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Prospect of mobile TV broadcasting in China: socio-technical analysis of CMMB's development

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Drawn from extensive document analysis and interviews with stakeholders, this socio-technical study examines the shaping powers of the subsystems (technology, policy/government, and market/industry) of China Multimedia Mobile Broadcasting (CMMB). After the Beijing Olympics, the first commercialized mobile TV expanded its infrastructure and business operations faster than other 3G and mobile TV broadcasting, covering 346 cities by November 2010. The findings show that CMMB, which is the leader in Chinese mobile TV development, is policy/government-driven and technologically ready. However, multiple technological standards and discrepancies between regulatory bodies slowed down its initial rollout. In the market/industry subsystem, content/services scarcity, undesirable pricing schemes, and low brand awareness are the inhibitors that curbed CMMB's diffusion. However, its strategic collaboration with China Mobile allowed it to quickly increase its user base and sale of CMMB-enabled handsets. Moreover, the socio-technical approach is a useful framework to investigate the forces that shape emerging technological trajectory holistically.

Keywords: mobile TV broadcasting; mobile TV technology; mobile TV policy; business model; socio-technical analysis

Mobile television has advanced tremendously in China since 2008, after the Beijing Olympics impelled the remarkable launch of China's selected mobile TV standard, CMMB (China Multimedia Mobile Broadcasting). CMMB intensified the competition between analog mobile TV, 3G TV operators, and mobile TV broadcasting services (MTVS) by providing a new platform for people in 37 cities to watch real-time videos on the go. With strong endorsement from the State Administration of Radio, Film, and Television (SARFT), CMMB, the homegrown industry standard, launched its MTVS, which attracted more than one million users, or 22% of China's total mobile TV users, in just a few months (In-Stat, 2008). It rapidly developed infrastructure, commercialized operations, and established alliances in the value chain. As of 19 November 2010, CMMB MTVS, which diffuses the fastest among all mobile TV standards, has been available in China's 346 cities (Sarft.net, 2010b). Furthermore, as of April 2010, CMMB's coverage has the capacity to serve 500–700 million users nationwide (CBC, 2010).

According to the Ministry of Industry and Information Technology in China (MIIT), China had 710.5 million mobile subscribers in August 2009 (Hua, 2009a). Furthermore, 40 million mobile phone users subscribed to 3G services at the end of

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2010—almost 5% of all mobile phone users (Shanghai.gov.cn, 2011). As of January 2011, more than 246 million units of mobile phones had been sold in China in the previous year, representing an annual growth of 57 percent (Shanghai.gov.cn, 2011), as a result of the increasing use of 3G services and smartphones in response to Chinese carriers' promotion. China's vast mobile subscriber base and rising GDP continue to fuel the expansion of the mobile industry. With these beneficial external factors, the fledgling mobile TV is growing steadily. The China Internet Network Information Center (CNNIC) reported the penetration rate of mobile TV to be 3.8%, signifying that it had reached the early adoption stage. As the Chinese government has set triple play and digital TV as its national developmental goals, mobile TV has a huge development space. Market analysts have predicted that China's mobile TV will maintain its growth at least until 2013 (CCID Consulting, 2008; RNCOS, 2011). Besides, CMMB's satisfactory performance in fast infrastructure and business deployment has led to optimistic forecasts that it will dominate the growing Chinese mobile TV market (In-Stat, 2008).

Although CMMB has outplayed the development of other mobile TV broadcasting standards, like TMMB (Terrestrial Mobile Multimedia Broadcasting), and the analog mobile TV market has reached its peak (In-Stat, 2008), its strong rival is, in fact, the MIIT-endorsed 3G TV standard, TD-SDCMA (Time Division-Synchronous Code Division Multiple Access). Regarded as the killer application of 3G or smartphone services, mobile TV business, owing to its convergent nature, triggered unprecedented conflicts and competition between SARFT (broadcasting and content regulator) and MIIT (telecommunication and Internet regulator). China's dual-policy system complicated the settlement of mobile TV standards and slowed down the rollout of CMMB. After MIIT, the supporter of the TD-SDCMA standard, granted temporary licenses to a few CMMB-enabled mobile devices during the 2008 Olympic Games, it initiated the quick diffusion of CMMB with great potential.

Currently, the SARFT and MIIT are still competing for the leading position to supervise the development of China's mobile TV industry. However, a breakthrough occurred in 2008, when China Mobile, the leading Chinese telecommunication company (telco) and the world's largest wireless operator, collaborated with the China Broadcasting Corporation (CBC), the SARFT-appointed national CMMB operator, to expand the mobile TV user base and accelerate its adoption rate. It was estimated to have more than 10 million CMMB users by the end of 2010, and it was expected to triple this number in 2011 (CMMB8.com, 2010). In China's emerging but competitive mobile TV industry, how are the social-technical subsystems (technology, policy/government, and market/industry) shaping the developmental trajectory of CMMB, the first commercialized MTVS in China? Adopting a socio-technical theoretical framework, this exploratory study, through document analysis and interviews with stakeholders and experts, aims to provide insight into this emerging mobile multimedia service in China. Due to the heterogeneous cultures and markets that exist throughout China's massive geographical landscape, this study not only examines the national development of CMMB but also selects Beijing, the capital city, as the case for investigation, to enhance the understanding of China's unique mobile environment.

Socio-technical analysis of emerging technologies

New media development can be characterized as a socio-technical phenomenon (Bijker, Hughes, & Pinch, 1990; Bijker & Law, 1992; Suchman, 1996). The socio-technical perspective is derived from the root of the social shaping of technology (SST), a major research body on explanations of technological development in society (Boczkowski, 1999; Mackenzie & Wajcman, 1999; Williams & Edge, 1996). SST emphasizes the significance of human choices and action in technological change. In the social construction of technology (SCOT), the development process of a technological artifact is described as an alternation of variation and selection (Bijker et al., 1990). Scientific controversies and interpretative flexibility result in a multi-directional technological trajectory. Bijker and colleagues (1990) argued that heterogeneous social groups play a critical role in defining and solving problems during the development of artifacts. Thus, the SCOT descriptive model presents technological development as a nondetermined, multidirectional flux that involves constant negotiation and renegotiation among and between the groups shaping the technology.

