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Research and Practice on the Engineering Management Method of Financial Informatization Project

Abstract From the perspective of systems engineering, this paper analyzes the characteristics of China's bank card industry, including its accessibility, scale, and complexity. The author proposes a series of management methods for the financial informatization project by researching the general requirements of the financial information system and the characteristics and implementation of informatization in the bank card services. The paper concludes with an outlook on the future development of China's bank card industry.

Keywords: system engineering, financial informatization, engineering management method, bank card, informatization switching system

1 Introduction

The Golden Card Project is one of the pilot projects in China's financial informatization process, with the aim of developing electronic currency and to focus on its adoption. As a result, it will greatly promote the development of China's bank card industry. By 2014, China had issued 4.6×10^9 bank cards, and the inter-bank transaction amount has overtaken major international payment networks to rank first worldwide. The success rate of inter-bank transaction reached over 99% and the bank card penetration rate is 47%. In only 12 years, China managed to achieve the popularization of bank cards, skipping the stage of personal paper checks that developed countries once went through. The bank card informatization construction process not only promotes the industry's development but also drive the informatization of the entire financial industry, making informatization the pillar of the industry's development. Demonstrating features of a large industrial chain, low start-up level and demanding huge coordination efforts, the informatization in the bank card services is an epitome of that in China's financial sector. A systematic and in-depth summary of the experiences of the application of information technologies in the bank card services and a study of the systems engineering management method will offer important theoretical and practical guidelines for improving the level of information technologies and management level in China's financial sector. It also helps reduce the potential risks brought about by the application of information technologies.

From the perspective of systems engineering, the bank card information technology system is a complex giant system. The informatization project in the bank card services has the characteristics of systems engineering of accessibility, large scale, and complexity. It is tasked with solving the issues arising from the informatization in the payment system and the imbalanced level of information technologies among various stakeholders in the industry. Besides dealing with internal problems, the project is also expected to create a favorable external environment. Based on the theory and method of systems engineering and the informatization in the bank card services, this paper studies and proposes a series of engineering management methods that is applicable to China's financial informatization project.

2 Study on the general requirements of the financial information system

Informatization is the application of information technologies. Financial informatization is the process in which modern information technologies are applied to the financial industry. Through the application and evolution of modern information technologies, the financial industry is further developed so as to shift the focus for financial activities from the physical space to the information space, thus creating new models of financial management, service and operation. Financial informatization incorporates engineering technologies as well as complicated and

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unquantifiable factors such as people, information, society and commerce. The payment and settlement services can reflect the capital flow and the related information flow of economic activities. A financial information system is faced with both the problems of system and other complicated factors such as people and information. The settlement process is able to reveal the transaction price of a certain article as well as to discover the internal usage value of the capitals, hence playing a fundamental role in the distribution of market resources. Therefore, it calls for sustainable scientific management methods and correct guidance for the financial information system and the design, management and implementation of related technical standards.

2.1 Overall optimization

The construction of the financial informatization project involves breaking the previous balance and creating a new balance. It should realize the overall optimization and the sustainable development of the platform by optimizing the information system and achieving a win-win result for the financial services and the external environment. Due to its external environment and unique internal structure, a complex huge system should take both the internal and external factors into consideration as a whole. The system should coordinate the relationships among its sub-systems and make the best use of these components. The following two principles should be taken into consideration. First is the overall optimization. This ensures that when conflicts arise between the overall system and its sub-systems, the sub-systems should subjugate to the overall optimization. Second is to bring benefits to the external system. This requires a high-level analysis of the relationship between the system and its external environment and handling them as a whole. When programming the system, one has to realize that it is subject to the external environment. Therefore, only when benefit is delivered to the external system can it in turn bring positive feedback.

2.2 Balance and coordination

The components of the information system include people and the system itself. With the changes of time and market requirements, the overall balance will be influenced. It is pivotal that two states of balance coexist in order to improve the overall balance: One is to achieve static balance by coordinating complex internal factors; the other is to form a forwarding dynamic balance by identifying some stable, sustainable and constantly innovative driving forces, finally realizing self-learning and self-enhancement. Due to the correlation, interaction, dependency and constraints among the internal factors, when the decision-making process is complicated by multiple-goals, the decision maker should carry out a comprehensive analysis or evaluation on the goal and the factors, determining the priority and coordinating these factors so as to strike a balanced development of the whole system.

