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# The Development of Information and Communication Technology Standards in China: A Historical Analysis

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# THE DEVELOPMENT OF INFORMATION AND COMMUNICATION TECHNOLOGY STANDARDS IN CHINA: A HISTORICAL ANALYSIS

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## Abstract

*China's recent success stories in ICT standardization initiatives are among many remarkable examples to illustrate the country's evolution as an innovation powerhouse. While China's standardization activities experienced significant failure rate in the beginning, there is growing recognition that the country may have a higher chance of success in more recent IT standards. In this paper, we provide a historical analysis of China's standardization activities. We identify and analyze several disruptive events related to standardization initiatives such as milestones, catastrophes and legal/administrative happenings (Hannigan, 1995).*

*Keywords: China, information technology, standardization, disruptive event, historical method*

# 1 INTRODUCTION

The People's Republic of China (hereinafter: China) is rapidly evolving as an innovation powerhouse. China's recent success stories in ICT standardization initiatives are among many remarkable examples to illustrate this trend. Chinese are working hard to create Chinese standards in many ICT industries such as computer operating systems, audio-video compression and third generation (3G) data standards (ZDNet Asia, 2003). Chinese, after all, believe they have ability to set their own standards in these areas (Koprowski, 2004). Observers have noted that Chinese standards related to cellular technologies and Internet Protocol TV (IPTV) are likely to capture significant market shares both abroad and at home (Einhorn, 2003). From the standardization perspective, while China still has plenty of wind in its sails, these are notable accomplishments for a developing country.

China's standardization activities experienced significant failure rate in the begging. Yet, having said this, it is apparent, too, that there is growing recognition that China may have a higher chance of success in more recent IT standards. From the U.S. perspective Vogelstein et al. (2004) put the issue this way:

*For the tech industry, it's China-not Europe, or Japan, or other Asian countries-that will soon be its [USA's] main rival. The implications are profound. No longer content to cheaply make other people's products, a task it has clearly mastered, China wants to be a global standards setter. .... One place to watch the flexing of power is in mobile phones.*

A deeper understanding of how China's idiosyncratic features have influenced standardization measures will provide academics, managers and policy makers with valuable insights. Although a good deal of attention has been focused on the Chinese ICT industry, less attention has been devoted to explaining China's position in the standardization landscape. Origination of ICT standards in developing countries such as China can help the creation of a sustainable information society. Contribution of the new innovation regime to a sustainable information society and identification of policies to promote such an end have been identified as important research and policy issues (Bohlin et al., 2001). Additionally, part of the fascinating character of this topic stems from the fact that China arguably deviates more than other economies from standard assumptions of economics, especially the way institutions function and relations between the market economy and democracy (Hermann-Pillath, 2006). Such a deviation is likely to lead to the government's standardization measures that are unique to China. In an attempt to fill the research void, in this paper, we provide a historical analysis (Mason et al, 1997a) of China's standardization activities.

According to Mason et al. (1997b), historical research offers perspectives that could reflect the cultural circumstances and ideological assumptions that underlie phenomena. Additionally, it could identify the role played by key decision makers together with long-term economic, social, and political forces in creating the phenomena. With applying historical analysis, a better understanding could be generated in terms of the processes by which information technology standards are developed and the forces that shape their uses in China.

In the remainder of the paper, we first address the research design of this study. We then analyze four stages in China's standardization activities. The final section provides discussion, implications and conclusion.

# 2 RESEARCH DESIGN

We applied a historical method (HM) to study China's ICT standardization initiatives. Historical methods begin by focusing on "a question or a cluster of coordinated questions" (Mason, McKenney and Copeland 1997) about past events that are open ended and answering them with selected facts arranged in the form of an explanatory paradigm (Fischer 1970; Smith and Lux 1993). Historians follow several steps to construct such an explanatory paradigm. For MIS studies with a historical

orientation, Mason, McKenney and Copeland (1997) propose a seven-step process: asking a question or a cluster of coordinated questions, specifying the domain and the unit of analysis, gathering evidence from multiple sources, critiquing the evidence, determining patterns, telling the story, and writing the script. However, HM is seldom executed strictly in such linear way (Mason et al. 1997). Smith and Lux (1993) refer to the first four steps as research design and the last three steps as historical analysis.