The development of technological artifacts is interwoven in a seamless web of technical, political, social, and economic forces. Following the line of the social constructivist account of technology, the socio-technical approach has been regarded as a good framework to investigate the technical and social processes of emerging technologies at macro levels, such as the prediction of emerging broadband technologies (Sawyer, Allen, & Lee, 2003). Han (2003) used the technology, policy, and culture model to analyze South Korea's adoption of broadband technologies and concluded that the ICT policy was the main driving force. To predict the future mobile environment, Bauer, Ha, and Saugstrup (2007) used a similar framework that viewed technology, industry, market, and policy as a co-evolving ensemble. Later, Shin (2006) applied the socio-technical system theory to investigate DMB's technical subsystem (infrastructure, equipment, and competing standards), social subsystem (market, customers, and industry), and the regulatory environment. He also analyzed the relations among the three entities in South Korea. His study attributed the adoption of DMB to a technology push to market and found business model discrepancies between broadcasters and telcos. Adopting Shin's model (2006), Lin and Liu (2011) examined the complex socio-technical relations between the co-evolving subsystems of industry/market, policy, technology, and culture of mobile TV broadcasting in Singapore and Taiwan. They found that industry pull was the driving force in the development of mobile TV broadcasting, while policy delayed this technology-ready mobile service. As some socio-technical studies have highlighted the significant cultural influence in shaping the development of emerging technologies (Han, 2003), Lin and Liu (2011) also found that the cultural factor exerted the underlying shaping power that deeply and subtly affected the social ensemble of mobile TV broadcasting in the two Chinese-dominant societies of Singapore and Taiwan.

Method

There are abundant market analyses and news reports regarding this fast growing CMMB technology. However, no prior scholarly research has applied any theoretical framework to analyze its development systematically. This study adopts Shin's (2006)

model to seek a solid understanding of how technology, industry/market, and policy/government have shaped the development of CMMB and further examines their interrelationships. Methodologically, this exploratory study employs document analysis to explicate the huge amount of second-hand data such as CMMB news reports, China's mobile TV market analyses, and policy news. In April 2010, semi-structured interviews were conducted with stakeholders, including an expert involved in CMMB technological development, a CBC marketing manager, a manager of Beijing's CMMB experience shop, and several citizens on the street to obtain various perspectives of CMMB's development.

This study investigated the current status of CMMB in China by analyzing its technological standardization, commercialized strategies, and policymaking from a socio-technical perspective, and tackled the interrelationships among three socio-technical entities. Due to China's expansive geography and resultant diverse markets, this study selected Beijing, the capital city in which the first CMMB trial was launched, to investigate CMMB's diffusion. In the next section, CMMB will be delineated and analyzed in each subsystem in the sequence of technology, government/policy, and market/industry from a socio-technical ensemble approach.

CMMB technology subsystem

While worldwide 3G TV and mobile videos began to slowly diffuse in early 2000, broadcasting mobile TV technologies emerged in 2005 and reached critical mass in South Korea, Japan, and Italy. From a socio-technical perspective, setting standards is a critical technological change mechanism (Sawyer et al., 2003). Moreover, establishing proprietary standards as global or industry mobile TV standards is lucrative (Curwen & Whalley, 2008). Although Europe's DVB-H (digital video broadcasting-handheld) standard has become prevalent in most countries, South Korea's DMB (digital multimedia broadcasting), Japan's ISDB (integrated services digital broadcasting), the United States' MediaFLO (Choi, Koh, & Lee, 2008), and China's CMMB also lead in some regions. The selection of important technological standards like DTV and HDTV usually arouse heated competition and debates nationally and globally, as it involves tremendous business interests, national pride, and cultural preferences. There is no exception in the mobile TV standard. Usually, when a single mobile TV standard is mandated, like DMB in Korea, the rollout is much faster than in other countries that hold a technologically neutral approach for multiple standards to compete under market forces. The multitude of mobile TV technologies is regarded as one of the inhibiting factors of its widespread adoption (Gill, 2008).

Infrastructure and equipment

China's triple play system has allowed telcos to provide audiovisual services via their mobile networks. Situated in a triple-network setting with three 3G standards, the emerging CMMB faces huge competition from different mobile video services enabled by various mobile technological standards. Created in 2002, SARFT-supported CMMB demonstrated a prototype in 2006 that was selected as the "Ten-One-Five" national prioritized technology and given a 0.4 billion RMB budget (Liu, 2008). Adopting the homegrown STiMi (Satellite-Terrestrial Interactive
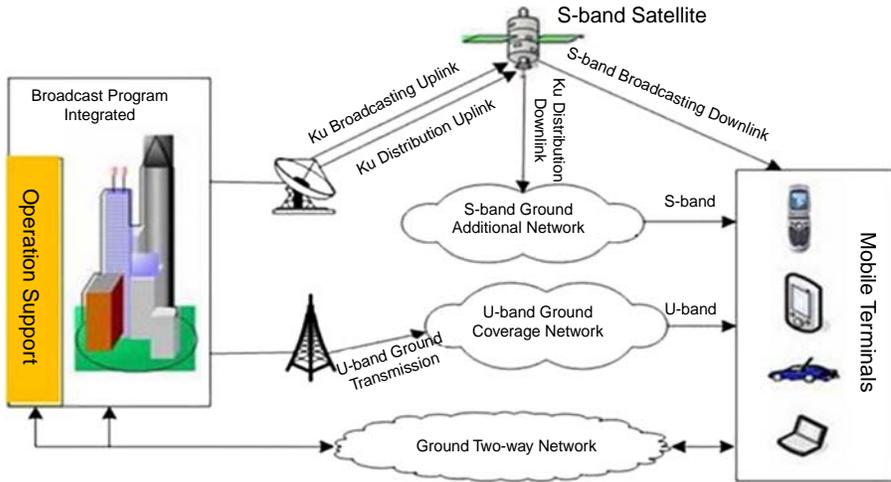
Figure 1. CMMB transmission network Source: Cctv.com News, 2008.

Multi-Service Infrastructure) technology, CMMB signals are transmitted through an S-band satellite and U-band terrestrial broadcasting networks and received by portable devices, such as mobile phones and PDAs (CCTV News.com, 2008).

