Understanding the Development and Diffusion of Mobile Commerce Technologies in China: A Biographical Study with an Actor-Network Theory Perspective

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ABSTRACT: Mobile commerce technologies cater to multiple types of users who use them for various purposes in a dynamic fashion over time. Their development and diffusion therefore involves many actors who participate in changing market configurations. In this study we address this complex sociotechnical setting by investigating the "biography" of mobile text messaging, an instance of mobile commerce technologies, in China. Specifically, we apply an actor-network perspective to understand the development and diffusion of text messaging over time and the changing actor configurations. This analysis was based on 1,403 news items pertaining to the Chinese telecommunications market, which were screened from over 40,000 news items produced over sixteen years. The deduced pattern indicates that the diffusion of text messaging, and possibly other mobile commerce technologies, includes four actor network configurations. Mobile commerce platforms begin to operate within a small network of actors, and via a dynamic process of events and interactions, they end up with a complex network of actors, which can include content and service providers, customers, regulators, and businesses that drive mobile commerce technology diffusion and breadth of uses across markets. The suggested pattern provides a "biography of artifacts" regarding mobile technologies at the national level.

KEY WORDS AND PHRASES: Actor-network theory, mobile commerce platforms, mobile services development and diffusion processes, short messaging services.

Many new mobile commerce technologies or platforms, especially ubiquitous ones, can serve multiple purposes in varying contexts [21, 23]. These multipurpose devices, applications and features present users with many ways, some unanticipated, in which the technology can be used [33]. For example, mobile data services, mobile microblogging platforms, and short messaging services (SMS) can serve business purposes as well as hedonic, social, and personal purposes, providing users, such as individuals, organizations, and governments, with a broad and constantly evolving range of features and uses. They can therefore be used differently and for different purposes by diverse types of users. We call such platforms, which are at the heart of mobile commerce, multipurpose information and communication services (MICS) to describe the broad nature of users and uses of these technologies.

It is important to study the development and diffusion of such artifacts because these underlie the benefits of using these technologies. Among the many studies that have accordingly focused on this topic, the majority rely on diffusion metamodels, such as the diffusion of innovations theory [35]. Such models recognize the dynamic nature of diffusion. Nevertheless, the

application of these models has taken mainly a narrow view; studies have often focused on a snapshot of the way users perceive the technology and the environment [30], and taken a limited genealogical microperspective [5], according to which the information technology (IT) artifact is static, offers a constant set of features, and serves a single general purpose. Because MICS and mobile commerce technologies do not meet these criteria (e.g., the IT artifact and its uses often evolve over time), we argue that a macro, dynamic, and longitudinal perspective can supplement existing views and help to explain the processional intricacies of the development and diffusion of mobile commerce technologies.

Specifically, we suggest that to generate a more nuanced understanding of this phenomenon researchers need to consider at least four often overlooked elements: (1) the simultaneous evolution of the technology and its uses; (2) the broad and dynamic range of IT uses (e.g., hedonic, social, organizational), including both positive and negative uses (e.g., spamming); (3) the broad and dynamic range of stakeholders (e.g., users, service providers, and regulators); and (4) the interplay between technology uses and stakeholders. To this end, we employ the actor-network theory (ANT) approach, which has been suggested as an adequate means for exploring complex dynamic situations [36], and examine the diffusion of services related to mobile text messaging in the Chinese market. These services are a representative instance of mobile commerce technologies, and more broadly MICS because they offer ubiquitous multipurpose functions and cater to many types of users [46, 48, 49, 50]. The facts that the diffusion of text messaging has involved many parties (e.g., service providers, content providers, users, regulators, etc.) and that it has evolved over many years, not just in terms of volume but also in the variety of uses, demonstrate the complexities of modern sociotechnical systems and can enrich traditional genealogical microperspectives on technology diffusion.

The objective of our research is to investigate the dynamic development and diffusion process of such mobile commerce technologies using a multi-stage actor-network theory perspective. By doing so, we aim at capturing a "biography of artifacts" [52]. Using this perspective we explore what, when, and why actors participated in the mobile commerce network, how focal actors advanced the network into new configurations, how new uses of the IT artifact have emerged, and how each configuration of the actor network was initiated and stabilized. Our investigation is based on 1,403 news items pertaining to the Chinese telecommunications market, which were screened from over 40,000 news items generated over sixteen years. The deduced pattern indicates that the diffusion of text messaging, and potentially other mobile commerce technologies, includes four macro-configurations: mobile commerce technologies begin to operate within a small network of actors, and via a dynamic process of events and interactions end up with a complex network of actors, which can include customers, regulators, content and service providers, and businesses, that drive their diffusion across markets. This process framework may serve as a platform for exploring the development and diffusion of other mobile commerce, and general technologies.

Theoretical Background

Diffusion of Technology Innovations

Diffusion of innovations is the process of communicating, adopting, and adapting new products over time, within a social system [35]. Management information systems (MIS) researchers have often treated the adoption of new technologies as a manifestation of diffusion [16], and many studies have treated the continued use of organizational IT artifacts over time as the diffusion phenomenon, presumably for simplicity reasons [20]. Other studies correctly note that adoption is only one step in the broader process of diffusion [9]. This study continues with this line of thought, and treats diffusion as in Rogers [35] in the broader sense— as a wide range of socio-technical processes that lead to dynamic and continued system use over time, by a different and dynamic set of stakeholders, and for a changing set of multiple purposes [18]. In doing so we adhere to recent calls in the MIS literature to go beyond mere IT use, or a single dimension of IT use as the only diffusion phenomenon, and take into account the breadth and depth of functionality that is being used by the growing variety of user types [19].

Diffusion of Mobile Commerce Technologies

Several studies have examined the diffusion of mobile commerce technologies. While some take a factor, micro-perspective approach, of interest to this study are the ones that take a processional, macro-level perspective. The key empirical studies in this domain are outlined in Table 1. Most of these studies employ a case analysis approach, focus on the industry or national levels, and often document interactions of multiple actors.

This body of studies demonstrates that the dynamic interactions among key actors at the national level can affect the diffusion of information systems (IS) standards and technologies. It further shows that this diffusion may be influenced by unique national, social, technological, and commercial contexts. Notably, empirical studies that have focused on mobile commerce technologies and taken into account the dynamic and complex nature of actor interactions at the country level are rare. To bridge this gap, the current work explores the development and diffusion of one mobile commerce technology, namely, text messaging service. We adopted a case analysis strategy and the actor-network theory (ANT) perspective, and focused on a sequence of key happenings in one country, that is, analyses were conducted at a national level.

The ANT Perspective

The analytical lens of the current study is actor-network theory, an interpretive theory initiated by Callon [7] and Latour [24] with an attempt to address the increasingly complex sociotechnical world. ANT treats the social

Table 1. Empirical Studies on the Diffusion of MICS Adopting the Processional Approach.

Study	Phenomenon	Unit	Theory/lens	Major finding
Yang et al. [56]	Role of standards in diffusion of broadband mobile services in South Korea	Country	- ANT (actor-network theory)	- Standards both enable and constrain innovation. - Path-dependency of operators enables them to innovate rather than be locked-in.
Allen [3]	The source of enrollment strategies in the early PDA industry	Industry	- ANT - Theory of technological change	- The PDA industry spends too much time and energy enrolling the "wrong" social groups and the "wrong" technologies. - Enrollment is not only a matter of negotiation and power plays but also a matter of redefining the technology, including and excluding different network elements.
Yoo, Lyytinen, and Yang [58]	Diffusion of broadband mobile services in South Korea	Country	- ANT	- Successful innovation and diffusion of broadband mobile services are collective achievements and firms need to deploy strategies that enable them to mobilize broad sociotechnical networks
Funk [15]	Mobile phone industry structure and mobile Internet interface standards in Japan	Country	- Value network - Social network theory	- The mobile phone industry is changing from a value chain to a value network in the Japanese market. - Each new interface standard requires a new critical mass of users building from previously created critical masses of users.
Shin, Kim, and Lee [37]	Digital multimedia broadcasting (DMB) in South Korea	Country	- Stakeholder theory - Sociotechnical system theory	- There are complex interactions in a web of stakeholders: (a) government versus market (users), (b) government versus industry, and (c) interactions among industry players.
Troshani and Hill [43]	Diffusion of mobile services in Australia	Country	- Stakeholder theory - Social Network theory	- Carriers' definitive position may be threatened by content providers. - Industry associations have ineffectively undertaken diverse mechanisms for achieving power for themselves and end users - Government regulators have successfully undertaken coregulation to fulfill their end-user protection objectives.