2.3 Layered management

The financial information system is hierarchically structured. One should familiarize himself with the layers and the distribution of the factors in the system, especially to identify the immediacy, importance, and priority of various factors before establishing an effective hierarchical management system. By appropriately layering the managed object, one can then design management methods according to each layer's requirement, improving management efficiency.

2.4 Development and improvement

The only thing that does not change is change itself. The financial information system undergoes constant improvement even the best system cannot remain static. With the changes of internal factor, external environment and people's perception, the system undergoes development and the perspective, viewpoints and criteria for the optimal choice also experience changes. The system should adapt to the new environment and develop corresponding new features and services in order to meet market changes and dynamic requirements.

3 Analysis on the features of China's bank card informatization project

The credit card was first invented in United States in 1950, which marks the bank card as a new payment medium coming into the financial market. It gradually became an emerging power in the financial industry. In 1993, as the informatization wave started to sweep the world, many countries began to employ information technologies to advance their level of financial modernization. Compared with the developed countries where financial communication networks and electronic payment are widely used, the financial informatization level in China lagged far behind. A great many financial transactions were handled manually, and the economic operation depended heavily on cash, which accounts for 90% of the whole financial circulation. The over-reliance on cash and circulation outside the regulation system brought much inconvenience to both individual consumption and financial supervision and regulation.

To improve the situation, China put forward clear goals in 1993 on the electronization of financial management, i.e., to construct a non-cash payment system, to rapidly develop the bank card industry and to establish a unified bank card market. Soon, a national key project, the "Golden Card Project", was launched aiming at popularizing and interconnecting the bank card system.

The Golden Card Project is an informatization project with the goal of achieving currency circulation through electronic payment transfer and computer network system. It takes computer and telecom communication technologies as the foundation and the bank card as the medium. As the first major information system project driven by cross-ministry efforts since the foundation of the People's Republic of China, the Golden Card Project promoted the electronization and informatization in finance, commerce, tourism and other industries. It has also improved the development of China's information industry in all aspects, raised the public awareness of informatization, and facilitated the scientific, harmonious and sustainable development in the economy and the society, boosted social advancement and national informatization process. The project is highlighted by the following features.

3.1 Difficult coordination

Because the informatization is a subversive and recreation process that overturns the established mindset, creates new procedure, changes the system, innovates the application model and redistributes interests, it posed great difficult in coordination. At the inception of the project, the government emphasized the importance to overcome sectionalism, mobilize the enthusiasm of various parties, and implement matrix management to organize the project. In September 1993, the office of National Golden Card Project was established by 5 ministries or ministry-level institutions, i.e., the Ministry of Electronics Industry, the Ministry of Posts and Telecommunications, People's Bank of China, the Ministry of Internal Trade and the National Tourism Administration. In addition, the Coordination and Leading Group of the National Golden Card Project was formed by 11 departments, responsible for facilitating the coordination efforts. The Golden Card Project was the first cross-ministry, cross-region informatization project on the national level approved by the State Council since the launch of the informatization construction in 1993.

3.2 Low level of informatization

From the time when the first credit card was issued in Zhuhai in 1985 to the launch of the Golden Card Project in 1993, 5 commercial banks had issued a total of 4×10^6 cards nationwide. In 8 years, one card per 300 people on average and only 40,000 merchants were enabled. The bank card usage was low and the consumers were far from being used to making electronic payments. Furthermore, the function was relatively simple and inter-bank or cross-region transaction was impossible. Meanwhile, the communication network and optical cable technology had not been widely adopted, and the transfer of payment information had to rely on satellite communication. The overall informatization was in a relatively backward stage. By contrast, credit cards were widely used in developed countries, with an average of 1.5 to 5 cards per person. In the United States, cash flow even accounts for only 18% of the financial circulation.