Figure 1 shows CMMB's satellite-terrestrial unified infrastructure, which forms a combination of one-way broadcasting and two-way interactivity with central and local coverage. Compared with unicast cellular TV, this one-to-many CMMB MTVS is ideal for reaching a large audience in extensive geographic areas, like China, with relatively low operation costs. After CMMB's satisfactory trial during the Beijing Olympic Games, its commercialized MTVS was inaugurated in Shanghai in February 2009.

Competition standards

Mobile TV trials with various international and homegrown standards were held in different parts of China for several years. Since China Mobile and China Unicom launched mobile video services on 2.5G cellular networks in 2004, China's unicast cellular mobile TV has witnessed a slow but steady growth (Lin, 2009). In April 2008, China Mobile, which controls approximately 70% of the country's mobile subscriptions, launched 3G mobile TV trials with a mainland-developed TD-SCDMA standard that was strongly supported by MIIT (China IT & Telecom Report, 2008a).

On 17 January 2009, the long-awaited 3G licenses were issued to China's telecom carriers with different standards: China Mobile's homegrown TD-SCDMA, China Telecom's CDMA2000 (Code Division Multiple Access), and China Unicom's WCDMA (Wideband Code Division Multiple Access). China became the only country using a triple-network setting with three 3G technological standards worldwide (Li, 2009). China Mobile rapidly developed its 3G network available in 70% of China's cities by the end of 2009, while the other two were left behind. As of December 2010, there were 47 million 3G users in China and China Mobile occupied 44% of the 3G market, followed by China Telecom at 29.88% and China Unicom at

26.12% (International Business Times, 2010). According to Xia (2011), the existing penetration rate of 3G in China is far below the global average of 14%, and it may take time for it to exploit the market as a result of the lack of full-scale 3G commercialization, killer applications, and demand push. He further forecasted that the future migration toward 4G could enable this late-mover nation to leapfrog over its Western counterparts. Even so, China Mobile keeps expanding its current 3G coverage and heavily investing in 4G, partnering with mobile hardware developers, like Nokia Siemens, Huawei, and Samsung (Froggatt, 2010). The development of 3G, 4G, and beyond will provide a positive impetus toward the expansion of China's cellular mobile TV industry.

Another homegrown standard, TMMB (Terrestrial Mobile Multimedia Technology) is China's "recommended but not enforced national standard" for mobile TV broadcasting, announced by the Standardization Administration of China (SAC) on 21 June 2008 (Xinghuanet.com, 2009). With just a few manufacturers to develop TMMB-enabled mobile phones, TMMB run by NUFRONT encountered an embarrassing situation with little support from vendors in the value chain (Xinghuanet.com, 2009). Table 1 illustrates the comparisons of CMMB and its competitive technological standards.

Compared to 3G TV standards, CMMB technology provides superior mobile TV services with bandwidth, signal quality, and continuous streaming that outrival the competition (Z. Zao, personal communication, 3 April 2010). Besides, CBC made great effort to increase the affordability and variety of CMMB mobile phones. After collaborating with China Mobile, the sale of CMMB-enabled handsets, including both high-end and low-end models, increased to 845,000 by April 2010, and the total number of models that support CMMB reached 67 in 2010 (NAVIBIZ, 2010). 3G TV and TMMB mobile TV services are far behind CMMB's development.

CMMB policy/government subsystem

Policy changes in China

China does not have an integrated regulatory body to oversee the converging communication and information industry. Instead, its SARFT supervises the TV broadcasting industry, while the MIIT manages the telecommunication industry. Since 1999, SARFT has applied Article 75 to prevent malicious competition and to forbid crossover between broadcasting and telecommunications companies to run each other's businesses (Chang, 2005). However, the convergence brought by the Internet and mobile technologies challenged the appropriateness of Article 75, as the new media, like IPTV, has blurred the distinctive boundaries of the two industries. To secure power, in October 2004, SARFT announced the directive to regulate "Disseminating Audiovisual Programs on Internet Networks". Its second chapter specifies that SARFT is the regulatory body to issue permits for online audiovisual services or other similar networks, like mobile TV (Du & Hu, 2009). In 2007, MIIT's Infocomm Industry Integrated Planning Division also highlighted its key missions, including pushing mobile TV trials, R&D, commercialization, frequency allocation, and policy development (Liu, 2008). Both the broadcasting and telecommunication operators depend on different core factors to develop this profitable industry. That's why SARFT and MIIT both claim that they should be supervising mobile TV.

Table 1. Comparisons of CMMB and competitors.

	CMMB	TD- SCDMA	CDMA2000	WCDMA	TMMB
Mobile technology standard	mobile broadcasting	cellular	cellular	cellular	mobile broadcasting (national standard)
Operator	CBC	China Mobile	China Telecom	China Unicom	NUFRONT
Government support	SARFT	MIIT	MIIT	MIIT	MIIT SAC
R&D	homegrown	homegrown	international	international	homegrown
Status	available in 346 cities (early 2010)	available in 238 cities in (Dec. 2009)	available in 342 cities (Dec. 2009)	available in 284 cities (Dec. 20090)	not yet commercial-zed
No. of users (as of 2010)	>10 million	20.7 million	12 million	14 million	0

In 2008, the government passed "Document No. 1", a big policy breakthrough to allow cross ownership between telcos and broadcasters, in an effort to establish a triple play system to integrate the telecommunication infrastructure, digital broadcasting network, and next generation Internet. Shanghai Media Group (SMG) President Li Rui said, "Document No. 1 has accelerated the pace of triple-play convergence and re-organized the communication industry" (qtd. in Chang, 2008, p. 32). Document No. 1 has plans to finance new digital TV (DTV) services including mobile TV, such as by actively supporting state-owned telecommunications enterprises and the adoption of DTV-related businesses (Chang, 2008). By lifting the restrictions on convergence and providing financial support, Document No. 1 accelerates the integration of the broadcasting and telecommunications sectors.

According to Dr Zao (personal communication, 3 April 2010), who participated in the development of CMMB technology, the greatest concern of the Chinese government is whether the "pull" effect of any technology can create national economic prosperity. Since the government views mobile TV as a focal national business and holds high expectations for it, it offered a three-year subsidy to major industry players in CMMB's value chain, in order to lower users' adoption costs and upgrade the content/services, thereby maintaining and facilitating stakeholders' technological and commercial viability.