Table 2. Network Acts.

Network behavior steps	Description
Problemization	An actor may suggest that it shares a common problem with potential allies in order to convince them to join the network.
Interessement	One focal actor convinces allies with the necessary skills, knowledge, or other resources to devise a solution to their common problem, and thus makes it indispensable.
Enrollment	Allies (both human and nonhuman) join the network by means of translation—that is, by being persuaded to join the network and stabilizing the relationship.
Mobilization	Previously enrolled actors mobilize resources toward solving the common problem. Unsuccessful or declined attempts may lead to further changes in network configuration.
Inscriptions	Actors in a network embed "scripts" for future action and behavior in the network. They standardize actions and make them visible and understandable.

Note: For the terminology, see Akrich and Latour [1].

and the technical as inseparable and argues that people and artifacts should be analyzed with the same conceptual apparatus [51]. As such, ANT has been applied in MIS research to understand complex IT-environment dynamics [42]. This perspective suggests that network members perform different acts that continuously adjust the power structure and configuration of a network (see Table 2).

The ANT view of innovation diffusion is different from traditional diffusion perspectives in at least two aspects. First, instead of viewing the adoption phenomena as an interaction of a fixed set of elements (e.g., the innovation per se, users, the communication channel, social networks, and change agents), the analytical lens of ANT examines the adoption and post-adoption processes from a dynamic and holistic network viewpoint [17]. The number and configuration of actors within the diffusion systems may change in different diffusion stages. This can potentially provide a more nuanced understanding of the diffusion processes. Second, ANT offers a tool to open the "black box" of mobile commerce technology development and diffusion processes by suggesting a general analytical framework often not available in traditional diffusion theories. In particular, the general framework, especially the four steps of problemization, interessement, enrollment, and mobilization, sheds light on the driving forces behind the learning, reinvention, and adaptation processes [1]. Rather than offering common answers to general diffusion questions, ANT suggests idiosyncratic answers to specific diffusion inquiries [51]. These attributes of ANT make it suitable for understanding the dynamic diffusion processes of mobile commerce technologies.

ANT has often been applied to obtain a snapshot of market configurations. Given the dynamic nature of the phenomenon we examine, we apply it to multiple evolutionary stages of the phenomenon of interest, and perform a biographical study [52] using multiple ANT iterations. To this end, we build multiple time frames of analysis by identifying key events and stages of

evolution processes. We also look at different application areas across different types of users and organizations. We consequently identify multiple configurations of actor networks over time rather than a single configuration of actor networks. We can thus study the social fabric of a mobile commerce artifact and explain how it evolves over time.

Methods

We conducted a longitudinal holistic investigation in order to explain the development and diffusion of mobile commerce technologies and to shed light on future trends of mobile commerce technology development. It is appropriate for addressing exploratory "why" and "how" questions [57]. ANT provides us a theoretical perspective to investigate the dynamic diffusion process, but it does not provide a procedure to identify the actors and their interaction in a specific context. Because "following the actor" can be difficult" [8, 24] we adopt the "following the space and time" method as suggested by Willams and Pollock [52]. Specifically, we considered multiple time frames and locales in our efforts to examine the design, implementation, and use of SMS and related technologies.

We collected data and used them to systematically identify the ANT perspective concepts. In terms of coding, grounded theory method (GTM) techniques were used to perform this task. Grounded theory is a qualitative research method that helped us with developing context-based, process-oriented descriptions and explanations of organizational or societal phenomena. The GTM coding techniques can be used under an overarching framework of other theories [31], and this is what we have done here. It is particularly suitable for application in the sociotechnical milieu of the IS field, in which data change with technological advancements [6]. Following the GTM coding process [39], data collection and analysis were conducted in four stages: (1) data collection, (2) open coding, (3) selective coding, and (4) theoretical matching [34].

Data Collection

This study entails capturing main events and activities in the mobile industry in China, identifying key stakeholders at different historical stages, and exploring their dynamic interest-alignment process. Because the proliferation of mobile commerce technologies has been well documented in online media, Internet news portals were selected as the main data source. They are a good source because: first, Internet portals publish timely and relevant news [14]; second, since most Internet portals in China have formed alliances with newspapers, they tend to capture all critical news events; and third, many official interviews conducted by newspaper journalists were available online and could be used for cross-referencing and authenticity verification.

To overcome possible opinion biases, we cautiously collected, compared, and analyzed multiple sources of documentary evidence [57]. These included the three leading Internet portals: Sina.com, Sohu.com, and Netease.com. Sina.com was the main data source because it is the top online news portal in China. The other two websites were used for cross-checking. To ease the process of relevant news sifting, the intrasite search engine of Sina.com (iAsk.com) and Baidu.com were also employed. This is primarily because in Mainland China, Baidu is the market leader in search.

The time interval selected was from January 1997 to July 2013—a 16.5-year period that covered most of the historical evolution of China's SMS. At first, two authors (both proficient in English and Chinese) thoroughly read the latest news reports of Sina.com during a two-month period, identifying the formats and subjects of news that were relevant to our research theme. Then, many of the relevant key words that could appear in the titles of pertinent news reports were identified. These key words included service provider, short messaging services, text messaging, mobile phone, wireless Internet, wireless commerce, mobile commerce, mobile data service, and others. To verify the ability of this pool of key words to identify useful reports, we manually selected reports from other time periods that were relevant to the current study and then tried to retrieve reports by these key words using iAsk.com. Each of these manually selected reports was located successfully by this search engine, providing stronger confidence in the key word coverage. Subsequently, iAsk.com was employed and over 40,000 news reports, originating from various media sources, were gathered. Independently, the Baidu.com search engine was used in this step to retrieve missing but relevant event reports.

Next, a filtering procedure was used to manually screen out irrelevant, redundant, or less insightful reports. By browsing the report titles for relevancy, about 70 percent of the 40,000 reports were excluded. This is common practice for screening search engine results. Another 20 percent of the reports were eliminated by carefully reading the full text and detecting duplicates.

Open Coding

When parsing the collected data, the authors tried to maintain an outside and independent observer stance. They did not rely on these reports but rather on the chronological events to reconstruct history.[1] The above data analysis procedures were meticulously and rigorously implemented in order to minimize the biases originating from the data collection methods. The search and screening processes resulted in 1,403 relevant news reports. The key events identified from the news reports are summarized in Appendix 1.

During open coding, data were broken down into discrete parts, closely examined, and compared for similarities and differences [39]. We started codifying with a microscopic examination of each report to create initial codes for making comparisons without predetermined ideas or a preconceived model. We constantly compared and contrasted reports in the search for similarities and differences and the differentiated concepts became

Table 3. News Report Statistics by Formats and Subjects.

Themes	Survey	Interview	Viewpoint	Event report	Subtotal
Technology	15	17	54	80	166
Content/Service Provider	66	45	149	388	648
Consumer	77	53	88	106	324
Regulator	25	48	76	116	265
Subtotal	183	163	367	690	1,403

categories. Finally we arrived at four elemental categories: technology, content/service provider, consumer, and regulator, which represent the major groups of actors as discussed in detail in the next section. The cross-tabulation of different types of news reports with the elemental categories is given in Table 3.