3.3 Distinct features of platform, multiple participators, difficult management

The bank card industry as a representative of the financial service industry is a typical two-sided market. Only when the transactions are conducted via a unified and standard platform can the major parties interact with each other which results in a scale effect. Specifically, the information exchange platform plays a fundamental and crucial role. The essence of the financial informatization is, with the assistance of information technology, to design and build a transaction platform in the two-sided market. Through the platform, it is enabled to coordinate the relationships between the service objects on two sides, establish a bilaterally beneficial business model, develop the standard system, regulate the participators' operations and finally achieve the scale effect. As the process involves multiple players in the two-sided market in addition to the balance between the internal and external factors, it requires enormous efforts on the management and coordination.

3.4 Large industry chain and complicated relations between the whole and the parts

The degree of difficulty to manage a huge engineering system is proportional to the management scale, the number of the objects and the related systems. From the perspective of the ecosystem, the bank card industry covers 23 categories and 69 subcategories, ranging from issuing, switching, acquiring, card manufacturing, and terminal manufacturing, to the related third parties and value-added service. It also relates to four industries comprising finance, manufacturing, service and information. From the technological perspective, the disciplines involved include system integration, integrated circuit, information security, cryptography, the Internet, communication, risk control, trouble-shooting and the related testing and certification technology. The large industry chain calls for outstanding administrative wisdom and effective method to balance the interests between the whole and the part and to unite the entire industry and concentrate the resources.

4 Practice of China's bank card informatization project

The bank card informatization project has witnessed the cooperative efforts by various parties in the industry through the integration and innovation of information technology. By taking the experiences from the process, the author has proposed innovative engineering management methods that are suitable for China's real situation.

4.1 Insistence on the high-level design approach of ordered macro-planning, and overall optimization

The start-up stage of China's bank card market lasted from mid-1980s to the early 1990s. In this period, China issued the first bank card and the general public gained an initial impression on the bank cards. However, due to the lack of unified organization and administration, individual commercial banks had to adopt their own technical standards and business regulations, which posed restraints on the business and made the inter-bank transaction impossible. The development was relatively slow at that time.

In 2002, China UnionPay was founded under the approval of the State Council. Serving as the core of China's bank card industry, China UnionPay has centralized the processing of China's bank card information exchange.

Due to the special position of the bank card switching system in the industry chain, it requires that the construction of the system can correctly lead the innovation trend of the bank card industry from an overall perspective and with a high-level design, so as to construct a secure and efficient financial information platform to serve the interest of its customers.

Before China UnionPay established its inter-bank transaction switching system, the bank card systems were faced with a series of issues. For instance, the networks were decentralized, resulting in a low transaction quality with a success rate of 48%. The development of the switching system was a massive and challenging project which is featured by its complicated functions, various interfaces, long duration and high demand for compatibility, security, reliability and stability. When the project was launched in 2002, we started up the high-level design based on the guideline of "grasping the principal contradiction" and following the three basic principles of overall optimization, appropriate hierarchy and ordered coordination. We have also set up three general design requirements. First, the planning of the project should be integrated, systematic and coordinated. Second, the system design should be strategic and take security as the first priority. Third, the solution should be operable and feasible.

According to the high-level design, the architects of the project have demonstrated three stages for the development of the bank card system, i.e., the centralization of the switch system, the unification of the settlement system, and the construction of a cloud-based electronic payment platform. The project follows the principles of integrity and synthesis. The adaptability of the system towards a complex and dynamic environment was greatly improved through multi-layered interaction within the industry chain. After continuously optimizing the system model and the unit components, the core switching system was finally established and named as China UnionPay Switching System (CUPS). *Figure 1* illustrates the architecture of the CUPS. It could well fulfill the transaction requirements of carrying billions of bank cards and serving hundreds of millions of customers and tens of millions of merchants. The system is capable of processing tens of thousands of transactions per second and a single transaction can be processed within several seconds with a success rate of over 99%. The CUPS achieves an advanced level both in China and worldwide in terms of transaction processing