Like all other good research, the key to historical method lies in “asking the right question” (Bouchard 1976). The question(s) asked determine the domain for inquiry (Mason et al. 1997). A question addressed in this paper is: What factors have influenced China’s standardization measures and success of its standards?

Historians can draw evidence by using a host of research procedures including the analysis of secondary data, case study, and library or archival research to match the data to the interpretive end driving the research questions (Smith and Lux 1993, p. 601). We used most of these sources to draw evidence.

In the beginning, institutions related to standardization were thin and disfunctional. Gradually more efficient institutions evolved which led to the success of Chinese standards. Based on the level of success of standards generated in China, we divided the period 1998-present in four stages.

### 3 MAJOR STAGES RELATED TO CHINA’S STANDARDIZATION INITIATIVES

Several disruptive events related to standardization initiatives in China are presented in Table 1. Table 2 presents organizations involved and level of success associated with various standard developed in China.

*Insert Table 1 and Table 2 here*

#### 3.1 Stage I: 1978-1984

Standard-setting initiatives in the post-Mao China started in 1979. In the beginning, the central government, Chinese Academy of Science, and academic institutions were involved in the R&D on operating system standard. Indeed, operating system development was listed in National Key Technology R&D program of the National “Sixth Five years” plan (Ministry of Science of Technology, <http://kjzc.jhgl.org/intro/lw.htm>).

The establishment of Chinese National IT Standardization (CITS) Technical Committee in 1983 was a major milestone on the standardization front. Currently, CITS is managed by Standardization Administration of China and Ministry of Information Industry (MII). It is responsible for national standards development and corresponding standards transformation of ISO/IEC JTC1 standards. CITS is the biggest technology standardization committee in China (NITS, 2007).

A project for UNIX/POSIX operating system development started in 1979 is probably the earliest high-profile standardization project initiated in the post-Mao China. The Chinese Academy of Science led the project. 17 academic institution and local government agencies were involved in the project and more than 200 researchers participated (Sun, 2001).

Some notable achievements during China’s early standardization efforts include the development of Chinese Character DOS(CCDOS), database management system, network communication system, and some middleware products. The CCDOS was launched in 1982. The CCDOS, however, was largely unsuccessful. Microsoft DOS1.0 was launched during the same period and with a better marketing strategy. The Chinese operating system market was thus dominated by Microsoft DOS1.0. (Xie,

2002). Microsoft bundled its product with IBM-PC and charged a fee of one cent per copy of its software (Xie, 2002)

David and Steinmueller (1994, p. 29), like many standardization theorists, argue that one of the major motivations behind technology policies and standard-setting for regulatory bodies is to achieve national goals such as protection of domestic employment and reduction in foreign dependence. Consistent with the theory, the standardization efforts were directed towards reducing dependence on foreign know-how (Linden, 2004; Sun, 2001) and enhancing national defense.

Sun (2001) points out several problems in China's R&D efforts in the early phase. First, the standard setting was isolated from market and customers' demand. Note that Mao viewed the market as "embodiment of capitalism" and suppressed it with a central plan-based economic system (Dittmer and Gore, 2001). Prior researchers have noted that that "soft" concept of management such as marketing and consumer behavior were not integrated into Chinese thinking (Borgonjon & Vanhonacker, 1992). There are opinions that such concepts are perceived by the Chinese Communist Party as a threat to the communist ideology. Most obviously, customers were not involved in the R&D processes. A second, probably more significant factor, is the project's failure to catch up with changes in the market. Most people involved in the project were from academic institutions, who were mainly concerned with technology development rather than commercialization. Third, the research team didn't learn from foreign advanced techniques and research experiences. In this regard, one obvious concern very limited foreign investment during the period. Fourth, weak coordinating and management skills hampered the projects. The researchers and developers were dispersed at different locations. Finally, the projects faced funding problems. The projects were mainly financed by the central government.

### **3.2 Stage 2: 1985-1993**

In 1984, Deng Xiaoping emphasized the importance of informatization in China's four reforms. The government then began to shift its focus from the goal of self-sufficiency to use of IT in all economic sectors and production of internationally competitive IT products (Kraemer and derrick, 1994). The central government also set targets for improving information infrastructure and started to promote IT production and use.