Selective Coding

The selective coding stage is about the interpretation of categories. This analysis detected and examined patterns in the data. We first browsed the chronological data and identified critical historical events that had a significant effect. Critical events should signal and signify points in which the SMS diffusion trend was transformed to a different theme or to a more advanced stage with a potentially far-reaching influence on the trajectory of SMS diffusion. According to such criteria, four historical events that initiated four network configurations of SMS evolution were identified: (1) the launch of SMS service that initiated the network configuration of person-to-person SMS communication, (2) the launch of China Mobile's Monternet (mobile portal), which started the network configuration of SMS-based information services, (3) the launch of MobNIC, which instigated the network configuration of SMS enterprise applications, and (4) the launch of Micro Blog, which started the network configuration of SMS maturity and convergence with social media applications. The number of SMS news items for each type of topic is graphed in Figure 1, wherein critical events show the beginning or the peak of the stage. As one can see, the four stages synchronized very well with the waves of event reports. The number of news items peaked close to each critical event, and then declined and stabilized. After microblogging products were launched and accepted by a growing number of users, all SMS applications reached the maturity stages shown in Figure 1. Meanwhile, a natural extension and possible replacement of SMS that is significantly different from SMS has emerged. Social media applications have been growing fast. It indicates the transition of focus from SMS to a new mobile-communications platform, and may signify the full maturation of SMS services.
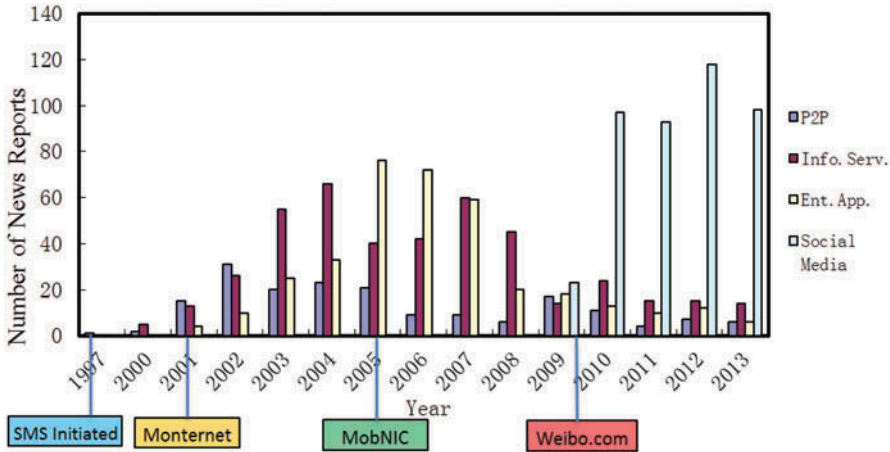
Figure 1. SMS News Reports in Each Year

Notes: P2P = person to person; Info. Serv. = information services; Ent. App. = enterprise applications; Social Media = SMS maturity and social media applications.

Theoretical Matching

After categories were created and related, the next analysis was to specify explicit associative linkages between individual interpretive constructs. We structured our finding under the ANT theoretical framework, and we describe this process in the following section.

Results

The pattern identification process yielded four actor-network configurations. The first network configuration is termed *Person-to-person (P2P) communication* in which SMS was used mostly for individual communication. This began in 1997 when the first text message was sent over the network of China Telecom. The second network configuration is termed *SMS information services*, in which mobile carriers collaborated with Internet content providers for SMS-based content delivery and payment mechanisms. The third network configuration of SMS diffusion, namely, *enterprise applications* was then initiated. This was characterized by diffusion of SMS-based applications in enterprises. The fourth network configuration is SMS maturity and the transition to alternative mobile commerce communication platforms such as social media applications, in which microblogs have facilitated the sharing of personal and social information. It is worth noting that the four stages highlight key evolutionary characteristics. Their evolutionary progress is distinguishable but the stages have overlapped to a certain degree along the time dimension.

Person-to-Person Communication: Initiating the Individual User Market

In the 1990s, wireless communications were luxury services that only the social elites could afford. Voice communication service was virtually the only source of revenue for mobile carriers. Mobile carriers wanted to attract more customers to enlarge their revenue base. Therefore, as the first step of *problemization,* mobile carriers as the focal actors sought to be indispensable by recognizing the problems (in this case, unaffordable mobile communications) of potential actors (customers) and suggested SMS as the solution (see Figure 2).

To *interest* cell-phone subscribers, mobile carriers utilized a low-cost marketing strategy. For each SMS message the senders were charged only 0.10 RMB (about 1.25 cents in U.S. dollars), a price much lower than that to make mobile voice calls (0.40 RMB per minute) [55]. Such a low price was justifiable because SMS utilizes limited bandwidth compared to voice channels. Moreover, carriers offered a favorable one-way charging policy (free for the receivers) and waived the roaming charges for long-distance communications. As such, SMS was very cost-effective for service providers and attractive for price-sensitive customers. Due to their simplicity, SMS service modules were also available on virtually all cell phones. This made SMS widely accessible to a wide range of audiences. From a cultural perspective, besides low cost, SMS is especially useful when disturbing others is impolite. When people cannot be reached by phone calls, leaving a text message seems to be more appropriate than leaving a voice message in the Chinese culture [55].

While ease of use is an important factor for technology adoption [12], typing text messages using a small keypad can be challenging, especially when entering Chinese characters. Fortunately, many intelligent Chinese character input methods were developed and implemented on cell phones during this stage, which enabled consumers to overcome the typing barriers [26]. For these reasons, SMS became more and more popular [45, 48]. The
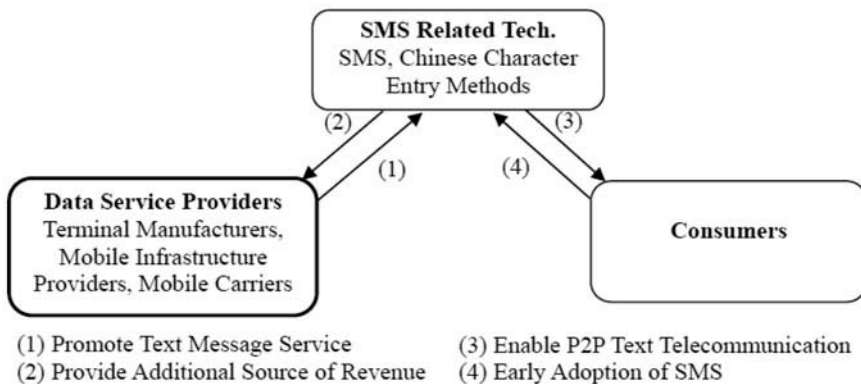

Figure 2. Actor-Network Configuration I: Person-to-Person (P2P) Communication

actor network then proceeded to *enrollment*— that is, customer adoption of SMS. For similar reasons, mobile network operators successfully translated end users while inscribing their interests. Due to positive network effects, SMS provided enlarged social connectivity to subscribers as the size of the customer base increased. As a result, carriers succeeded in retaining subscribers through the process of *mobilization*.

However, due to the lack of information and commercial services in the first configuration of the actor network, virtually all short message exchanges were person-to-person communication. In addition, the two mobile networks maintained by China Mobile and China Unicom were not interconnected. Subscribers of China Mobile could not exchange text messages with users of China Unicom, and vice versa. This inhibited the fast development of SMS in China.[2] Therefore, although subscribers embraced SMS, its further growth required technology advances in SMS connectivity, and new business models, beyond the first network configuration.

