mentioned, in China the university-industry-link is replacing the traditional mode of knowledge industrialization and most Chinese firms appears to be very positive in evaluating their own experiences of collaboration with universities. These companies worked together with universities to develop prospective research and publish papers. These activities prepared research condition for the Chinese telecom companies to support their own standard.

d) International Experience

The situation drove China to interpret and implement an approach of standard, which focuses on market power in the face of technological weakness, under the condition that China has confidence in its ability to set innovation standards that can positively affect its international competitiveness (Rosen 2003). This approach is reflected in the "indigenous innovation" policy. As has been introduced, the policy highlights the internal technology breakthrough through the efforts of the China-originated technology development. Instead of borrowing technology from other countries, China endeavored to improve its overall R&D level and technology competency in the global production network. In this case, a homegrown standard for 3G network could provide Chinese companies an edge and enable them to acquire a slice of a market dominated by European and US suppliers, while simultaneously promoting the TD-SCDMA standard. Relevant mobile industries can thus be upgraded to a new technology level.

Therefore, the rising interest of standard setting by the Chinese government is actually a strategic response to globalization and the global economy, where standards have become important tools used to leverage gains in international production networks. For example, in Korea, domestic firms have contributed intellectual property to worldwide video compression standards by rapidly expanding patent portfolios. In addition, even the smaller economies can procure domestic-made standards. China's large and growing market allows for more possibilities and fuels the ambition of domestic firms to pursue local standards and allow the standards to find their own way. From this point of view, China's increasing interest in standard setting focuses on practicing neo-techno-nationalism by assuming a risky and costly task to devise its own standard.

The 3G standardization system in China is highly politicized in comparison with the usual standard setting in elsewhere. In fact, the telecommunication industry is most likely to be determined by government committees because of government ownership of the communication infrastructure in many countries. However, this state of affairs is not unique. For example, Japan uses government consortia to drive development of standards for new markets such as networked digital products (METI 2004). In Europe, the effort to create the very successful GSM standard in the 1980s was initially led by state-owned telecom operators and the European Commission.

V. Conclusion

In this paper, we review the process of TD-SCDMA's application as an international standard, from the very origin of the technology, to an accepted international standard, and then to a commercialized standard. The Chinese government also supported the development of this technology in terms of policy, resource, capital, and spectrum. A TD-SCDMA alliance was also established to support the industrialization of the standard.

The telecom industry is a typical "network economy." The Chinese government aims to achieve a breakthrough in the telecom industry because this is a typical network economy, and the telecom standard is the most crucial factor that controls the Chinese telecom industry. The highest priority of standard setting is to address the fact that interoperable, technical compatibility standards do not flow "naturally" from the best engineering practice but reflect the full range of strategic behavior. Thus, in terms of the Chinese standard, even technically, TD-SCDMA may not be as matured or advanced as the other two, but strong government support for this technology provides a solid back up. Mobile technology is a very sophisticated technology. Many factors, such as companies, research institutes, and government support, are involved in the process of becoming a standard. The complicity of the technology also increased the confidence of the government to promote the TD technology as a standard because the complex factors behind the technology might increase the bargain power of the technology and increase the possibility of it becoming a final standard. This mission fell on TD-SCDMA for many reasons. The R&D capacity of the telecom industry is stronger than that in other industries, and the cycle of establishing and eliminating a standard in telecommunications is longer than that in the other industries. In addition, building a new standard during the transition of the technology life cycle in mobile communications from 2G to 3G is ideal. All these complex factors drive the Chinese government to implement the decision of standard setting.

When we examine the entire process of 3G standard setting from the perspective of economics, we found that the major success factors of TD-SCDMA arise from the three aspects listed below.

1) The Chinese government successfully promoted this technology to be an international standard even though it had little experience in international standardization.
2) Afterwards, the Chinese government largely supported the development and commercialization of this technology, finally making it a practical standard widely used throughout the Chinese market.
3) Although TD-SCDMA is a Chinese-applied standardization, the process of standard setting and industrialization of the standardization helped a number of Chinese telecom companies learn and catch up. For the industry, this effect has become the real benefit of standard setting.

The success of setting up TD-SCDMA as a standard marks the success of the operation by the Chinese government. Every step of improvement cannot be executed without careful planning and implementation with the support of the Chinese government. Long before the process of the standard application, the Chinese government invested substantial human resources and capital to develop its own technology to make it competitive. Finally, when TD-SCDMA was submitted to ITO, it gained special advantages to compete with other standard candidates. When the process moved to negotiation, the Chinese government fully leveraged its advantage as a large country and large market, finally fostering its own technology to become an international standard. After the success of the standard setting, more challenges arose from the industrialization and commercialization of the technology. The Chinese government surpassed the obstacles in the frequency distribution, allocating favorable frequency to TD-SCDMA. TD alliance was also created to motivate industrial partners in different levels of the value chain to join the development of TD-SCDMA. Finally, the Chinese government selected the largest mobile operator, China Mobile, to operate the 3G standard at the appropriate time.