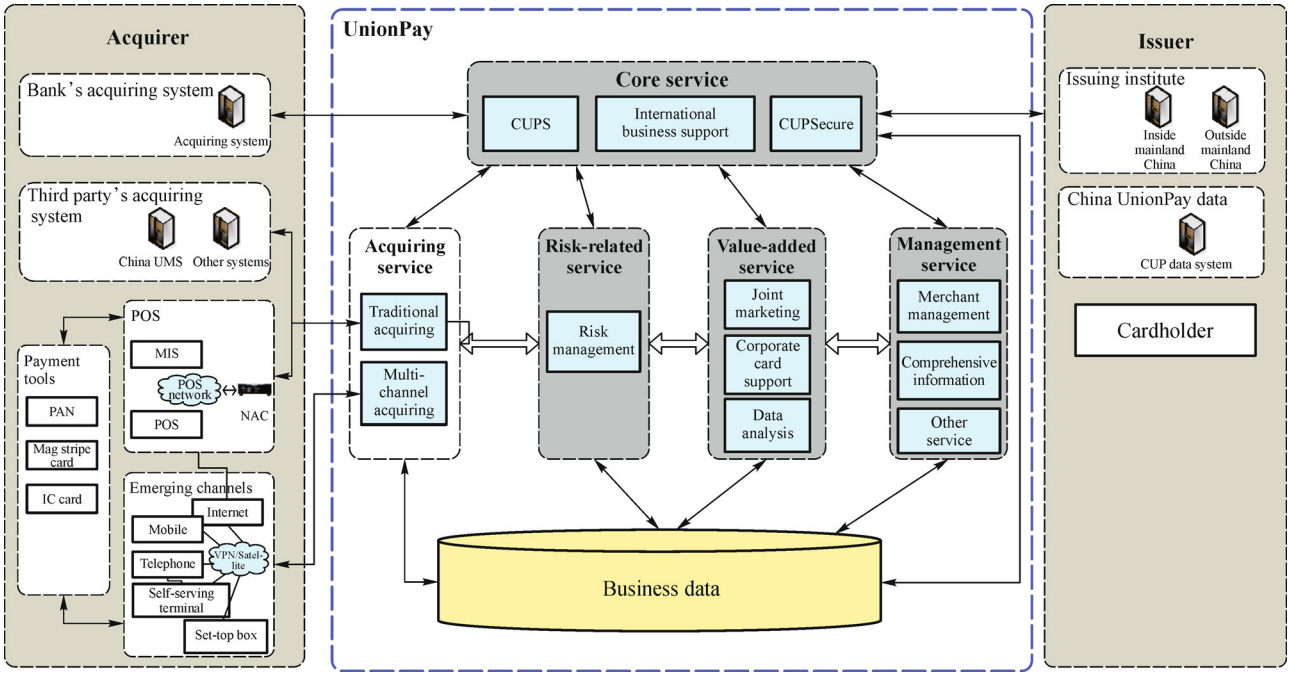

Figure 1. The architecture of CUPS.

capability. So far, the bank card service of China UnionPay has been extended to 150 countries and regions.

4.2 Building hub by developing standards first

The bank card standards system plays a guiding role in the development of the bank card industry. A well-established and mature standards system is the basis for the industry to be well-operated and sustainable.

The establishment of China UnionPay promotes the interconnection of the settlement systems among different banks through China UnionPay's standard switch interface and settlement network, which makes the inter-bank, cross-region and cross-border transactions become possible. As the standardization progresses, all the participators in the industry chain begin to adopt the standards. The transaction quality has been improved rapidly with the advance of the standardization level and information processing efficiency, resulting in a scale effect in the bank card industry.

Technical standards can standardize the research and development process of different technologies and unify the communication interface, which brings the benefit of reducing the cost, coordinating the development of each section, integrating resources and improving efficiency. More importantly, as far as the bank card industry is concerned, the concept of "developing standards first" points out a way for innovation and facilitates the progress of internationalization, realizing the rapid and sustainable development of the entire industry. By the end of 2014, a total number of 4.6×10^9 UnionPay cards have been issued, ranking first in the world. As shown in *Figure 2*, The bank card transaction amount reached 4.499×10^{14} CNY in 2014, an increase of 37.5 times as against the amount in 2002; at the same time, the inter-bank transaction amount even hit 4.1×10^{10} CNY, increasing by 228 times. The numbers of merchants accepting UnionPay card, POS terminals and ATM machines were 1.203×10^7, 1.594×10^7, and 6.15×10^5, respectively. The rate of bank card transactions in the domestic total retail sales was constantly on the rise, increasing from 2.7% in 2002 to 47.7% in 2014. The wide acceptance and popularization of bank cards have brought convenience to both consumers and merchants, which plays a key role in stimulating the domestic demand, increasing consumption and employment while promoting the economic development.