Information Services: Bridging Mobile Network and the Internet

By the end of 2000, mobile voice service was still the main source of revenue, but its growth slowed down. The average revenue and minutes of use per user (ARPU) of China Mobile declined from 1997 to 2000. These have signaled an increasing percentage of low-end subscribers [55], or increased use of inexpensive communication channels, such as SMS. Hence, mobile carriers realized that without value-added services, they were unlikely to get onto a growth trajectory. Therefore, in the first ANT step of *problemization*, mobile carriers tried to broaden their revenue source to include value-added data services (see Figure 3).

By the year 2000, the ideal partner for providing value-added services seemed to be Internet portals, which had real-time access to news, weather, stock quotes, and other information services. They were also struggling and highly motivated to look for viable business models that could help them recover from the dot-com burst. Recognizing the business opportunity, mobile carriers invested in SMS gateways, the network facilities that link the carriers' wireless networks to Internet portals' fixed-line network. On November 10, 2000, China Mobile launched its mobile portal Monternet and began sharing with authorized content providers its charging platform. Collaborative content providers of China Mobile were allowed to keep 85 percent of SMS-related revenues, which was very attractive for portals. In August 2001, China Unicom also launched its mobile portal called Uni-Info and thus offered another option for content providers. Concerning the above *interessement* efforts, Xiangdong Lu, vice president of China Mobile, pointed out: "The reason why [the business model of] Monternet was so successful was twofold: firstly, China Mobile successfully identified the joining of mobile handset with the Internet, and secondly, China Mobile established a profit sharing policy which accelerated the maturity of mobile data services."[3]

Internet portals also started recognizing the business potential of SMS. A director of the China Social Academy later commented: "several pieces
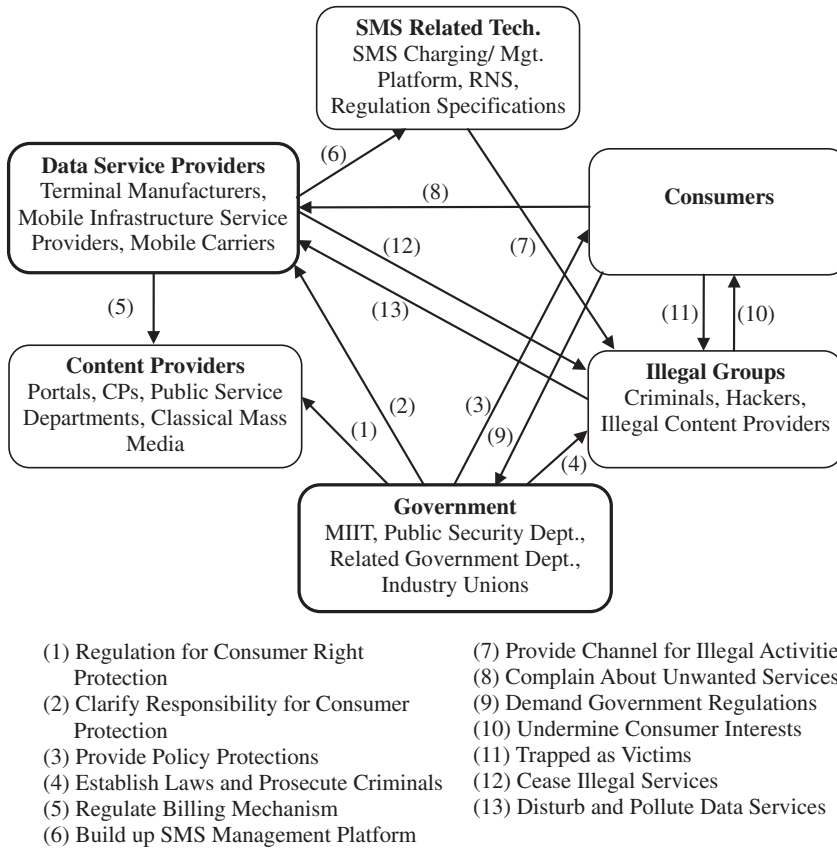
Figure 3. Actor-Network Configuration II: Information Services

Notes: RNS refers to Real Name Subscription; MIIT refers to Ministry of Industry and Information Technology.

of bread dropped from China Mobile's dinner table are large enough to suffice all Chinese portals."[4] In *enrollment*, the third step of ANT evolution, more and more portals started delivering content service through SMS. Presumably, the portals were translated because they saw their interests being inscribed in the actor network. Some content providers did not have the necessary technologies for SMS service. They used aggressive acquisition strategies to seize this business opportunity. For example, in January 2003, the largest Chinese Internet portal Sina.com, once a laggard content provider, purchased SMS service provider Guangzhou MemeStar Corp. and thus became the largest mobile content provider of that time. The past chief executive officer (CEO) of Sina.com, Daolin Mao, recalled:

In the year 2000, mobile handset manufacturers such as Motorola had sought collaboration with Sina about information content provision.

But we had no idea what this business model might mean at that time. In addition, *China Mobile* was providing information content by itself. It wasn't until the second half of 2001, when *China Mobile* announced their profit sharing policy, that utilizing the new charging channel [by SMS] became possible.[4]

Along with Internet portals, government public service departments, newspapers, TVs, and radio broadcasters started using SMS. As a result, mobile carriers and content providers reaped considerable income in the years following their initial investment in SMS. According to one survey carried out in November 2001, 70 percent of cell-phone subscribers used SMS in their everyday life. In 2001, a total of 18.9 billion SMS messages were sent in China. In the following two years, this number soared to 90 billion and 137.1 billion, respectively [28]. SMS became a key source of revenue for many Chinese Internet portals. In August 2002, Netease.com became the first portal to recover from financial deficit to profit making, followed by the three largest (at that time) Internet portals Sina.com, Sohu.com, and TOM.com. One IT commentator summarized the situation using the following metaphor: "SMS is a gold mine accidentally run into by the Chinese portals in the Dot.com winter."[5]

But the huge market value of SMS also attracted unethical and illegal groups—individuals and organizations that use illegal or unethical techniques to profits from SMS at the expense of other actors. According to a survey carried out by the China Internet Association in July 2008, the volume of unwanted SMS messages reached an astonishing 353.8 billion in 2007, an increase of 92.7 percent over the prior year. Junk messages accounted for 45.5 percent of the total number of messages sent. The integrity of the market was greatly undermined by junk messages.

Thus, beginning in early 2004, various government departments and mobile carriers initiated a series of regulation activities with the objective of curtailing illegal text messages. In May 2004, the Ministry of Industry and Information Technology (MIIT) issued the decree "Notification on Issues About SMS Regulation" [28], in which policies were announced to prohibit the unethical and illegal behaviors of content providers. To combat junk and fraud messages, carriers also established the real name subscription (RNS) policy. In China, the registration of personal profiles of prepaid users was not obligatory. The issuance of RNS meant that both individuals and organizations must provide real identity profiles to be registered as authorized users. In June 2008, the MIIT started a new round of regulation spanning a six-month period with the emphasis on reducing junk SMS.

These regulations significantly affected illegal groups, as well as Internet portals. In July 2004, Netease.com announced lower revenue expectations as a result of the government "Notification," and indeed, revenues from value-added services have dropped [32]. Consequently, Internet portals were forced to self-regulate their services to meet the regulation requirements of carriers. As a result of these regulation efforts, the volume of junk messages declined significantly, as manifested by the

number of customer complaints, which shrank from 380,000 cases per month to 40,000 cases in July 2008.

With more stringent regulation, it became harder for illegal content providers to impair the healthy development of the SMS market in China. As a result, in the last actor network step, *mobilization,* the actor network's health is maintained and collaboration between carriers and portals is stabilized.