Beginning 1985, the Chinese government encouraged technical development within state-owned enterprises (Linden, 2004). The government also emphasized on technology and science development. Several national technology development projects were started. By 1987, there were over 5,000 state-operated research units employing more than 230,000 scientists (Baark 1988). The transfer of technology from state operated research units to industrial enterprises fuelled rapid technology diffusion. In the mid-1980s, the penetration rates of consumer durables in China were about the same as South Korea, Japan and then USSR (Sklair 1994).

The 863 Program started in 1986 targeted eight strategic technologies for development. They included IT, biotechnology, energy, materials, automation, lasers, space and telecommunications. In 1988, the State Science and Technology Commission launched the "Torch Plan", which led to the establishment of science parks and high-technology development zones to accelerate the development and commercialization of new technologies.

Chinese policy makers' attitude toward technology transfer also changed gradually. Joint-venture (JV) projects were encouraged where foreign vendors could bring technology and manufacturing skills and local companies would offer labor and access to domestic market (Kraemer and derrick, 1994).

In 1986, the databases technology standards research project was included in the national "Seventh Five Year" plan. The database technology standard committee was set up by the national OSI technology council. The targets for this projects were eight standards on the four technology levels of database technology including database management referential model, information resources directory system, database language (SQL, NDL), and remote access of database. In fact, the ISO/IEC

has already made corresponding standard resolution. So major task of the Chinese national database standard technology committee is to comprehend SQL standard and establish the plan for national database standard development. In 1989, the committee submitted the national standards—GB/T 12991 databases language SQL. It should, however, be noted that the core technology for this is relied on the international standards SQL.

The slow development of the national standards reflected several problems in this stage. First, due to a low level of diffusion IT products, researchers, developer, and users lacked familiarity with the new technologies and standards. Second, the communication between the IT standards developers and users were limited leading to a neglect of users' needs (Ma, 2005). A final issue that deserves mention relates to a lack of a national agency to coordinate standardization activities (Kraemer and derrick, 1994). Responsibilities were divided across several government agencies and industry associations.

### **3.3 Stage 3: 1994—2000**

In 1994, National informatization expert workgroup was established to develop strategy to push the advancement of IT and Chinese informatization process (Boxin 2006). Several state-owned enterprise and private enterprise were involved in the development of IT standards and products.

In the mid-1990s, China also attempted to introduce its CD standard, Super Video CD. The attempt, however, was largely unsuccessful because it faced foreign market resistance as well as a lack of strong consumer support within the country (Goad & Holland, 2000).

Various standards related to Enhanced Versatile Disk (EVD) and Linux were developed in this stage.

#### **Linux**

During 1999-2000, many Chinese versions of Linux were launched. These products were developed by various institutions including the government associated research institution, state-owned enterprise, private enterprise, and online community. The products include Redflag Linux 1.0, Bluepoint Linux 1.0, XstreamLinux1.0, TOM Linux, Happy Linux from LENOVO, and Maric Linux from an online community. However, except the Redflag Linux, almost all Linux products failed. The failure can be attributed mainly to the unfamiliar user interface. Microsoft software still dominated the market. All major office software, computer tools and games run with Microsoft Windows. The compatibility issue has not been resolved in Linux.

#### **Enhanced Versatile Disk (EVD)**

Chinese standard EVD was originally developed by the Beijing E-World Technology Company. The standard was targeted for use in the greater China (Ma, 2004, IT Times). The Ministry of information industry (MII) approved EVD and recommended national standard for high-definition discs (Suttmeier et al, 2004).

In May 1999, major players in Chinese Home Appliance industry established an EVD Alliance and requested the State Economic and Trade Commission (SETC) for the National Key Technological Innovation Project to support for the special project on a new generation high-definition digital laser video disc system. In October 1999, the SETC approved the formation of the China Digital Optical Disk Technology Consortium". SETC allocated 10 million *Yuan* for the project.

In October 2000, China's National Audio Video and Multimedia Systems and Devices Standardization Committee under the State Bureau of Quality and Technical Supervision and MII approved the formation of a "New-Generation Digital Optical Disk Standardization Working Group". The working group's major task was to develop the specification of next generation laser video disc system. This working group was also led by Beijing E-World (Ma, 2004, Suttmeier et al, 2004). In 2001, the design of EVD digital video disc system passed national technology standard evaluation.