4.3 Establishment of forward-looking and innovative organizing mechanisms

Modern payment industry is the most robust emerging industry in terms of innovation and business model. It serves as the foundation for the financial modernization. In order to adapt to the market change, it is important to keep promoting the self-improvement of the information system. On the aspect of the innovation, the author has developed a "Dual Drive" mechanism, which is driven by market demand and the technological development, as illustrated in *Figure 3*.

On the market level, a rapid transmission mechanism should be established to react to the market change and the consumer's requirement change. New research and development topic can be set up through market investigation and consumer feedback. Based on the principle of SMART (specific, measurable, attainable, relevant, and time-based), a goal management mechanism can then be formed. The requirements can be classified into different

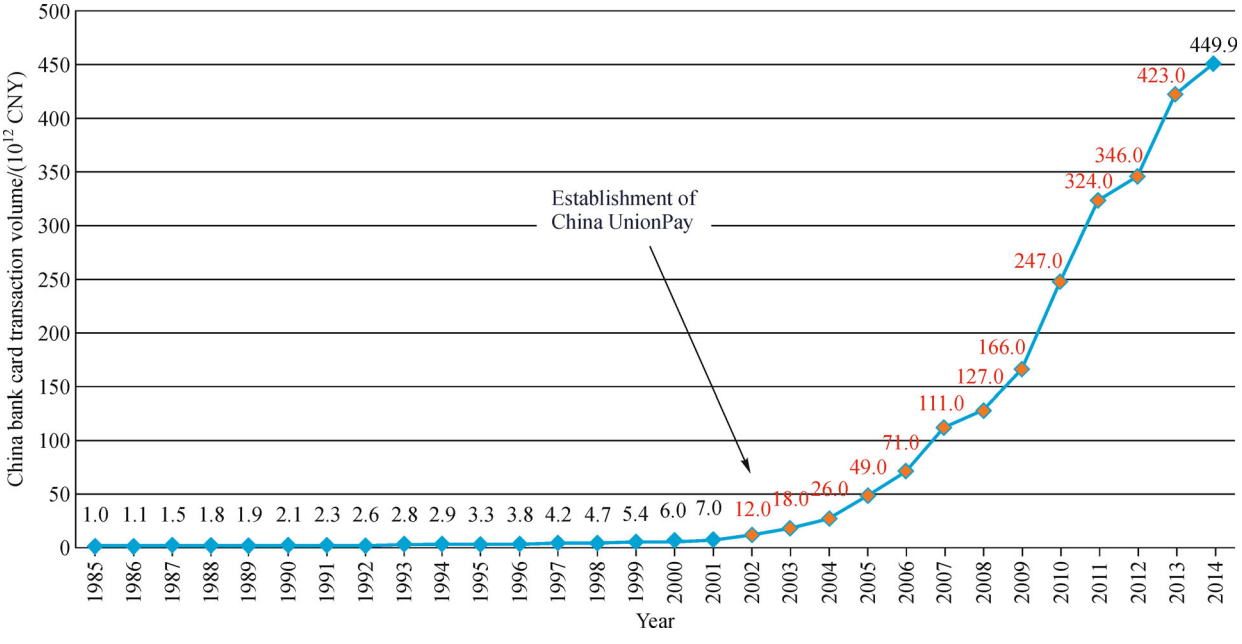

Figure 2. China bank card transaction amount (1985–2014).