The Chinese government is always working as the final decision maker and general coordinator. From the beginning, the government made relevant decisions for action, verified TD-SCDMA technology, and then coordinated resources to apply the standard. The government later organized the industrial alliance to increase the industrialization speed. In the midst of the process, the Chinese government also made several adjustments to provide more time for the Chinese companies to deliver a mature 3G product. All these efforts, perhaps, can only be achieved with careful consideration and with the strong implementation power of the Chinese government. As a technology latecomer, China can identify a technology to use in catching up and maximize all the national resources to work toward meeting international standards. After more than ten years, the Chinese government helped the standard build a technology industry train. Although the standard is not used worldwide, during this process, many of the Chinese domestic companies began to acquire knowledge and skills, greatly increasing the technology capability and international market share of Chinese telecom companies. Finally, the standard became commercialized in 2008, until the Chinese government accomplished the escorting for the TD-SCDMA, from its birth to a commercial standard, by harvesting a significant amount of industry growth and experience of standard setting, enabling China to progress further.

The case of TD-SCDMA is a good example of how a developing country leverages the opportunity in the technology life cycle and its own market resource as a bargain power to make a breakthrough in international standardization. Particularly, the active support and significant contribution from the Chinese government are key factors in winning in this game. This inspiration might be good for other developing countries when they are facing similar decisions. However, the success of the TD-SCDMA is not a duplicated case that can be manipulated by other countries. Regardless of government power or market resource, no other country in the world can be compared with China. It is impossible to find other countries in the world that possess a level of government implementation power or market resource similar to that of China. However, these factors are crucial in adopting TD-SCDMA as an international resource and as industrialized technology. Thus, the China experience is an inspirational case other than a duplicated case. Owing to space limitation, we did not include the interviews with key experts. In this paper, we examined the topic mainly through a literature review, but we hope that in future publications, we can also include the interview materials to provide more inspiration and reveal further insights on other economies or industries.

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Appendix 1: Chronicle of TD-SCDMA (1998-2008)

1998	• Under direct instruction by the MII, the China Academy of Telecommunication Technology (CATT) drafted the TD-SCDMA proposal, which conformed to IMT-2000 based on SCDMA technology. It was submitted to ITU on June 30, 1998 and became the 15th candidate of IMT-2000. In November 1999, the 18th meeting of ITU-TG8/1 in Helsinki, ITU reviewed all the evaluation results systematically. In the May 2000 ITU-R meeting in Istanbul, TD-SCDMA was officially accepted as one of the CDMATDD designs.
2000	• Datang Group presented the TD-SCDMA technology on behalf of the Chinese government. It was accepted as one of the 3G standardizations. This event was a significant breakthrough in Chinese telecom history. • On December 12, 2000, TD-SCDMA technology forum was established.
2001	• On March 16, TD-SCDMA was accepted by 3GPP (3G's partner project). • In April 2001, telephone calls were enabled between the TD-SCDMA station and analogue terminal. Telephone calls were also enabled between TD-SCDMA prototypes in the site trial. • On July 4, 2001, graphic transmission was realized between the TD-SCDMA station and analogue terminal. • In September 2001, Philips signed an agreement with Datang to develop jointly the TD-SCDMA chip. • On October 3, 2001, the TD internal trial network system passed the test.
2002	• In January 2002, Nokia, TI, LG, Petvio, DBtel, and CATT jointly established Commit in Shanghai. FTMS made the first dual direction MOC voice call. • On February 2002, the demonstration of the internal trial network was a success, which proved that TD-SCDMA technology was eligible for the ITU requirement. • On March 2002, Datang Mobile was established in Shanghai, paving the way for full industrialization of TD-SCDMA. • In May 2002, TD-SCDMA passed the first stage test by MTnet. • On October 23, 2002, MII allocated spectrum 155 MHz (1880 MHz-1920 MHz, 2010 MHz-2025 MHz, and 2300 MHz-2400 MHz). • On October 30, 2002, the TD-SCDMA industry alliance was established. Datang, Huawei, Holley, Lenovo, ZTE, Zhong CECT, and Petvio became the first group members and signed "Agreement of Initiator" to promote collectively the TD-SCDMA enterprise for China. This event indicated that TD obtained a response from industry, which was a significant breakthrough in the process of industrialization. • In November 2002, Datang Mobile, Philips Semiconductor, and Samsung signed an agreement to set up a joint venture. UT Star