It took a long time for the E-world to develop the EVD Standard and launch it. Several problems seriously hampered the efforts. First, the EVD standard was not authorized by international audio and

video association. This led to a resistance of the standard by the foreign players. Second, the quality of EVD player was not high. Also the price of EVD player was two to three times of DVD player. Third, there was limited video source in the EVD format. Finally, researchers and developers involved in the project made the same mistake--- neglecting the market. EVD's market share was just 0.5% during January-May, 2007. (Technology Daily, 2007)

### 3.4 Stage 4: 2001-2007

#### 3.4.1 ICT standard body

China's entry into the WTO in 2001 resulted in a drastic overhaul of its national standards structure (Zhao and Graham, 2006; Weeks and Chen, 2003). China reformed national standards system through the creation of a new national-level standards setting body. In April 2001, Administration for Quality Supervision Inspection & Quarantine (AQSIQ) was formed by merging the former State Administration for Entry-Exit Inspection and Quarantine (CIQ) and the State Quality and Technical Supervision Bureau (QTSB). The AQSIQ combined the standards and certification systems for foreign and domestic goods to ensure that China was meeting its WTO national treatment obligations (Weeks and Chen, 2003).

**Standardization Administration of China (SAC):** SAC was established by the State Council in April 2001. SAC was authorized to exercise administrative functions and carry out centralized administration for standardization. As of 2007, 294 national technical standards committee were administrated by SAC. SAC's main responsibilities include organizing, managing, and coordinating activities in ISO, IEC, and PASC; (2) undertaking the national committee secretaries of ISO and IEC; (3) organizing and managing the participation of departments, local organization, technological committee in the standardization activities at international and regional level; (4) drafting and implementing international standardization cooperation agreements, assessing and organizing the implementation of international cooperation programs, and auditing the standardization-related international activities ([www.sac.gov.cn](http://www.sac.gov.cn) ; Zhang, 2004). As of 2007, SAC and other related standard bodies represented China in 12 international organizations. 6683 ISO/IEC issued standards were transformed into Chinese national standards by 2004 (Zhang, 2004). As of 2003, SAC established cooperative relationships with 52 countries (Weeks and Chen 2003). SAC has sent experts to join 300-500 working groups in international standardization related organizations. SAC is also responsible for carrying out the notification and inquiry work of standards stipulated by the World Trade Organization's (WTO) Technical Barrier to Trade (TBT) Agreement.

**MII Special Standards Working Groups:** From 2001 to 2005, 29 special standards working groups were established by the MII. They include Working Group for Intelligent Grouping and Resource Sharing( IGRS), Working Group for Broad Band Wireless IP Standards , Working Group for Digital Audio Video Coding and Decoding Technology Standards, Working Group for Cable Digital TV STD Card Separated Interfaces Standards, Working Group for Tax Control Machine Standards, Working Group for Products Standards for Chip Module Special for 2nd Generation ID , etc. These working groups are responsible for a special area of technology standards development. ([www.mii.gov.cn](http://www.mii.gov.cn); ESI 2005)

**China National Certification and Accreditation Commission (CNCA):** It was established in august 2001. The responsibilities of CNAC include establishing, guiding, implementing, and supervising compulsory product certification system, publishing an official list of certified products and manufacturers; directing local AQSIQ branches to find violators of compulsory certification and dealing with compulsory certifications. The main divisions under CNAC are certification bodies, testing laboratories, inspection organizations, and certificate-mark issuing bodies. ([www.cnac.gov.cn](http://www.cnac.gov.cn) ; Weeks and Chen, 2003)

**WTO TBT Inquiry Center:** It was established in 1995 to comply with the WTO's TBT Agreement. The center serves responds TBT-related inquiries from WTO members, represents China when

submitting TBT-related inquiries to other WTO members and conducts research on international standards and technical regulations (<http://www.tbt-sps.gov.cn> ; Weeks and Chen, 2003).

### *3.4.2 ICT standard*

Turning to the main focus of our analysis, there are some highly visible examples of ICT standards in China developed in this phase:

#### **Time Division - Synchronous Code Division Multiple Access (TD-SCDMA)**

The TD-SCDMA standard was originally developed by Datang Telecom Technology Co. Ltd. Datang was a telecom infrastructure systems group separated from the China Academy of Telecommunications Technology. In 1999, Siemens joined with Datang for the further development of TD-SCDMA (Dano, 2005).