Enterprises Applications: Penetrating into the Institutional Market

In addition to serving individual consumers, SMS could also be used to improve the productivity of mobile workers and the quality of customer service. However, the SMS market was dominated by personal use [58]. Hence, mobile carriers attempted to enter the underexplored enterprise market. However, the exploration of the SMS enterprise market involved barriers. Foremost among them, there was no unified service-locating mechanism [59]. In the e-commerce domain, customers can easily locate online services by accessing URL (universal resource locator) addresses. Comparatively, within the mobile commerce domain, the only identification mechanism available was cell-phone numbers, which are hard to memorize. Therefore, in the process of *problemization,* mobile carriers made themselves indispensable by advancing into the SMS enterprise markets (see Figure 4).

In January 2005, China Mobile, China Unicom, and China Mobile Communication Union jointly launched the SMS Domain Name Information Center (short for MobNIC later), an organization committed to the standardization, marketing, and promotion of the SMS Domain Name technologies [29]. Using this, cell-phone subscribers can locate registered mobile services simply by sending text messages to a unified service number.

To further promote the adoption of SMS within enterprises, in December 2005, the MIIT and the National Development and Reformation Bureau also announced a series of policies to promote the implementation of enterprise SMS applications in small and medium-size enterprises (SMEs). Therefore, in this step of the actor network, mobile carriers and regulators made efforts to facilitate and promote the adoption of SMS enterprise services with the objectives of attracting the *interest* of enterprises, individual customers, and also some software vendors (who have expertise in developing SMS-based enterprise applications).

The establishment of MobNIC *enrolled* the mobile application service providers (mobile ASP) into the actor network. They were translated presumably because their interests were addressed by the focal actors. In addition, the potential of SMS enterprise applications provided new market opportunities for both incumbent software providers and entrants with new market opportunities, such as SMS OA (office automation), SMS CRM (customer relationship management), SMS SCM (supply chain
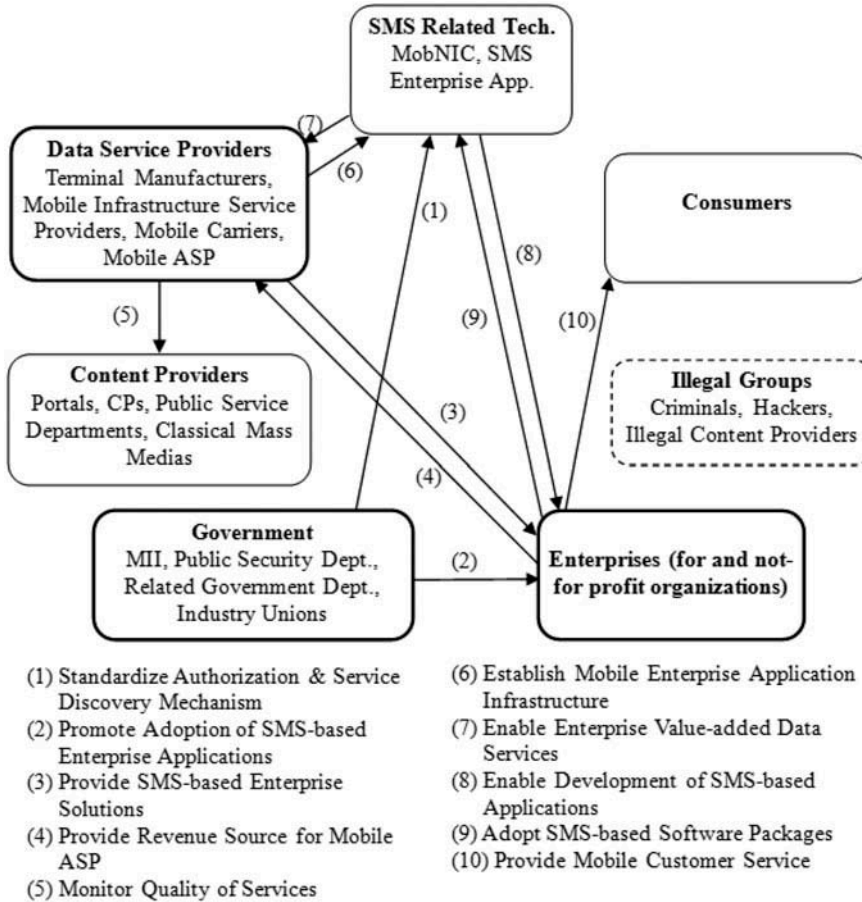
(1) Standardize Authorization & Service Discovery Mechanism
(2) Promote Adoption of SMS-based Enterprise Applications
(3) Provide SMS-based Enterprise Solutions
(4) Provide Revenue Source for Mobile ASP
(5) Monitor Quality of Services

(6) Establish Mobile Enterprise Application Infrastructure
(7) Enable Enterprise Value-added Data Services
(8) Enable Development of SMS-based Applications
(9) Adopt SMS-based Software Packages
(10) Provide Mobile Customer Service

Figure 4. Actor-Network Configuration III: Enterprise Applications

management). Enterprises had the motivation to deploy SMS-based applications for two reasons. First, their mobile workforces could be supported with mobile technology. Second, enterprises could benefit more from their cost-effective investment in SMS-based applications. Due to the low setup cost (usually only several hundred renminbi or less than $100), the return on investment of enterprise SMS platforms was reported to be superior compared to that of its fixed-line counterparts [2]. As such, it was reported that the number of enterprise subscribers had exceeded 200,000 by March 2009 [29].

As witnessed in the fixed-line enterprise solutions market, the positive interactions between ASPs and their enterprise customers often signaled market advancements. Whereas more mature enterprise solutions could trigger the adoption of SMS, the widespread implementation of enterprise applications would reward ASPs with cash flow. Based on the positive evidence observed in the SMS enterprise market, it is possible that SMS

will further diffuse into enterprises in the foreseeable future. The last step of the actor network—mobilization—however, had not fully unfolded before the new configuration of social media started.

SMS Maturity and Transition to Microblogging Applications: Interacting Through Social Media

While SMS related services were maturing, social media applications quickly caught people's attention and served as perhaps a more efficient alternative for sharing information and engaging in mobile commerce [38, 44, 47]. Numerous factors helped drive Chinese people to engage in social media use. These include rural-to-urban migration that has separated families, the presumed loneliness of the one-child generation, and distrust regarding information from government-controlled media [10]. However, foreign social media services were blocked by the Chinese government. Recognizing this potential, in May 2007, the first domestic microblogging site, Fanfou.com, was created in China, followed by a number of homegrown microblogging websites such as Digu, Taotao, Jiwai, and Zuosha. Similar to Twitter, these text-based social media services provide multiple functionalities such as posting and receiving messages, forwarding messages, "following" other users, commenting, and so on. With messages that are limited to a mere 140 characters and embedded video and pictures, users are able to broadcast information to their community immediately. These features attracted Chinese users to socialize and share information in an easier and faster way [25]. Therefore, in the first ANT step of *problemization*, social media service providers became a focal actor by recognizing the problems (in this case, the need for more efficient socialization and information sharing) of potential actors (customers), and by suggesting microblogging services as the solution.

After the trial of most early microblogging sites such as Fanfou and Jiwai, in August 2009, the biggest Internet portal Sina.com launched its microblogging product Weibo.com and it grew quickly to be the largest in China by 2010 [13]. By the end of the second quarter of 2013, Weibo's registered user population had increased to 536 million (http://tech.sina.com.cn/i/2013-06-16/14318443942.shtml). This success triggered the interest of Internet service providers. Consequently, in 2009 and 2010, other main Internet portals such as Tencent.com, Sohu.com, and Netease.com, mainstream media institutes such as People.com and Xinhuanet.com, virtual communities such as Tianya.cn, and search engines such as Baidu.com all launched their own microblogging websites. Microblogs have achieved the leading position in China's social network services [54]. This illustrates the second ANT step of *interessement* in which the focal actor (microblogging service providers) convinced allies (the large Internet portals) with the necessary skills, knowledge, or other resources to devise a solution to their common problem, and thus made it indispensable (see Figure 5).