SARFT vs. MIIT: Mobile TV licensing and standard

Mobile TV is listed as China's focal technology agenda for developing triple play systems. Without a convergent regulatory body, debate is raised as to which body should be responsible for mobile TV regulation. According to the existing rules, the SARFT has full responsibility over all content-related issues including broadcasting channels and any program delivered to the audience; on the other hand, MIIT is responsible for overseeing other communications sectors, such as broadband Internet access and mobile and fixed-line operators (China IT & Telecom Report, 2008b). Essentially, mobile TV content is regulated by the SARFT, while its signal transmission is controlled by the MIIT. Thus, the SARFT is in charge of mobile TV licensing, mobile TV content copyright, and the broadcasting network, while MIIT manages the telecommunications industry with two-way interactivity and a mature business model.

The competition in mobile TV standards reveals a year-long conflict of interest between China's broadcasting and telecommunications industries that has yet to be resolved. In 2006, the SARFT announced CMMB as China's national standard for mobile TV, even though it did not pass the formal procedure. When the SAC announced MIIT-supported TMMB as China's "recommended national standard" for mobile TV broadcasting in June 2008, the SARFT's Science and Technology Bureau Chief, Wang Xiaojie, immediately publicly criticized this evaluation and selection process for not being rigorous or legal, and thus, the SARFT refused to accept TMMB as the national standard (Li, 2008). Thus far, TMMB, which only conducted small-scale trials, remains behind CMMB in terms of infrastructure construction, promotion, and commercialization.

Licensing is a fundamental regulatory issue for mobile TV development that involves controversial selection and spectrum allocation (Curwen & Whalley, 2008). China's mobile TV operators must establish an infrastructure to obtain a transmission

permit and a mobile TV operational license from the SARFT. In 2005, the SARFT issued six analog mobile broadcasting TV licenses to SMG, China Central Television (CCTV), Southern Media Corp (SMC), China National Radio (CNR), China Radio International (CRI), and Beijing TV Station (BTV). These companies collaborated with mobile operators to transmit a commercialized mobile TV business (m-Govworld, 2010). Nevertheless, the rollout of analog mobile TV in China has been sluggish. In January 2011, China's first 3G TV license was granted to Shanghai Broadcast TV, which has experiences in creating and aggregating mobile content and services. It enables users to watch live broadcasting and popular films, as well as surf information via mobile broadband (Sarft.Net, 2011).

Copyright issues

Another important legal problem in developing mobile TV in China lies in protecting the copyright of mobile content (China IT & Telecom Report, 2008a). Digital rights management (DRM) is crucial for content providers to control authorized content distribution across platforms (Eckhardt, Lundbog, & Schlipp, 2007). So far, China's mobile TV services have not implemented a DRM solution. CMMB encrypted content only includes national and regional broadcasting TV programming and some made-for-mobile content/services. Without copyright protection, international media companies hesitate to provide content to China's mobile TV operators. Hence, it is crucial to integrate DRM into handsets so as to protect international, national, and local mobile video content and applications.

CMMB market/industry subsystem

China's mobile TV market dynamics

Since December 2004, the SARFT-led analog mobile TV trials and operations have been launched in different provinces (Du & Hu, 2009). In 2005, after obtaining China's first national license issued by the SARFT, SMG offered "Dreamo" mobile TV service with China Mobile. Subsequently, the other five analog mobile TV licensees launched MTVS. These services, led by regional broadcasters, diffused slowly over the past five years and never took off nationwide. As CMMB's regional operators, their cumulative mobile experiences in content/service development and customer relationships have contributed to their commercial operation of CMMB. The SARFT's strategy for facilitating CMMB is to lure local broadcasters as affiliates and link their local networks into a national web, in exchange for shared resources and profits; in so doing, it can control China's TV programming so as to isolate TMMB's content supply (Du & Hu, 2009). This is effectively propelling CMMB's diffusion and suppressing TMMB's growth.

At the end of 2009, China boasted more than 800 million mobile phone users, out of which 40 million subscribed to 3G services (Shanghai.gov.cn, 2011). With the largest mobile subscriber base and CBC's collaboration, China Mobile is likely to dominate the 3G TV market, even though China Unicom and China Telecom are accelerating the development of their mobile TV businesses (Hua, 2009b). By May 2009, China Mobile had 830,000 TD-SCDMA subscribers and also transmitted analog MTVS for local broadcasters via its TD-SCDMA network. For instance, it

struck a deal with Shenzhen Media Group to deliver mobile news and other value-added services. In March 2010, it also partnered with CBC to not only develop TD-CMMB integrated handsets, but also to dispatch CMMB content (four national channels and two local channels) to its own subscribers in 27 provinces (Dataxis News, 2010). Liu (2008) suggested the adoption of a consortium model in China, as it could combine broadcasters' networks and diverse content with mobile operators' customer experiences and interactivity. This model would likely increase MTVS' strategic competitiveness and obtain support from both regulatory bodies. Hence, the collaboration between CBC and China Mobile to diffuse CMMB, indeed, creates a new promising, win-win consortium model.

Currently, the three 3G TV operators are seeking opportunities to develop content with news media like CCTV and transforming existing audiovisual content into streaming or downloadable formats to enrich their content. In November 2009, China Mobile announced a partnership with CCTV to launch a mobile news summary service. Due to its lack of mobile experience, China Telecom partnered with Youku.com and launched its first mobile TV channel in May 2009. Four months later, it collaborated with the Xinhua News Agency to launch a mobile TV channel to broadcast Xinhua's political, financial, entertainment, and sports news around the clock. In comparison, China Unicom only allowed users to download videos and access video on demand (VOD) programs. In addition to the enhancement of content lineup, a decrease in mobile data fees may stimulate the rollout of 3G TV. However, before it can reach critical mass, there remain pressing problems that must be resolved, including technical difficulties in network capacity and data speed, as well as high subscription fees.

According to Z. Zao (personal communication, 3 April 2010), the competition between CMMB and 3G TV is not as strong as expected at this initial stage, as they concentrate on different core businesses; that is, the former focuses on broadcasting audiovisual content and the latter emphasizes voice, SMS, and MMS. Thus far, CMMB MTVS has rolled out more rapidly and optimistically than 3G TV in China.