The government invested \$123 million in helping the R&D in TD-SCDMA (Dano, 2005). In May 2000, China submitted the TD-SCDMA proposal to IMT-2000 for consideration as a global 3G mobile communications standard. Later TD-SCDMA was accepted by both ITU in May 2000 and by the Third Generation Partnership Project (3GPP) in March 2001.

#### **WLAN Authentication and Privacy Infrastructure (WAPI)**

The purpose of developing WAPI was to overcome known security problems with the existing 802.11x “wi-fi” standard developed by the IEEE (Gao, 2005; Kennedy, 2006). In 2001, the Chinese government established broadband wireless IP standard workgroup for R&D on the national WAPI standard. In March 2003, WAPI was issued by Standard Administration of China. In the same year, SAC announced (Announcement No. 113) that from June 1<sup>st</sup>, 2004, foreign manufacturers would be required to embed a Chinese-designed data encryption technology known as WAPI on all WiFi equipment sold in the country.

The U.S. argued that WAPI was against WTO rules. The WAPI implementation was thus delayed. In 2005, WAPI was submitted to ISO/IEC, but failed to get approval. Events leading to the failure of WAPI are reported by Qiao (2006) and Suttmeier et al (2006). The U.S. high-technology companies, the Department of Commerce and the U.S. Trade Representative vigorously opposed WAPI. WAPI was defeated by 802.11 as an international standard in the balloting period of ISO/IEC.

In December 2005 Beijing announced that WAPI-compliant devices would be given preferential consideration in government procurement (MacDonald 2006). In March 2006, the WAPI industrial alliance of Chinese companies was formed to promote the standard. In October, 26 domestic companies were involved in WAPI platform tests and implementation.

#### **Internet Protocol TV (IPTV)**

In 2006, the ministry of Information Industry launched project for IPTV standard development. A total 60 to 70 IPTV related standards are expected to be developed. The IPTV market in China is thus sizeable and clearly gaining speed (Kshetri, 2008). Based on the statistics from two major service vendors, China Telecom had trial IPTV networks in 23 cities (SinoCast, 2006d) and China Netcom (CNC) had such networks in 21 cities (SinoCast November 23, 2006). By the end of 2006, 60% of China's major cities were IPTV-ready (Chan, 2006).

Chinese think that patent charges on IPTV standards--MPEG-4 and H.264-- are huge. China's push to develop its own standard is motivated to avoid paying license fees to MPEG LA and the ITU for using the H.264 standard (Sin, 2007). According to a vice director of SVA's central research academy, the patent cost for each AVS decoding system is US\$0.13 compared to H.264's cost of US\$2.50 (Shenshen, 2007).

China is determined to promote home grown encoding technology, AVB, and digital broadcast technology, DMB-T (Sin, 2007). The video aspect of the digital audio and video encoding and decoding technical standard (AVS), a homegrown standard for IPTV, won approval to become the

national standard in March 2006 (SinoCast, June 8, 2007). Note that China owns full intellectual property rights (IPR) in AVS, which is considered as part of ITU's global IPTV standard (SinoCast, March 19, 2007). China plans to make AVS-supported IPTV network available to 4 million users by 2009 (Asia Pulse, March 27, 2007; SinoCast, March 19, 2007). Some analysts argue that among China originated ICT standards, AVS is likely to be the standard most likely to achieve widespread adoption after the China's homegrown 3G cellular standard Time Division - Synchronous Code Division Multiple Access (TD-SCDMA) (Asakawa, 2007). IPTV related companies from mainland China have also teamed up with those from Chinese Taipei to further develop the AVS standard (China IT & Telecom Report, July 27, 2007).

## **4 DISCUSSION AND IMPLICATIONS**

This paper examined the Chinese standardization landscape following the 1978 economic and political reforms. We analyzed the clear contexts and attendant mechanisms associated with the development of various Chinese IT standards and their success. Our historical analysis of Chinese standardization activities paints a complicated picture.