With the growth of microblogging services in China, both personal and enterprise applications of SMS have declined considerably. Besides
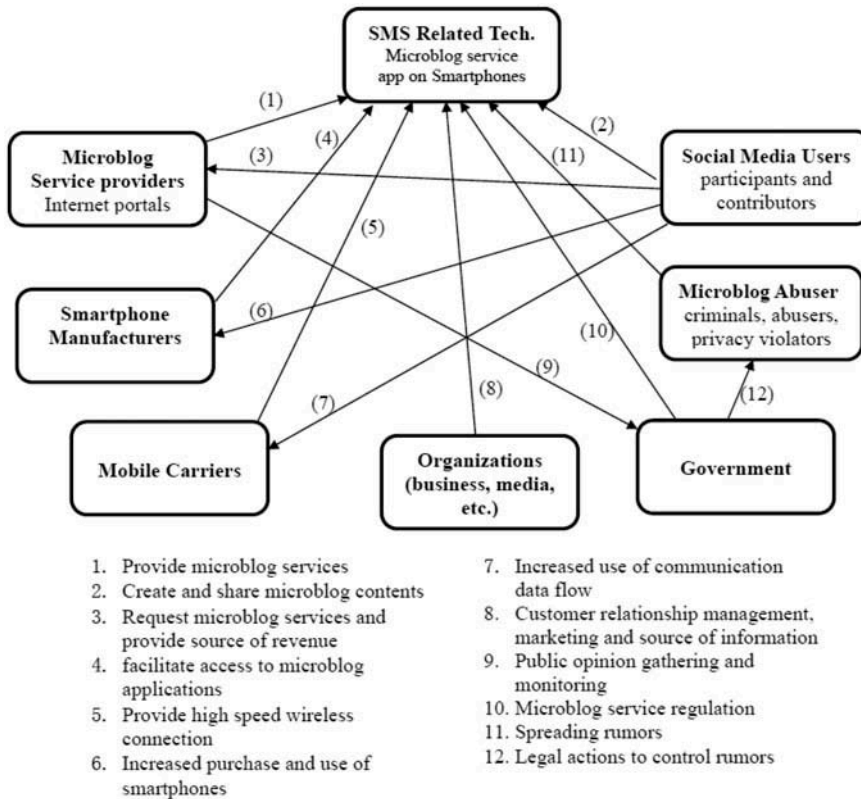
1. Provide microblog services
2. Create and share microblog contents
3. Request microblog services and provide source of revenue
4. facilitate access to microblog applications
5. Provide high speed wireless connection
6. Increased purchase and use of smartphones
7. Increased use of communication data flow
8. Customer relationship management, marketing and source of information
9. Public opinion gathering and monitoring
10. Microblog service regulation
11. Spreading rumors
12. Legal actions to control rumors

Figure 5. Actor-Network Configuration IV: SMS Maturity and Transition to Microblog Applications

microblogging service providers and individual users, other stakeholders were also *enrolled* quickly. This suggests successful translation of network actors. Smartphone manufacturers made microblogging software embedded in mobile phones and microblogging service providers also issued mobile client applications. Hence, users gained mobility with regard to microblogging. Using the cameras built into smartphones, videos and pictures can also be easily attached to microblogging messages to enrich information sharing. With the large population of mobile users in China, the telecommunication carriers found that more and more users were replacing simple P2P SMS message services with microblogs. As a result, their revenue from SMS decreased, while revenue from data flow increased. One unique aspect of microblogging is that the users not only access information but also provide information and thus serve as content creators and providers. Consequently, microblogs attracted celebrities and influential people such as movie starts, athletes, and professional experts to open their V (identity verified) blogs and created many online opinion leaders that attracted millions of fans and followers. For instance, Liu Xiang, a 2004 Olympic Gold medalist and 2007 World Champion in men's 110 meter

hurdles, created his microblog (http://liuxiang.blog.sohu.com/), which attracted over 10 million fans and became the most popular microblog in the world.

Social media also became the original information source of traditional media. To collect real-time information from every corner of society and to reach and interact with large audiences, 353 newspapers, 151 TV stations, and 331 radio stations have created official microblogs. Consequently, microblogging websites were widely reported as outperforming the mainstream information channels in numerous ways. For example, during the massive China earthquake in 2008, microblogs quickly reported the initial tremor, earlier than the first official mainstream news released from the U.S. Geological Survey [25].

Social media have also been used for sharing personal experiences about consumer products and services. Word of mouth can be more powerful and trustworthy than organizations' official advertisement. Due to the features of quick information spreading and interactive social communication, enterprises realize the great potential business value of microblogs and using them for marketing and customer relationship management. Microblogs, therefore, have extended their role into enterprise applications identified in network configuration III.

Government departments and agents have also created microblogs to post official information and deal with public affairs via this new media platform. For instance, police blogs are used to post crime warnings or traffic condition updates and to collect and search for crime tracking tips. In 2011, more than 1,300 government blogs had already been established, including 692 police blogs, 216 government agency blogs, and 426 individual officer blogs [53].

Meanwhile, social media abuse started developing, as some people used them to quickly spread rumors or conduct criminal activities. For instance, rumors have been spread to violate people's privacy, damage individuals' or organizations' reputations, or cause public panic with fake information about emergency events such as epidemics. In response, the government carried out a campaign to crack down on rumor spreading, established a system to monitor network activity, issued laws to legally charge large-scale rumor makers, and prosecuted a few big V bloggers for their wrongdoings (http://news.china.com.cn/live/2013-06/16/content_20575899.htm). Microblogging services providers also developed mechanisms to stop rumors and to regulate system use. So far it is clear that in this enrollment step many allies are enrolled in microblogging services and play essential but different roles in advancing its success.

According to a "2012–2013 Micro Blog Development Research Report,"[6] almost all Internet users in China are microbloggers, and 76.2 percent of active microbloggers are using mobile devices to access microblog services. Since 2012, various actors have constructed a new society, in which individual users, government, social organizations, and enterprises actively participate and interact through the microblog platform. China's microblog applications have experienced incredibly fast development and have influenced the whole society. Correspondingly, SMS services, although still useful in many instances, have been partially replaced by microblogging

services, especially because broadband Internet services are within reach. Thus, we can see that the actor network has shifted to the status of *mobilization.*

Discussion

This study examined the development and diffusion of SMS in China, as a representative type of mobile commerce technologies, via a biographical, multistage application of ANT. Examining 16.5 years of biographical data, a rich set of findings emerged, which shed light on what, when, and why actors participated in the network, how focal actors advanced the network into new configurations, how new uses of the IT artifact have emerged, and how each configuration of the actor network was initiated and stabilized. The emergent pattern can help in understanding the diffusion patterns of mobile commerce technologies, and can serve as a platform for further empirical research on this important topic. A summary of the four ANT configurations of SMS evolution is presented in Table 4. For each ANT configuration, we cross-tabulate the key attempts of various actors to advance SMS diffusion with the protocols that were inscribed as a result of each ANT configuration.

Mobile Commerce Technology Development and Diffusion Patterns

The findings suggest that the development and diffusion of SMS, and potentially other mobile commerce technologies (similar patterns were observed at least with regard to social media, hence demonstrating some potential generalizability), is a complex process that involves addressing new challenges repeatedly, dealing with new actors, and catering to a growing and changing user base (see Figure 6).The evolution of mobile commerce technologies is best depicted as an upward-going spiral curve that goes through multiple configurations as discussed in the previous section. The width of the spiral represents the enlarged (number and types) user and uses base, until it reaches a maturity stage. It is worth mentioning that when a technology reaches a maturity stage, a new technology may take over to continue the innovation process if more efficient technologies emerge. Thus, as long as the striving for better and more efficient technologies continues, the maturity of an old technology is often accompanied by the birth of a new technology. The new technology will then create and drive a new innovation diffusion life cycle.