CMMB's commercialized deployment

The SARFT appointed CBC as its national operator of CMMB. In September 2008, it officially took charge of CMMB's infrastructure construction and commercialization. CBC is the mother corporation that leads provincial and municipal companies in deploying commercialized CMMB services. Its operational principle is to "separate the central and the subsidiaries" (总子分离). According to J. Zhang, CBC's marketing manager (personal communication, 13 April 2010), "'Unify construction, Unify operation,' means that the local affiliates still have their autonomy; for marketing and promoting, CBC has control over the provincial companies and the provincial companies oversee the municipal levels". He mentioned the two-level central and provincial sale supporting system. The CBC headquarters are just responsible for making unified plans and policies as well as supervising the overall CMMB commercialized performance at the national level. In a country with such an expansive geography, such a strategy of "separating the central and the subsidiaries" is appropriate for managing the more than 300 CMMB MTVS operators in China.

CBC used the excellent timing of the Beijing Olympic Games to unveil the free CMMB services. As part of CMMB's trials, free terrestrial and satellite CMMB

MTVS were made available in 37 cities during the Olympic Games, where users could watch live broadcasts (i.e. CCTV's Olympics Channel, CCTV's News Channel, and BTV1's channels), enjoy VODs and downloaded videos, search for information, and participate in interactive content/services (Cai, 2008). After the large-scaled infrastructure setup in 2009, CBC believed that CMMB would take off quickly and attract 10 million users in 2010. As of last November, 346 cities in China are covered by CMMB signals and services. Currently, CMMB users can use mobile phones, GPS, or MP4 portable devices to watch TV channels (CCTV-1, CCTV-5, CCTV-6, CCTV-news, provincial channels, and city channels), listen to the radio, receive stock and traffic information, and read newspapers and magazines (Sarft.net, 2010a). Today, CMMB is the largest mobile multimedia and broadcasting TV network in the world.

In July 2008, CBC signed a three-year exclusive agreement with China Mobile to make CMMB-enabled handsets, which signified the first cooperation between the broadcasters and the telcos. Up to October 2009, there were 3.12 million users of TD-SCDMA mobile phones (CBC, 2010) who could use their mobile phones to view CMMB content in more than 303 cities in China. In March 2010, TD + CMMB handsets obtained the MIIT license to connect to the Internet (CBC, 2010). Meanwhile, CBC and China Mobile expanded their collaboration and officially launched a joint commercialized CMMB MTVS (CBC, 2010). CBC's public relations department indicated, "The strength of CBC is broadcasting, while China Mobile is good at interactivity. Their collaboration is complementary" (J. Zhang, personal communication, 13 April, 2010). The win-win collaboration accelerated the diffusion of CMMB MTVS (CBC, 2010). After 2012, CBC is likely to use the same collaborative model to integrate CMMB technology with the handsets of China Telecom and China Unicom.

CMMB business model

Among the two dominant mobile TV business models worldwide, broadcasters and satellite operators favor the advertising-supported free-to-air (FTA) model that has proved successful in several Asian countries, such as South Korea and Japan, while most mobile operators prefer the subscription model for its ability to quickly generate revenue (Gill, 2008; Oh & Jablon, 2008). Since 2008, CMMB has utilized an FTA business model to appeal to the mass market by providing free terrestrial TV channels and some made-for-mobile content/services (e.g. stock exchange, traffic, weather information). Many experts suggested the adoption of the FTA advertising model to kick-start the nascent CMMB MTVS. Later, CBC introduced a subscription model to generate revenue to improve CMMB's content quality and customer service (J. Zhang, personal communication, 13 April 2010). However, the rollout slowed down due to this switch to the paid model, coupled with insufficient made-for-mobile TV content (Z. Zao, personal communication, 3 April 2010).

In fact, it is difficult to ask the price-conscious Chinese audience to pay for any emerging technology in a media-saturated, competitive market, especially when the new one focuses more on hardware (infrastructure building) than software (improvement of mobile TV content/services) (Sohu.com IT, 2009). As pricing is a key factor that affects the adoption of mobile TV in China, it is crucial to set affordable pricing schemes and offer some free content as incentives to attract critical

mass. In March 2009, SMG was the first to charge CMMB MTVS at 20 RMB (US$3) monthly, and this was perceived as overpriced and, thus, caused sluggish market responses and postponed this implementation. On 26 November 2009, CBC announced the fixed price for the combination of paid "Chingtasi" content with a few free channels. Finally, CBC set up a national structure to standardize CMMB's pricing and programming strategies and synchronize the management at the national, provincial, and local levels. To solve pricing discrepancies, CMMB's standardized monthly subscription fee nationwide was set at 12 RMB (US$1.8) from July 2010 onwards (Sohu.com IT, 2009).

The content of mobile TV directly affects whether users will be interested in adopting mobile TV (Gill, 2008). Informa Telecoms & Media estimated that China's mobile video and TV in 2010 accounted for US$47.8 million, or less than 1% of all mobile content revenues, but forecasted its soaring future (Froggatt, 2010) due to the increasing investment from the industry and the burgeoning user demand. International MTVS market trials indicated that 40 to 70% of users would like to subscribe to 8 to 15 channels, representing a mixture of FTA programming and made-for-mobile content (MDA, 2007). The 2009 CNNIC report showed that early adopters of Chinese mobile TV were most interested in news and sports (34%), followed by entertainment (27.7%). Previously, analog mobile TV's sports broadcasting had attracted a large viewership, while made-for-TV dramas had only received good word-of-month without a substantive increase in revenue. Key sports events, like the Olympics, the World Cup, and the NBA, stimulated CMMB's viewership. Another study on China's mobile TV content (Zhou, 2006) revealed that most potential users (ages 15 to 35) preferred to watch short mobile video clips and complete stories in fewer than five episodes. Furthermore, more than 89% of respondents stressed the significance of having original mobile TV content, instead of retransmitted terrestrial TV programs (Zhou, 2006).