	signed an agreement with Datang Mobile in Beijing to develop jointly TD-SCDMA equipment.
2003	• On January 16, 2003, Datang Mobile authorized ST Microelectronics to develop a multimode multimedia system on chip. Datang Mobile, Philips, and Samsung jointly established T3G. • In March 2003, Datang Mobile TD-SCDMA Industry Park began operation in Shanghai Qingpu Industrial Park. Tektronix United States joined the Chinese 3G standard development. • In April 2003, CQCYIT enabled 3G mobile terminals to call the Datang station. TI technology was applied in the Chinese TD-SCDMA wireless station. • In May 2003, RTX transferred GSM/TD-SCDMA chip IPR. TI planned to introduce TD-SCDMA chips. Philips turned to work on the TD-SCDMA standard and claimed that this standard would not only limit in China. • In June 2003, TD technology forum joined a 3GPP partner program. The TD-SCDMA terminal entered the crucial stage. • In July 2003, demonstration of TD-SCDMA 384 k/bps data transfer was held in Beijing. Nortel and Datang established a joint laboratory. The first TD-SCDMA portable terminal was presented. • On December 26, 2003, the TD-SCDMA alliance absorbed more new members including Beijing T3G, CQCYIT, Hisense Group, COMMIT Shanghai, Xi'an Haitian Antenna, and Spreadtrum Communications. • The new recruit joining ceremonies of the TD-SCDMA Industry Alliance were conducted in December 2003, April 2005, October 2005, April 2006, November 2006, June 2007, November 2007, July 2008, and December 2008. At present, the TD-SCDMA Industry Alliance is composed of 65 members. A complete and mature multi-vendor environment was formed.
2004	• On March 30, 2004, the first TD-SCDMA mobile terminal was developed by Datang Mobile. • On August 18, 2004, T3G presented the first TD-SCDMA/GSM/GPRS dual-mode mobile terminal chip.
2005	• From January to March 2005 and April to June 2005, TD-SCDMA began indoor and outdoor professional industrial tests. • In April 2005, TD-LTE was first proposed in China. • On April 16, 2005, the following companies joined the alliance: UTstar, Bell Alcatel, Zhongyou, Shanghai DBTEL, Okwap, TYCC, and ZCXC. The alliance had 21 members, including system vendors Datang and ZTE, chip manufacturers Spreadtrum and Commit, terminal producers Lenovo and DBTEL, and terminal manufacturers. The alliance also obtained cash support from MNCs, such as Motorola, Siemens, Samsung, Philips, Nokia, Texas Instruments, and others. • In June 2005, TD-SCDMA special tests were completed on schedule, and the state authority department announced that TD-SCDMA is

	capable of large-scale network construction, demonstrating that the technical performance and operation value of TD-SCDMA had stood the test. • On October 9, 2005, the first 3G TD mobile terminal chip was developed in China.
2006	• In January 2006, the Chinese Ministry of Information Industry (MII) announced that TD-SCDMA will become China's national technology standard for the telecommunication industry. • In March 2006, TD-SCDMA large-scale network technology application tests were launched by MII. The three major operators, China Mobile, China Netcom, and China Telecom conducted the tests in Shanghai, Beijing, Baoding, Xiamen, and Qingdao. On March 12, 2006, the scale test proposal was finally confirmed. China Telecom, China Mobile, and China Netcom selected Baoding, Xiamen, and Qingdao. • On June 20, 2006, MII announced that TD-SCDMA would become the industrial standard in the Chinese telecom industry. • On June 30, 2006, MII announced 21 MII-sponsored R&D projects. TD-SCDMA and AVS accounted for four. • In August 2006, TD-SCDMA's first stage of scale test was completed. MII organized more than 70 officials to participate in "China TD-SCDMA Training Seminar." • On August 29, 2006, the Chinese government signed with SK in South Korea "TD-SCDMA project cooperation memorandum of understanding." SK planned to build a TD test network in Korea. • On September 21, 2006, Mr. Lou Qinjian, vice minister of MII, revealed in a forum that TD's industrialization was almost ready. • In October 2006, the third stage of TD-SCDMA was completed. • In October 2006, IMT-Advanced Work Group submitted the technical evolution proposal to ITU. • In November 2006, TD-SCDMA entered the scale number allocation stage.
2007	• In February 2007, Datang Mobile and SK created a TD-SCDMA R&D center, which demonstrated strong cooperation between the two companies. • In March 2007, the TD-SCDMA network technology application tests have been conducted on a wider scope. TD-SCDMA trial networks were planned to be deployed in 10 major cities, including Beijing, Shanghai, Tianjin, Shenyang, Qinghuangdao, Qingdao, Guangzhou, Shenzhen, Xiamen, and Baoding. • In March 2007, China mobile began the TD-SCDMA equipment purchasing bid, amounting to a total of RMB 26.7 billion. China Mobile, China Telecom, and China Netcom began large-scale test networks in Beijing, Shanghai, Tianjin, Shenyang, Qinhuangdao, Xiamen, Guangzhou, Shenzhen, Baoding, and Qingdao. • On October 17, 2007, ZTE launched the "3G pioneer experience program" in Beijing, formally introducing the first TD-SCDMA/