An important point to bear in mind is China has a deep thirst for domestically developed ICT standards. In the Chinese policy landscape, there has been a strongly expressed desire for the representation of Chineseness in ICTs. A high level of advocacy for national self-reliance and domestic development of technology exists among Chinese policy makers, researchers, scientists and military leaders (Simon 2001). Foreign technology imports and the outflow of royalties have been a focus of concerns among Chinese policy makers (Einhorn, 2004). Chinese have paid considerably large amount of royalties in past ICT standards such as those related to mobile telecom and DVD (SinoCast China IT Watch, March 19, 2007). For instance, China is the world's largest maker of DVD players. Estimates suggest that by adopting its own technology, the country can save \$2 billion a year in royalties being paid to an 18-company consortium (Calbreath, 2004). There is also the matter of national pride in having domestically developed technological standards and setting standards for the world.

The above discussion indicated that factors critical to succeed in the development of standards were lacking in the early stages. The most glaring shortcoming included failure to understand customer needs and lack of project management and technical expertise. China's increasing integration in the global economy also helped the country to tap into that expertise needed for developing IT standard.

According to White (1992), overcoming above institutional inertia related to socialism became a major problem in the development of standards, especially in the early stages. Several disruptive events related to standardization initiatives in China are noted in Table 1. Hannigan (1995: 64) identified three types of disruptive events: milestones; catastrophes; and legal/administrative happenings. The events discussed in Table 1 can be categorized as milestones and legal/administrative happenings. It should, however, be noted that some of these are related to catastrophes. Some examples of catastrophes include the failure of the Chinese Character DOS (CCDOS) in the early 1980s and WAPI's defeat in the balloting period of ISO/IEC. These failures had significant long-term implications and subsequently contributed to the success of other IT standards.

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## Appendix

Time	Event
1978	Economic and political reforms started.
Mar. 1978	The National Science Conference set the outline of National Science and Technology Development, 1978-86 (Liu, 2006).
September	China was accepted by the International Organization for Standards (ISO) (Rongping and

1978	Zhuoliang, 2008).
1979	The Chinese Academy of Science led a project for UNIX/POSIX operating system development (Sun, 2001).
31 July 1979	The State Council promulgated “the Administration Statute for National Standardization” (Rongping and Zhuoliang, 2008).
1980	China joined the World Intellectual Property Organization.
1982	The Chinese Character DOS (CCDOS) was launched.
1982	The State Council promulgated “the Administration Statute for Adopting International Standards” (Rongping and Zhuoliang, 2008).
1982	China was elected as the member of the ISO Council (Rongping and Zhuoliang, 2008).
1982	First trademark law was enacted.
1984	The State Council promulgated “the Administration Statute for Adopting International Standards” (Rongping and Zhuoliang, 2008).
1986	The 863 Program aimed at the development and research of high technology was approved.
1986	The databases technology standards research project was included in the national “Seventh Five Year” plan.
1988	The "Torch Plan" was launched.
1989	China joined the Madrid Protocol and the Washington Convention.
Sept.1990	The first copyright law was enacted.
1991	Regulations protecting computer software were enacted.
1998	China started Linux development.
June 29, 1998	China sent TD-SCDMA proposal for the IMT-2000. The proposal was signed by the Minister and two Vice-Ministers of the MII.
August 1999	Red Flag Linux was established which is backed by the Chinese Academy of Science, and is headed by a son of then President Jiang Zemin.
May 2000	ITU accepted TD-SCDMA as one of the three 3G standards.
March 2001	TD-SCDMA was accepted by the 3GPP.
April 11, 2001	First test of TD-SCDMA was successfully conducted in Beijing.
Nov. 2001	China became a WTO member.
May, 2003	WAPI issued by Standard Administration of China.
Nov. 2003	China developed the world's first 3G handset based on TD-SCDMA.
Early-2000s	The MII organized domestic R&D institutions, telecom operators and manufacturers to join in the IPTV standardization research activity (Asia Pulse, March 27, 2007).
January 2004	EVD product was launched for the retail market.
Early 2004	Standard Administration of China announced that foreign manufacturers were required to embed a Chinese-designed data encryption technology known as WAPI on all WiFi equipment sold in the country (effective June 1, 2004).
January 2006	The MII formally endorsed TD-SCDMA as a Chinese national standard.
2006	The MII launched project for IPTV standard development.
January 2006	The MII approved AVS as China's national standard for digital video coding.