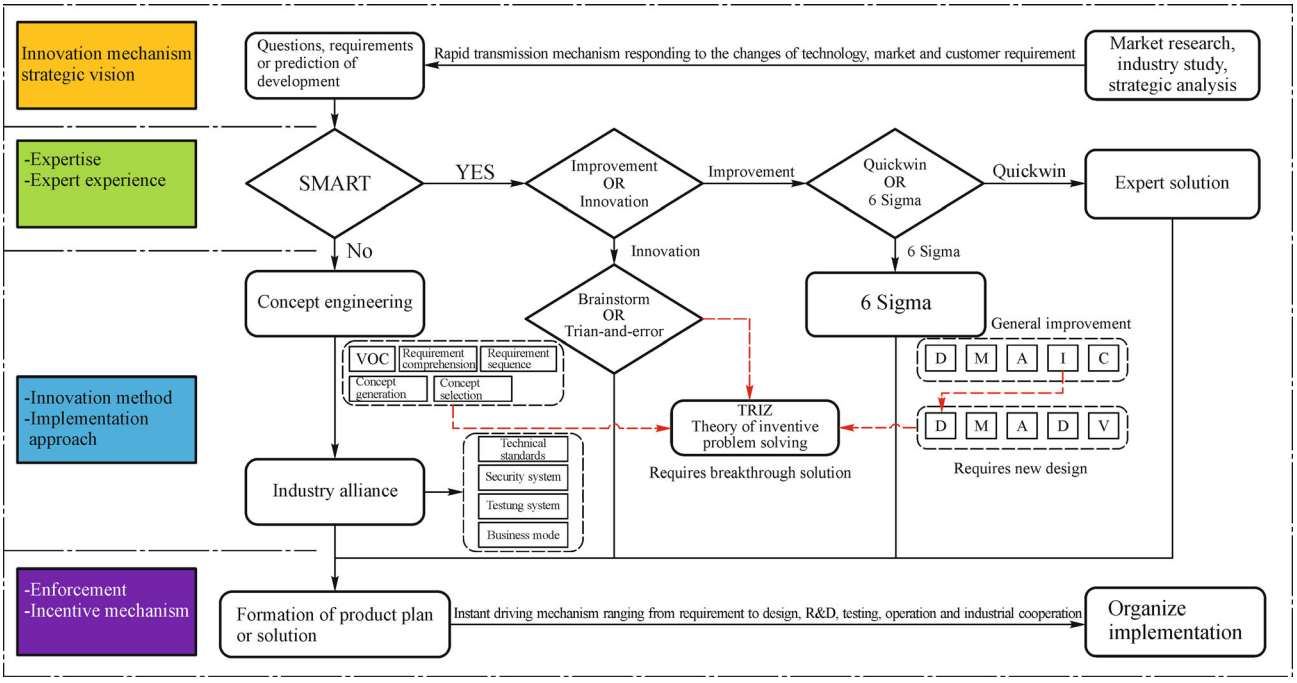

Figure 3. Innovative organizing mechanism based on SMART.

categories such as innovation requirements, improvement requirements and prototype concepts. Distinct innovation approaches and solutions could be adopted according to these categories and their priority, finally to improve the current system or to conduct pre-investigation on the advanced technology.

On the technology level, the product design is driven by new technologies in accordance with the requirements of "Dual Sides and Dual Extremes" to enhance the product, namely the extreme user experience on the client side and the extreme security and reliability on the platform side. For the user-oriented products, in particular the rapidly updated financial payment products, it is essential to distinguish the priority and immediacy and identify the customer's frustration or "pain point" so as to promote the ultimate user experience of the core requirement.

From the research and development perspective, to realize the requirements of a complicated system, it is crucial to employ the industry resources to tackle the key technical difficulties and to identify the trend of the innovation and conduct forward-looking research. Two effective measures were adopted in the bank card informatization project:

1) Establishing industry alliance and expert database to solve cross-disciplinary issues. By organizing industry alliances, we managed to form an expert database, which incorporates senior experts from the areas of chip, mobile device, terminal, card and mobile payment. Through holding regular seminars and setting up workshops, the experts convene to study and discuss the technical standards. Such a regular seminar mechanism supports the continuous development of the standard system, promoting the construction and application of several key projects including the establishment of the Financial IC Card National Security Testing Center.

2) Cooperating with key research institutions to form a research and innovation mechanism that engages the industry, universities and research institutes. It is important to conduct the research and application on the new technologies, especially the integration of cross-disciplinary technology. Strengthening the cooperation with the engaged parties can further integrate resources and make possible the sharing of results to an even wider scope. In this way, each party's advantage can be maximized to best effect and the joint efforts will lead to transforming the research outcome into industrial standards and applications.