	EDGE dual-mode mobile terminal U980. • On November 2007, the *Long Term Evolution, Time-Division Duplex* (LTE TDD) fusion technology program was signed by 27 companies during a 3GPP RAN151 meeting, and its frame structure was identified based on the frame structure of TD-SCDMA. This event enabled TD-SCDMA to evolve toward *TD-Long Term Evolution* (TD-LTE) and 4G mainstream standards. • On December 14, 2007, the first Sino-Korea TD-SCDMA Summit was held in Beijing. Participants discussed the development and popularity of TD-SCDMA in terms of the perspectives of technological standard, application, and financing.
2008	• In March 2008, MII was merged into the newly established ministry, Industry and Normalization Ministry. The 3G license issue and re-structure of the telecom companies would be promoted by the new ministry. • TD-SCDMA trial use was formally launched in Beijing, Shanghai, Tianjin, Shenyang, Guangzhou, Shenzhen, Xiamen, and Qinhuangdao on April 1, 2008. TD-SCDMA as an international 3G standard underwent trial commercial use after eight years of struggle. • In 2008, the TD-SCDMA Alliance grew to 58 members, covering the whole industry value chain in operations, equipment, terminals, test, and instrumentation. In addition, among the seven largest wireless equipment manufacturers, Ericsson, Nokia, Alcatel-Lucent, Huawei, and ZTE all joined. Nortel and Motorola did not join at that time, because they were experiencing downsizing and transformation. • China Mobile launched the TD-SCDMA social business test and trial-commercial project in the following eight cities: Beijing, Tianjin, Shenyang, Guangzhou, Shenzhen, Xiamen, and Qinhuangdao. • In July 2008, ten companies including Mobile, China P&T Equipment Company, and Media Tech joined the alliance. The alliance truly covers operation, manufacturing, channel, production, and market. • In August 2008, in the opening ceremony of OLG in Beijing, data from China Mobile showed that approximately 7000 users used TD-SCDMA mobile phones during that evening, and video calls reached 800. Meanwhile, MII officially agreed to get into a partnership with China Mobile to build the TD-SCDMA network and begin trial-commercialization. • In September 2008, China Mobile Communications Corporation issued the public bidding for the TD-SCDMA second-phase network construction project and confirmed that TD-SCDMA network coverage will be expanded to 38 cities. • In September 2008, the second stage of TD-SCDMA bidding began, which included 23 thousand stations and 160 thousand radio carrier frequencies, and reached an investment of RMB 30 billion. • In September 2008, ZTE promoted the first TD-HSDPA mobile phone and was ahead of schedule for three months.

- By the end of September 4, 2008, 45 TD-SCDMA terminals (including TD-HSDPA data cards) from 22 terminal vendors obtained MII and IT-issued network access licenses, and 6 infrastructure equipment vendors obtained network access licenses for TD-HSDPA equipment.
- On October 22, 2008, at the China International Communications Exhibition, China Mobile invited 42 enterprises together to promote the TD-SCDMA industry chain development, first demonstrating the key technology of TD-LTE.
- In November 2008, the result of the China Mobile's second stage bid of TD was released. Datang received 40% share, with ZTE and Huawei following closely. Nokia, Siemens, Ericsson, and Potvio had shares of no more than 10%.

Source: China Electronics (2008).

Appendix 2: Abbreviation

- (2G) Digital Mobile System
- (CATT) China Academy of Telecommunication Technology
- (CDG) CDMA Development Group
- (ETSI) European Telecommunications Standards Institute
- (EV-DO) Evolution-Data Optimized or Evolution-Data
- (FDD) Frequency-Division Duplex
- (GPRS) General Packet Radio Service
- (HSDPA) High-Speed Downlink Packet Access
- (HSPA) High Speed Packet Access
- (HSUPA) High-Speed Uplink Packet Access
- (LTE TDD) Long-Term Evolution, Time-Division Duplex
- (MII) Ministry of Information Industry
- (MPT) Ministry of Post and Telecommunications, which was later restructured as Ministry of Information Industry
- (NGN) Next Generations Networking
- (PHS) Personal Handy System
- (PTAs) Post and Telecom Administrations
- (PTEs) Public Telecommunications Enterprises
- (SOEs) State-Owned Enterprises
- (SPC) Statistical Process Control
- (TDD) Time-Division Duplex
- (TD-LTE) TD-Long-Term Evolution
- (TD-SCDMA) Time Division Synchronous Address
- (WiMAX) Worldwide Interoperability for Microwave Access
- (CDMA2000) Code Division Synchronous Address
- (GSM) 2G Standardization, Global System of Mobile
- (WCDMA) Wideband Code Division Synchronous Address

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