The multistage diffusion model may be plausibly observable also in the case of other mobile commerce technologies. The stages may overlap in the case of other mobile commerce technologies, may be reordered, and can have different emphases, all of which are promising avenues for future research. Nevertheless, the multistages seem to exist in the case of many mobile commerce technologies such as mobile search engines, mobile social network

Table 4. Four ANT Configurations of SMS Evolution in China.

Configuration	Step One: Problemization	Step Two: Interessement	Step Three: Enrollment	Step Four: Mobilization	Inscriptions
Configuration I: Person-to-Person Communication (1997–November 2000)	Voice call is too expensive, cell-phone users need a low-cost channel for mobile communication.	Carriers employ favorable pricing policy to promote SMS adoption.	Customers adopt SMS and enroll in the actor network.	Customers feel comfortable using SMS; carriers reap profits from SMS.	SMS protocol.
Configuration II: Information Services (November 2000 January 2005)	Internet portals need payment mechanism to sell information content; carriers lack information content to attract more users.	Carriers share the charging platform and invest in SMS gateway updating project.	Internet portals adopt SMS as a new channel to sell information content and enroll in the network.	By providing rich information to customers, carriers and portals reap great profits.	SMS gateway, SMS charging platform.
Configuration III: Diffusion into Enterprises (January 2005–August 2009)	The enterprise SMS market is underexplored but has great business potential.	Carriers propose SMS domain name and real name subscription (RNS) and promote SMS enterprise adoption.	Mobile ASPs and enterprises find their interests being inscribed by SMS and they enroll in the actor network.	Enterprises accept SMS-based solutions provided by carriers and mobile ASPs.	SMS domain name, RNS, SMS enterprise application software.
Configuration IV: SMS Maturity and Transition to Microblogging (August 2009-)	Microblogging (accessible on mobile devices) appears as a more efficient socialization and information sharing service.	Major Internet portals, government departments, enterprises, and social elites recognize the potentials of microblogging as a new socialization tool.	Traditional media, enterprises, and government use microblogging as a new information channel. More users select microblogs over SMS.	Microblogging partially replaces SMS as a new information sharing and socialization vehicle.	Microblogging services.

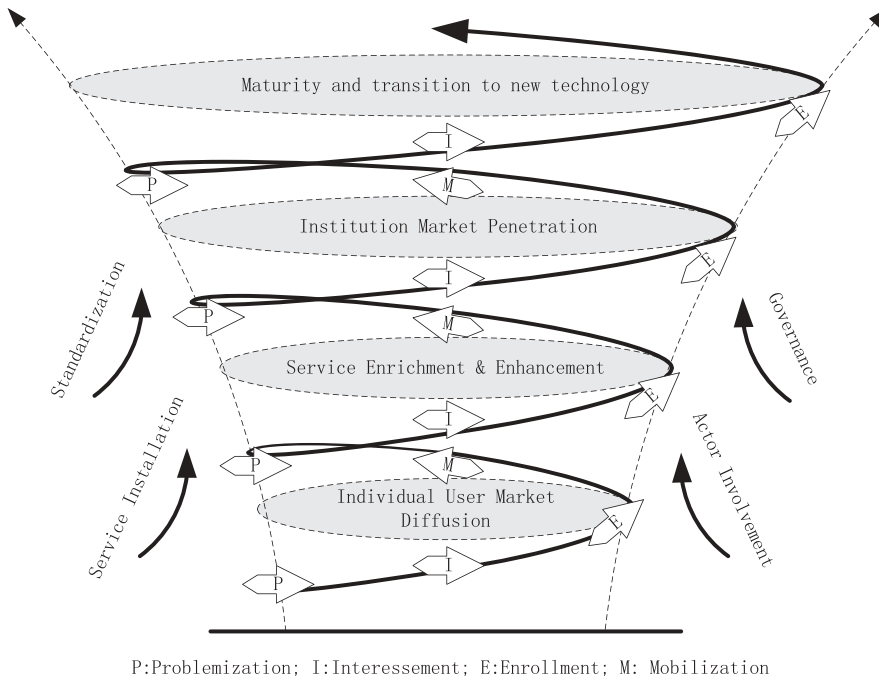P:Problemization; I:Interessement; E:Enrollment; M: Mobilization

Figure 6. The Development and Diffusion Pattern of Mobile Commerce Technologies

websites, and mobile application stores (e.g., Apple AppStore and Android Marketplace). For instance, Facebook began by catering to the individual user market providing basic social networking services. In the next phase they expanded their offerings to include online video games, and all sorts of widgets. Once they amassed many users, privacy concerns were raised, and Facebook was driven to deal with these through privacy management features. Facebook also started tapping into the institutional market by allowing businesses to setup accounts and promote their services on social networks [22]. To go beyond our exploratory work, it is advisable for positivist researchers to refine the pattern we have observed here, adjust it to different contexts, and test it across all possible contexts in future studies.

Our multistage mobile commerce technology diffusion pattern supplements existing meta-diffusion models that identify diffusion stages but often do not provide sufficiently nuanced details from multiple perspectives on the diffusion processes [9]. Furthermore, existing meta-diffusion models well suit single-purpose information and communication technologies, and, as is evident from our case analysis, the ways in which mobile commerce technologies are used change over time. Therefore, it is necessary, as noted before [19] to conduct further research in this realm. This study represents one of the first attempts to present a development and diffusion model that attends to the complexities stemming from the special nature of MICS. It can therefore serve as a platform for further research on this topic.

Implications

Taking an ANT view, the suggested development and diffusion pattern illuminates factors, processes, and interactions that are often overlooked in MIS research, and especially in the context of mobile commerce. This study emphasizes that diffusion is often a dynamic evolution process, and it supplements simpler views proposed in previous studies on technology adoption and diffusion. It demonstrates that the diffusion of mobile commerce technologies is driven by multiple forces. Because this study views mobile commerce technologies from both demand (individual and business users) and supply (e.g., wireless carriers and content providers) perspectives, it generates a meticulous view of these market dynamics that can be an advantage over taking either view separately [4].

By using the ANT lens of analysis, this study integrates and extends multiple, relatively isolated perspectives. First, as mentioned above, it integrates the supply and demand perspectives. Many diffusion studies have focused only on the diffusion stages of technologies. Our study goes one step further by noting that IT artifacts per se are subject to change and updating, with new features and functionalities being added continuously. As a result, it is necessary to take into account both the development and diffusion processes when studying mobile technologies. Second, the value-chain perspective focused primarily on how service providers collaborate in their efforts to promote new information services [27]. The current study supports a more balanced view, in which the multidimensional nature of user demands (multiple purposes) was simultaneously considered. Furthermore, this view includes human and nonhuman (i.e., technology artifacts) actors. Moreover, the proposed model includes regulatory powers that supplement the demand, supply, and technology forces. Government entities and their regulatory efforts can be instrumental to the diffusion of mobile commerce technologies [45], and as such, their integration with other actors is imperative. Finally, the proposed diffusion path includes negative uses, which are often overlooked [11, 40, 41]. Although these slow down the diffusion of MICS, they can be instrumental to the formation ("enrollment" and "mobilization") of the regulatory and usage climates that are needed to further expand the diffusion of mobile commerce technologies. Ultimately, this study adds to the body of knowledge on technology evolution and diffusion by focusing not only on different breadths and dimensions of IT use but also on the dynamic nature of actors and uses in a complex sociotechnical setting. It can therefore inform such studies by contextualizing them using the four proposed network configurations.