From the implementation perspective, commercial self-discipline mechanism and a management method can be adopted to ensure the effective implementation of the innovation. The bank card standards system is supported by scientific theories and technologies, as well as business modes and market administration methods. Therefore, in the construction and development of the bank card system, we adopted the most advanced technologies and integrated them into practice. In the meantime, we also introduced the corresponding market operation mode and self-discipline mechanism. For instance, China's bank card industry has established a certification management mechanism in the form of "bank card organization, labs and vendors". By restricting the products, the suppliers and consumers of the products through the testing and certification, the

mechanism is able to ensure the timely and effective implementation of the standards. Meanwhile, we also collected feedback from the market and made adjustment on the standards accordingly to meet the actual market needs.

4.4 Establishment of scientific requirements management model

The bank card informatization project is a complex systems engineering undertaking. Its internal and external requirements are also featured by being systematic, international, dynamic, inter-related and economic. It calls for scientific requirements management and organizing management method to optimize the process of research, analysis, design and realization.

In the process of requirements management, the requirements management method for complicated systems can be established by adopting integrated engineering method, as shown in *Figure 4*. The basic thinking is to follow the systems engineering principles such as integral view on the business investigation, synthesized application of the technologies and scientific decision making. Among these principles, the integral view is to take all the factors within the system as a whole, analyzing the relationship between the system and its environment from a high-level perspective. We integrated the experiences of the bank card industry with the theories, statistics and computer science technology and built a mathematical model and simulation system for requirement analysis and verification. By simulation, large-scale prototype validation and expert review, the validation result and solution can be formulated. Through various applications and empirical study, the methods are able to coordinate and synchronize the industry construction, project implementation and goal achievement. It further cooperates with the existing systems to ensure the correctness, accuracy and feasibility of the bank card information switching system.

4.5 Layered management method of technical security standards

The rapid increase of business requirements and forms of products requires a secure and unified standards operation management system. Hence, the author has proposed a layered management method of technical security standards with "the security principle" and "dual direction model" at its core. To be specific, the method divides standards into two layers, with the upper layer defining security management principles and the lower layer specifying concrete standard items. By summarizing the basic security requirements of standards of similar categories, the method creates a series of principles applicable to financial payment technical standards, which are used to instruct the development and improvement of the detailed standards. Instead of the one-way management, the relationship between the upper and lower layer is a two way model characterized by interaction, cross reference and mutual improvement.

From top down, the upper layer is characterized by three main functions. The first is to offer a security guideline. The upper layer provides the basic principle and security