Content development became CMMB's key agenda in 2009. Initially, CBC focused more on building networks and enhancing customer service than producing original mobile TV content (J. Zhang, personal communication, 13 April 2010). On 28 January 2010, CBC launched its mobile TV content called "Jingcai China" (睛彩中國) in Beijing. The lineup included made-for-mobile content such as Jingcai Finance (stock market), Jingcai Film, and Jingcai Navigation (traffic), as well as live CCTV broadcasting and provincial and municipal programming (CBC, 2010). Made by CCTV-6, Chingtasi Film is CMMB's first self-developed channel. Realizing that mobile TV content is king, CBC is continually investing in improving content, such as news-embedded videos, and the user interface. Insufficient content forced mobile TV operators, including CMMB, to depend heavily on broadcasters' programming. Except free CCTV News for the purpose of spreading propaganda, the rest of CMMB's content is encrypted (J. Zhang, personal communication, 13 April 2010). Yang T.B. (2008) proposed the use of CMMB MTVS to watch linear broadcasting TV programs complemented by 3G TV's customized and interactive services. In addition, emergence broadcasting, like sounding the earthquake alarm, will be CMMB's critical public service that will contribute to public security and safety. It is expected that more made-for-mobile audiovisual content and innovative information services will be created in the future to appeal to a larger number of CMMB users.

Few studies have been conducted thus far to investigate CMMB users. Nevertheless, it is crucial to understand user characteristics and the behaviors of

the emerging mobile TV medium. According to a study conducted by CMMB's Media Data Research Center (CBC, 2010), 70% of CMMB users are male and 65% are young and well-educated with a relatively high income, and these user characteristics fit Rogers' (2003) innovation diffusion theory. This study also indicated that 55% of users watch CMMB at home, 17% at work, and some on the go (CBC, 2010). Moreover, the 2009 CNNIC Report indicated that more than half of users watched MTVS for less than 15 minutes a day.

As the mobile attention span is short, mobile TV, an attention-expensive medium, should create content and services with shorter, quicker engagement and interaction. In different countries, MTVS viewing times vary, for example, from 15 minutes in the US to 50 minutes for commercial services in South Korea (MDA, 2007). In January 2010, CMMB's daily viewing pattern investigation of China's eight main cities revealed that the first viewing peak is between 7.00am and 7.30am (commuting); the second is between 11.30am and 3.00pm; and the third is between 6.30pm and 11.00pm (CBC, 2010). On weekends, it was found that the respondents watch less CMMB during the day and more at night.

Knowing CMMB users is crucial for building an appropriate business model, setting reasonable price schemes, and creating compelling content/services. Users in key cities are particularly important, as they set the examples that will influence the rest of China. As a result of China's diverse markets, this study uses Beijing's CMMB for investigation.

CMMB diffusion in Beijing

CMMB caught the world's attention with its debut during the Beijing Olympics Games in 2008 and later deployed its infrastructure and commercialization at a remarkable speed over the next three years. This metropolitan city is recognized as the political, cultural, and education hub of China, while Shanghai and Hong Kong dominate in economic fields. In 2009, Beijing's GDP per capita amounted to 68,788 RMB (US$10,357), with a population of 17.55 million permanent residents (People's Daily Online, 2010). Based on the standards of the World Bank, it has become a moderately well-off city, which is likely to have enough early adopters for CMMB's successful takeoff. Due to the advanced technological R&D, sophisticated media, and abundant resources, the development of CMMB MTVS in Beijing could foretell its commercial viability in China.

Endorsed by the SARFT, CBC's headquarters has been based in Beijing since mid-2005. In June 2008, the flagship CMMB Mobile TV Experience Center was established in "China's Silicon Valley", Zhongguancun, a technology hub in Haidian District, Beijing. In March 2010, CBC and China Mobile selected this city to hold the symbolic ceremony marking their official commercial launch of CMMB MTVS. Thus, Beijing is clearly significant to the diffusion of CMMB MTVS.

The strengths of Beijing's broadcaster-led CMMB model lie in content creation and supply, as well as broadcasting networks. CCTV, BMG, and digital media companies continue to develop innovative and interactive content and information services. BMG also worked closely with the CBC to develop CMMB infrastructure and commercialized plans in Beijing. The Beijing model takes a traditional TV managerial approach that relies on advertising revenue and separates the operation of content production, signal transmission, and customer management; however, the

operators tend to lack experience in handling direct relationships with customers, billing, and services (Du & Hu, 2009). To overcome these obstacles, the collaboration with China Mobile will enable the companies to complement each other's strengths, expand their user base, and increase the usage of CMMB-enabled handsets.

Beijing's CMMB mobile TV commercialization evolved in three stages. Until April 2010, 95% of the Six Ring vicinity was covered by CMMB's signals (Sina.com, 2010). From the trials to the early broadcasting of CMMB, users could enjoy free MTVS. After November 2009, users were charged 12 RMB (US$1.8) monthly, and Beijing CMMB users could watch CCTV1, CCTV-3, CCTV-5, CCTV-9, CCTV News, kids channel, BTV's 7 channels, Jingcai Film and Jingcai Beijing channels, and listen to two digital radio broadcasting channels (CMMB.com.cn, 2009). Additional digital services, "Jingcai Finance" and "Jingcai Navigation", were made available in May 2010 (Q. An, personal communication, 18 April 2010). Learning from the lesson of Shanghai, when its first overpriced CMMB MTVS inhibited the rollout, Beijing CBC has been careful to charge its services at affordable prices: a one-year card costs 126 RMB (US$19) and a three-year card is 240 RMB (US$36). Beijing CBC also bundles handsets with various content/service packages with discounts in order to boost subscriptions. CMMB users can pay their bills conveniently, either at CBC's shops or at post offices (Q. An, personal communication, 18 April 2010). Beijing's CMMB mobile TV subscribers are also promised that they will receive across-region CMMB services via roaming when they travel throughout China. Moreover, CBC has made constant efforts to collaborate with China Mobile and other device manufacturers to develop more CMMB-enabled handsets for users' diverse tastes and needs.