From a practical standpoint, this study shows that the diffusion of mobile commerce technologies involves the continuous extension and enhancement of multipurpose services. The suggested actor-network configurations allow business managers to pinpoint business opportunities and to identify optimal timing and roles, given the current market configuration. Furthermore, our study also touches on factors that can damage healthy diffusion

progress, such as criminal and unethical uses or poor regulatory policies. It implies that service providers should be aware of potential unethical uses and their implications. At the same time, regulators should be ready to go when such unethical activities emerge, because presumably fast resolution can put the diffusion back on track. This is especially important in heavy-investment technology sectors such as mobile services, and can ensure faster return on investment.

Overall, the current study provides a "biography of artifacts" [52] for mobile technologies, which is rare in the MIS literature but is also needed to account for the complexities in modern markets. The proposed multistage ANT perspective in a biographic study provides an integrative view that can extend and complement extant theories, suggest several practical implications, and open avenues for future research.

Limitations

Several limitations should be acknowledged. First, data collection relied in part on existing online data sources, which may not always reveal the full story. Although our analysis is guided by a well-established framework, the findings are primarily based on the subjective interpretation of archival data. More comprehensive data gathering (e.g., interviews) may be used to further validate the findings. Second, this study examined the diffusion of a particular MICS in a specific market. Due to China's unique cultural, economic, and political situations, the actors and configurations identified in this study may not be fully applicable to other countries, especially those with very different social and economic contexts. Furthermore, we employed SMS as a representative example of mobile commerce technologies and carefully examined its development and diffusion pattern in China. Given the existence of a plethora of mobile commerce technologies (e.g., Apple AppStore, WhatsApp), more research efforts are needed to elicit additional relevant factors and actors concerning their diffusion paths.

Conclusion

With the proliferation of mobile commerce technologies and the increasing sociotechnical complexities, it is imperative that MIS researchers better understand the actors and processes that lead to a successful diffusion of new technologies. Using the lens of ANT longitudinally and at the national level, this study examined the biography of the development and diffusion of SMS in China and identified key actors, actor network configurations, and stages in this evolutionary process. The analysis revealed a multistage mobile commerce technologies diffusion pattern, which can serve as a platform to further study and promote the diffusion of MICS.

Acknowledgments

NOTES

1. Such analysis techniques are termed "pattern matching" (in the ANT framework, p. 115) and "chronologies" (in [57, p. 125]).
2. The interconnection of SMS between China Mobile and China Unicom was achieved in May 2002.
3. http://tech.sina.com.cn/it/t/2002-12-28/0901158361.shtml. Retrieved Apr. 14, 2015.
4. http://tech.sina.com.cn/i/c/2003-02-10/1327164502.shtml. Retrieved Apr. 14, 2015
5. http://tech.sina.com.cn/i/c/2003-09-24/1823238080.shtml. Retrieved Apr. 14, 2015
6. http://www.iresearch.com.cn/Report/1982.html. Retrieved Apr. 14, 2015

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Appendix 1. Chronology of SMS Evolution in China (Grouped by Actor-Network Configurations)

Configuration I: Person-to-Person Communication

1997	The first Chinese SMS was sent in China Telecom's network (Tianjing Branch).
April 2000	China Mobile was spun off from China Telecom as an independent mobile carrier.
May 2000	China Mobile officially launched short message service.
August 2000	China Mobile collaborated with Sina.com, Sohu.com, 168wap, and Linktone on the first SMS subscription service—"Olympics Flash News."
May 2002	China Mobile and China Unicom achieved full interconnection of their SMS.

Configuration II: Information Services

November 2000	China Mobile launched Monternet and opened the mobile data service market to independent content providers.
August 2001	Uni-Info service was launched by China Unicom.
June 2002	SMS became the main revenue source of Sohu.com, according to the interview of its CEO, Chaoyang Zhang.
July 2002	The province branches (including Shanghai, Guangdong, Beijing, etc.) of China Mobile started investing in the SMS gateway updating projects.
August 2002	Fueled by SMS, Netease.com announced to turnover and reap profits.
January 2003	Sina.com purchased Guangzhou MemeStar Corp. (XunLong in Chinese) and became the largest content provider up to then.
November 2003	SMS subscriber number of TOM.COM reached 20 million.
May 2004	MIIT issued the "Notification on Issues about SMS Regulation," in which many policies were announced to prevent the illegal behavior of content providers.
July 2004	China Portals encountered crisis in the NASDAQ stock market. The stock prices of China Portals fell sharply: Netease.com −11.8 percent, Sina.com −10.2 percent, Sohu.com −5.4 percent.
September 2004	Sina.com, Sohu.com and Netease.com announced the establishment of a "Trust and Self-discipline Alliance" and invited more content providers to join.
December 2007	The SMS service numbers for all service providers and content providers were reallocated. All new service numbers start with "106," which eased the identification and tracking of junk SMSs.
March 2008	Focus Media, a mass media giant in China, and six other companies, were reported to be the key source of junk SMSs by CCTV (China Central Television).
July 2008	In Beijing, new Easyown (Shenzhouxing in Chinese; the most well-recognized cell-phone brand name of China Mobile) customers were required to provide their identity information to register. This requirement was mandatory at the 250 reception offices in Beijing.
October 2008	According to a report issued by MIIT, the number of customer complaints received by the public service number 12321 decreased significantly, from 380,000 cases in May to 40,000 case in July 2008.

Configuration III: Enterprise Applications

March 2004	SMS domain name was proposed by ViVend Networks Ltd.
January 2005	SMS Domain Name Information Center (short for MobNIC) was established by China Mobile, China Unicom, and China Mobile Communication Union.
September 2005	UFIDA (the largest ERP provider in China) integrated SMS packages into its solutions.
March–October 2005	More enterprise SMS solutions were put into market, which included SMS CRM system, SMS SCM system, corporation group SMS solutions, SMS OA, and so on.
November 2005	One unified number 50120 was announced to provide SMS domain name query service.
December 2005	MIIT and National Development and Reformation Bureau announced to promote the implementation of SMS solutions to small and medium-size enterprises.

(continues)

Appendix 1. Continued

March 2006	Both Alibaba (the largest electronic commerce company in China) and Haagen-Dazs won their lawsuits and thus finally got back their brands' SMS domain names that were originally registered by others.
June 2006	Kingdee International Software Group Company, one of the largest ERP providers in China, signed a collaboration contract with the Guangdong Branch of China Mobile and further explored the mobile commerce software application market.
July 2006	The very first "Book Search Engine" based on SMS Domain Name appeared in Shanghai, by which readers can retrieve and buy books via SMS.
July 2007	To address the huge volume of customer queries, many stocks and bonds companies used 50120 (service number of MobNIC) to provide in-time services.
September 2007	Guangdong Province branch of China Unicom launched "Corporation SMS" service. This service enables employees to notify, communicate, and collaborate using SMSs with premium prices.
March 2008	Baidu.com and China Netcom collaboratively launched an SMS search engine service.

Configuration IV: SMS Maturity and Transition to Microblogging Applications

May 2007	The first microblogging site Fanfou.com was created in China.
May 2008	During the massive 2008 China earthquake, microblog quickly reported the initial tremor, beating the first official mainstream news released from the U.S. Geological Survey.
August 2009	China's biggest Internet portal Sina.com launched its microblogging product Weibo.com and it grew quickly to first place in China's microblogging market.
August 2010	Guangdong Province branch of China Unicom cooperated with Weibo.com to facilitate application of mobile microblogging.
December 2011	The first multi- microblogging accounts management platform was launched. It helped enterprises manage, monitor, and evaluate their microblogging accounts.
December 2011	In 2011, there were already over 1,300 government blogs established, including 692 police blogs, 216 government agency blogs, and 426 individual officer blogs.
June 2012	Ministry of Industry and Information Technology of China issued a regulation, requiring all microblog users to register with their true names and identities.
April 2013	According to a report from China's Ministry of Industry and Information Technology [28], person-to-person text messaging in the country had decreased by 11 percent since 2012.
June 2013	The registered user population of Weibo.com increased to 536 million.

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