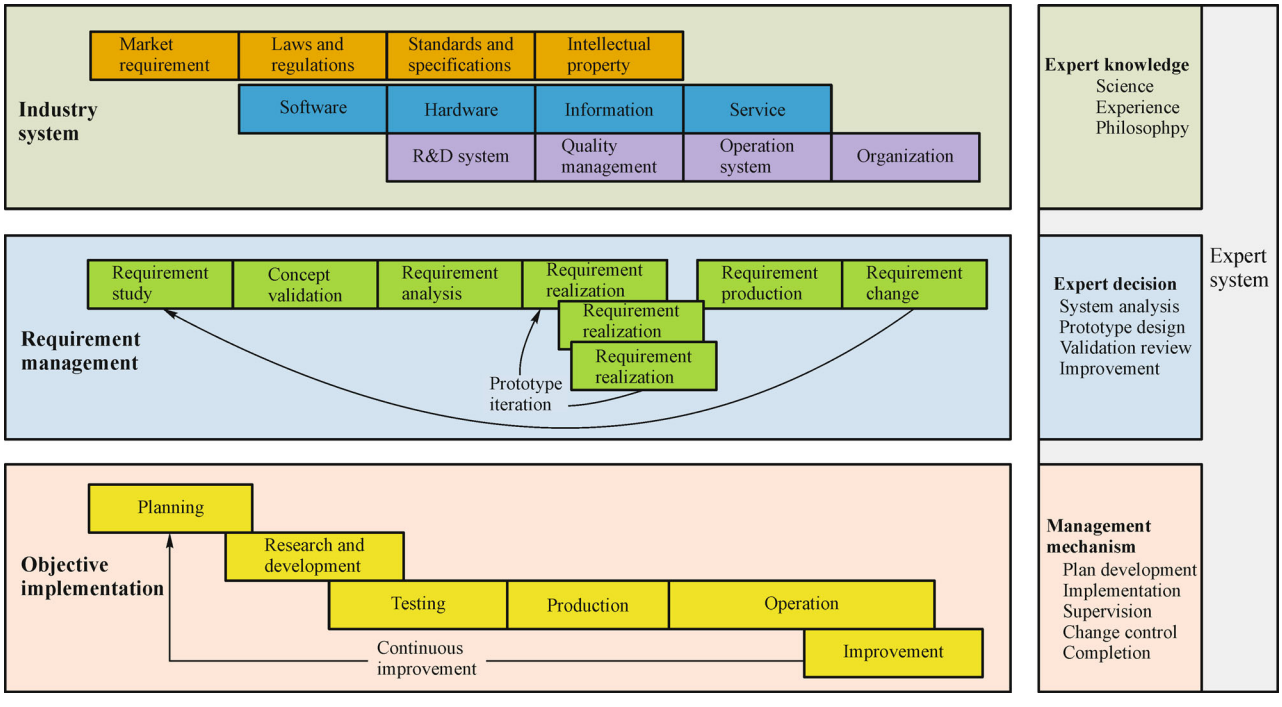

Figure 4. Requirement management method for complex system.

framework to guide the composing of the lower layer standards. This ensures that the basic security content of the lower layer is complete and in line with the established security requirements. The second is to validate. By verifying and scoring the basic security of the technical standards, it is the business security and the logical security that can be ensured. The third is to keep improvement in tandem. The principles of the upper layer should be constantly enriched and improved with the introduction of new technologies. It then instructs the lower layer standards to make adjustment accordingly. By this way, a regular and proactive improvement mechanism can be formulated.

From bottom up, the lower layer standards interact with and help improve the upper layer principles. The formulation of the concrete standards can inversely act upon the upper layer and test whether the security coverage is comprehensive. The application and constant improvement of its security capability will raise further requirements for the upper layer, facilitating the improvement of security level and integrity.

4.6 Emphasis on the balanced improvement method

The balanced improvement method is in essence the combination and application of strategy, mechanism, and evaluation. On the aspect of innovation, the "Dual Balance" strategy can be adopted, i.e., to achieve the balance of investment and risk control and the balance of technology advancement and market prevalence. On the aspect of the research and development of the products, the "Dual Mode" mechanism can be applied, i.e., to develop the key technologies on its own and to conduct common fundamental research jointly with partners. On the aspect of evaluation, the "Dual Effects" evaluation system can be used, i.e., to strengthen its own competitiveness and at the same time drive the coordinated development of the industry, so as to create a sustainable and balanced industrialization approach. In this way, it can be achieved that the effect of the whole is greater than the totality of its parts.

5 Outlook on the future of bank card informatization engineering

With the advent of the era of the internet, plus the bank card industry as the entry to modern financial service and payment, we are now facing a profound and complicated revolution. The following four aspects of the future bank card informatization trends deserve serious consideration:

1) First is to form a more open platform, to attract more participators in the industry and to fully reflect their interests.

2) Secondly, new technologies will bring about new opportunities. The emerging technologies such as the mobile internet, cloud computing and big data will give rise to innovation in the payment industry. To reflect these driving factors, the bank card informatization project should introduce the new technologies and business model, and cultivate an innovation consciousness and self-improvement mechanism.

3) Thirdly, the application of new technologies will pose challenges to the management of risk control. Technologies including big data, cloud computing and mobile internet confront the industry with new risks. Non-face-to-face transactions including mobile payment and remote payments break the original security rule. Card-not-present transaction and cloud-based payment bring better consumer experience but also lead to higher risk of information leak, thus complicating the protection of information. It is crucial to strengthen and improve the risk control system of the payment industry in such new technology environment.

4) Fourthly, the development strategy becomes increasingly international. With the advance of China's "One Belt One Road" strategy, the acceptance of RMB-denominated bank card as well as the scope of RMB settlement services will expand, making possible for the RMB to become an international currency and offering opportunities for exporting China's bank card service and the related standards. Therefore, it is essential to anticipate the market trend and follow the nation's development strategy. To facilitate the internationalization of the RMB, the industry can cooperate with overseas institutions to support local infrastructure construction, improve local bank card environment and devise localized payment products. The industry is also encouraged to share its experience with overseas institutions and in turn enjoy the outcome of cooperation.