Beijing CMMB's vice president Li optimistically estimated 0.6 million CMMB users in this city by the end of 2010 (Sina.com, 2010). The expected user size (only 29% of the permanent population) is still less than critical mass. The observations, as of April 2010, still showed that just a few people were using CMMB MTVS on Beijing's streets, in shopping malls, or on public transit. At the CMMB Mobile TV Experience Center, there were limited CMMB-enabled devices and not many consumers presented queries about CMMB. According to the manager of the CMMB Experience Shop, the sale of CMMB MTVS increased slowly in 2010, and its buyers were either middle aged or college students who were purchasing the service for personal entertainment or as a gift (Q. An, personal communication, 18 April 12010). Based on his experiences, consumers lacked knowledge about CMMB MTVS, as even those who had heard about CMMB and showed interest could not differentiate it from other similar services. Furthermore, he recalled that many had complained about insufficient made-for-mobile TV content and poor reception beyond the areas of the Fifth Ring (15–20 kilometers from Tiananmen Square, the center of Beijing) (Q. An, personal communication, 18 April 2010).

Street interviews with mobile customers and taxi drivers attributed the small number of Beijing users to pricy CMMB-enabled handsets and services. Therefore, these interviews revealed that Beijing's CMMB MTVS diffusion is at the chasm of early adoption and early majority (Rogers, 2003, p. 281), which requires better-quality content, more attractive packages, and stronger marketing to make a breakthrough. Despite unenthusiastic user responses, all interviewees believed that it was just a matter of time before CMMB MTVS would fully take off in Beijing and China (J. Zhang, personal communication, 13 April 2010; Q. An, personal

communication, 18 April 2010; Z. Zao, personal communication, 3 April 2010). Their faith was derived from the SARFT's support, CBC's painstaking, superior technology, and the well-developed CMMB value chain.

Beijing's media landscape is crowded with broadcasters, cable networks, various mobile video services, and other substitutes. It is full of social, cultural, and economic, and regulatory struggles, making it a challenge for any emerging media, like CMMB MTVS, to earn a position in the competitive market and in the audience's heart. CMMB MTVS must demonstrate its uniqueness to stand out among existing media and new competitors, as well as to show its capabilities to serve unexploited needs, such as watching live sports broadcasts on the go. Additionally, CMMB should make good use of its mobile, interactive, and broadcasting characteristics so as to create a conspicuous identity and serve the unfulfilled or underserved needs. Brand promotion, diverse content creation, and improved reception quality are the urgent issues for diffusing CMMB MTVS to the majority. According to CBC's vice president, the core mission in 2011 was to harness various marketing channels and tools to expand the CMMB user base and increase its brand awareness (C114News, 2011). Experts have suggested that CBC position itself clearly and strategize integrated marketing campaigns in order to propel its early adoption by the majority (Z. Zao, personal communication, 3 April 2010).

Discussion and conclusion

The 2008 Beijing Olympics was a turning point for the development of China's mobile TV industry. In less than three years, the commercialized CMMB MTVS has grown rapidly and become the largest mobile broadcasting TV network available in China's 346 cities, with more than 10 million users. Due to the support from the SARFT and Chinese broadcasters, its satisfactory performance in the early adoption stage has far outpaced that of 3G TV or other mobile TV operators. Furthermore, the strategic collaboration with China Mobile has contributed to the production of a variety of CMMB-enabled handsets and expanded the user base. This study, drawn from extensive industry research and interviews with CMMB stakeholders, provided the background of the development of CMMB, including regulatory influences, technological innovation, standard competition, CMMB operator's strategies, and user demands.

China has a unique government intervention economy that has equally powerful broadcasting and telecommunications regulatory bodies and industries. With a national agenda to foster mobile TV growth, the policy remains vague despite technology neutral and pro-innovative consensus. The struggles in setting national mobile TV standards reveal the turf war between the regulators of broadcasting (SARFT) and telecommunications (MIIT). The interviews and document analyses found that the competing regulators both consider mobile TV services to be part of their domain and facilitate their industrial players' mobile TV services. The SARFT, which controls content and broadcasters, introduced the proprietary technology standard to extend its influence across the mobile platform, while MIIT, which governs telecommunications, intends to lead this new mobile service and expand to audiovisual business. The SARFT controls mobile TV licensing and content, but MIIT oversees the infrastructure and the Internet. Hence, in the policy/government subsystem, the Chinese government is the driving force behind the growth of mobile

TV; however, the political interests of the two governing authorities restrain each other and affect licensing, national standard setting, and even content supply in the two camps, which unfortunately slowed down the rollout initially.

China's multiple mobile TV technologies are supported by various industrial stakeholders, R&D institutes, and government agents, and as a result, the competition among technological standards has slowed down the adoption of China's mobile TV. As of now, the myriad potential users still cannot differentiate between CMMB MTVS and other 3G video services. The multitude of mobile TV technologies is, therefore, considered a dragging force for the massive diffusion of CMMB MTVS. Based on the analyses, the Chinese government is likely to adopt a flexible approach to allow multiple standards or a non-mandatory standard, even though the authorities tend to support their homegrown technologies. However, to propel the development of this prioritized CMMB MTVS, the Chinese government should facilitate the industry players' resolution of the discrepancies among concerned parties and clarify the public's confusion.

While Shin (2006) regarded DMB as a socio-technical artifact in Korea, the socio-technical analysis here reveals that CMMB's quick diffusion is highly policy/-government-driven and that CMMB in China is much more of a political-technical artifact; it is an emerging media technology that is heavily shaped by the control powers between the SARFT and MIIT. CMMB is a significant part of the SARFT's convergence model for developing a triple play. Although CMMB has not been recognized as the national mobile TV standard, and some models of CMMB-enabled handsets may not be equipped for Internet connectivity, the new pro-convergence and pro-innovative policy, Document No. 1, is advantageous, as it can propel the large-scale deployment of digital TV business and infrastructure, including mobile TV and CMMB. In China, government/policy is a significant enabling factor that makes any technological development possible and opens its diffusion threshold (Rogers, 2003). Even though CMMB is influenced more by policy/government in China's context, it is also significantly affected by the forces of technology (standards, infrastructure) and market/industry (business models, alliances, users).

As for the market/industry subsystems, the recent turf war between SARFT and MIIT subsided after CBC and China Mobile forged their alliance in March 2010. The win-win collaboration between these two bodies has strengthened their strategic competitiveness and increased the mobile TV subscription base dramatically. CBC views the commercialized operation of CMMB MTVS as a promising new business, even if there is no precedent and there have been many cases of failure overseas (J. Zhang, personal communication, 13 April 2010). The SARFT's Science and Technology Bureau Chief, Wang, attributed the quick rollout of CMMB to a pro-innovative policy, successful domestic R&D for mobile TV technologies, and enthusiastic industry players (M. P. Yang, 2008). China's biggest advantage in developing mobile TV is its large mobile subscriber base. Its rising GDP may drive entertainment and cultural consumption and further push forward the upgrading of mobile TV.