*Table 1: Major events related to standardization in China: 1978-present*

Standard	Developing time	Organizations involved	Level of success	Remarks
UNIX/POSIX	1979~1984	Chinese Academy of Sciences (17 organizations and over 200 researchers) <sup>i</sup>	CCDOS could not compete with <b>Microsoft DOS1.0</b> .	Failure to target market and customer demand; weak coordinating and management skills; lack of financial support.
Database	1985-1993	National OSI technology council	In 1989, the committee submitted the national standards—GB/T 12991 databases	The core technology relied on the international standards SQL. Lack of communication between developers and users.

			language SQL. <sup>ii</sup>	
Linux	1999~2005	Redflag, Bulepoint, Lenovo, TOM, National University of Defense Technology, etc	Redflag Linux adopted by government agencies. Other Linux products failed in the market.	70 domestic PC producer adopted Redflag Linux in 2001; By the end of 2001, 2801 packages of Redflag Linux were installed by Beijing Municipality
Enhanced Versatile Disk (EVD)	1999~2004	Led by State Economic and Trade Commission. EVD Alliance was established with over 20 domestic DVD producers <sup>iii</sup>	Market share: 0.5% in 2007). Not authorized by international audio and video association.	Inferior quality, limited video source, price is 2-3 times of DVD player <sup>iv</sup>
WAPI	2003~2006	WAPI issued by Standard Administration of China ( May, 2003) <sup>v</sup> .	Not authorized by ISO/IEC.	U.S. resisted WAPI arguing that it was against WTO rules. Large MNCs (e.g., Intel) didn't support; Complete WAPI issued in 2006 and 26 companies involved in WAPI platform tests and implementation. <sup>vi vii</sup>
TD-SCDMA	1998-2007	Originally developed by Datang.	Accepted as one of 3G standard by ITU (2000); Adopted by 3GPP; First TD-SCDMA 3G mobile phone developed in 2003 <sup>viii</sup>	3G license was postponed for several times.
IPTV	2005~2007	Shanghai Media Group (SMG) got first IPTV license and launched first IPTV service in Harbin <sup>ix</sup> . CCTV gains second IPTV license.	Total six IPTV license issued by 2007; China Telecom's IPTV network in 23 cities and China Netcom's in 21 cities. 60% of major cities were IPTV-ready No. of IPTV subscribers: 5 million.	There will be a total of 60-70 standards involved in IPTV standard system. Some problems: Lack of policy and regulation <ul style="list-style-type: none"> <li>• Digital TV market</li> <li>• AVS not yet a IPTV standard</li> <li>• International competition</li> </ul>

Table 2: The evolution of Chinese major ICT standards

<sup>i</sup> Y, Sun (2001) "The Twenty Years Lessons of the China's Operating System Development" internet source, available from URL: [http://www0.ccidnet.com/html/focus/analyze/2000/07/19/73\\_846.html](http://www0.ccidnet.com/html/focus/analyze/2000/07/19/73_846.html) [cited 08/26/2007]

<sup>ii</sup> Y, Ma(2005) "Standards—The pulse of IT" Information System Engineering, Aug, 2005

<sup>iii</sup> X, Feng (2004) "Investigation of Chinese DVD standards -- who will win: EVD, HDV, or HVD?" *IT TIMES*.

<sup>iv</sup> Technology Daily, "DVD standards competition—where does Chinese EVD go?" Internet source, available from URL: [http://168.160.11.102/gnwkjdt/200510/t20051003\\_15182.htm](http://168.160.11.102/gnwkjdt/200510/t20051003_15182.htm) [cited 08/26/2007]

<sup>v</sup> Standard Administration of China: <http://www.sac.gov.cn>

<sup>vi</sup> Internet Source, "The three phases of WAPI standard development" IXPUB technology online community, available at URL: <http://www.ixpub.net/thread-664187-1-1.html> [cited 08/26/2007]

<sup>vii</sup> Communication World, "The establishment of WAPI Industry Alliance triggered the standards competition" Available at URL: <http://tech.sina.com.cn/t/2006-03-08/1451861324.shtml>

<sup>viii</sup> Internet Source: <http://www.tdscdma-forum.org/nenglish/admin/download.asp?id=2702&obj=1> [cited 18 /08/2007]

<sup>ix</sup> Liu, J. 2006. Internet TV finds an audience in Shanghai, *Business Asia*, September 4, P. 12