However, to attract critical mass, it is necessary for CBC to standardize the chaotic CMMB pricing schemes in different regions and offer attractive content/services at reasonable prices. Currently, the monthly fee charged to CMMB users who view the primary national and regional FTA channels with limited original programs and interactive services is higher than what cable TV subscribers pay for 50–60 channels. This explains why many Chinese people are not willing to

switch over or add CMMB MTVS as an additional media expense. To improve this, CBC may consider lowering the price and offering diverse payment schemes (e.g. free channels, paid premium content, pay per view, and valued added personal interactive services) and bundled packages. This may entice users who have experienced the convenience of watching free mobile TV content to pay for differentiated packages with reasonable pricing. Based on the findings of this study, the other key missions to further diffuse CMMB beyond the early adoption stage include increasing the public's awareness and their brand preference of CMMB MTVS, improving premium content and pricing schemes, maintaining beneficial relationships with alliances in the value chain, and ameliorating collaborations with its rival partners (e.g. China Mobile). Moreover, if CMMB MTV, for example, was positioned as a fashionable icon or a symbol of higher socioeconomic status, like the iPhone and iPad, its cool brand image would likely stimulate users' purchasing desires and foster its growth.

Figure 2 summarizes the socio-technical analysis of the complex interrelationships among the three subsystems. In general, China has a benign environment for developing CMMB MTVS. Unlike mobile broadcasting TV in other Chinese-dominant economies that are driven heavily by the industrial push (Lin & Liu, 2011), the development of CMMB, a socio-political artifact, is clearly a policy/government push. In terms of the interrelations between government/policy and technology subsystems, the government is pushing the converging triple play system to support different R&D projects to develop technologies and services in this emerging industry. The interaction between the technology and industry/market subsystems shows that the industrial players and technological R&D teams chose to work with the MIIT-led or SARFT-led allied forces to develop multiple technological standards. The competition and multitude of standards slowed down the diffusion of mobile broadcasting TV in its nascent stage. The policy/government and market/industry subsystems reveal even more interwoven inter-relationships. The government strongly propelled the development of China's mobile TV by subsidizing the
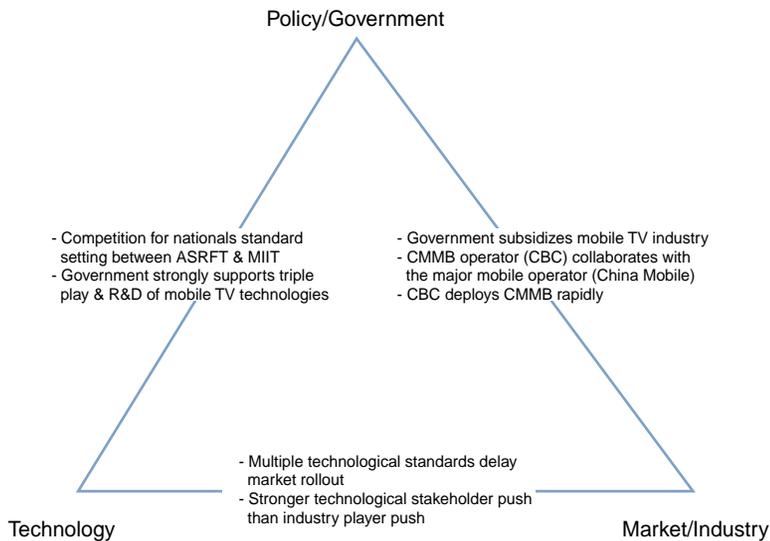

Figure 2. Interrelationships of socio-technical subsystems of CMMB MTVS.

industry. With the SARFT's full support, CBC gained the competitive advantage to ally with broadcasters and other vendors to form a strong value chain. Moreover, the collaboration between CBC and China Mobile signifies the initial transformation to a collaborative model in China's mobile TV industry.

Although China has demonstrated its capability to develop mobile TV broadcasting and 3G technologies, the multitude in standards and services has, in fact, diluted the investment, increased the risk, and confused the customers. High costs and insufficient content are found to be the inhibitors that have delayed users' adoption of CMMB. The findings also show that CMMB MTVS still requires time and effort to promote itself to China's general public in order to reach critical mass. CMMB MTVS in Beijing exemplifies this struggle. Overall, due to strong government support, ready business and infrastructure deployment, and a gigantic mobile subscriber base, the largest mobile TV broadcasting network, CMMB MTVS, is expected to not only lead the development of China's mobile TV but also become the fastest growing mobile TV service in the world.

This study finds that socio-technical analysis is particularly suitable to analyze the development of "emerging" technology in a social system at a macro level, because its technological trajectory shaping by various social actors in the key subsystems (government/policy, industry/market/economic, and technology) is multi-directional and multi-faceted. Following the social constructivism tradition, socio-technical analysis holds an unbiased, undetermined lens to investigate the evolutionary path of a nascent technology. This framework has the holistic explanatory and analytic power to study technological change in any society, including China. Even though CMMB is found to be a political-technical artifact, as it has evolved in a state of strong economic interventionism, CMMB's market/industry subsystem, in fact, gained increasing momentum after the early adoption stage. It is crucial not to downplay any shaping power that initially seems less significant. Hence, the open-structured, socio-technical framework is adequate to study technological development in any social, cultural, political, or economic system.

To conclude, this study provides insight into China's mobile TV experiences to offer important lessons for other countries who are trying to introduce similar mobile technology in a competitive market with regulatory controversies and ambiguous audience demands. Furthermore, its socio-technical analysis offers theoretical in-depth examinations for the forecasting the technological trajectory of this emerging mobile technology. The limitation of this qualitative study lies in the lack of interviews with policymakers in the SARFT and MIIT. Thus, the policy analysis in this study relies purely on secondhand data. In light of the geographically extensive Chinese market, future studies will require investigations of CMMB's development in other regions.

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