From Standards to Implementation: Multi-Application Financial IC Card Platform Design, Key Management, and Industry Application Deployment in China

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Abstract
China's financial IC card has evolved from a secure payment instrument into a multi-application carrier for public services, yet fragmentation in card specifications, key systems, and terminal standards has limited cross-industry and cross-regional interoperability. This article synthesizes and systematizes technical designs from a provincial-scale implementation, covering application card specification design, industry key management systems, POS terminal docking specifications, cross-industry financial IC card platform architecture, and typical industry applications including metro, bus, traffic enforcement, and SE-based mobile banking. By integrating specification-level design with platform and application implementation, the article provides a reproducible blueprint for constructing open, secure, and shareable multi-application financial IC card ecosystems aligned with national standards (PBOC, financial mobile payment standards) and GlobalPlatform-compliant TSM architectures.

1. Introduction

Although financial IC cards are widely deployed in China, early multi-application practices often followed a "one card, one application" pattern, with different industries, cities, and banks independently loading applications and defining card file structures (Luo & Xie, 2019; Zhao & Zhang, 2017). This autonomy led to incompatibilities in application card structures, key systems, and POS terminal behavior, making it difficult to achieve provincial or national-level networking and shared use of industrial applications (Luo & Xie, 2019; Kuckertz, 2006). As a result, citizens frequently needed multiple cards for transportation, healthcare, social security, and other services, wasting resources and undermining the policy goal of "one IC card for all purposes" (Zhao & Zhang, 2017).

In response, national and provincial authorities called for unified technical planning of application card specifications, industry key systems, and POS standards, as well as construction of cross-industry financial IC card platforms capable of supporting multi-application sharing and secure connectivity with mobile finance infrastructures (People's Bank of China, 2013; State Council, 2013). The implementation in Guangdong Province, building on PBOC standards, financial mobile payment standards, and GlobalPlatform-aligned secure elements and TSM, provides a concrete case of how specification design, key management, POS docking, and platform architecture can be integrated to address fragmentation and enable large-scale deployment (Li, 2017; GlobalPlatform, 2012).

2. Methods: Design- and Case-Based Synthesis

This article adopts a design- and case-based synthesis method using Chapters 3–6 of Hu Wei's dissertation as the sole primary technical source (Hu Wei, 2024). Formal specifications of application card structures for public transport, utilities, and health applications, as well as associated industry key systems and POS docking rules, are extracted and reorganized thematically (Luo & Xie, 2019). The overall architecture of the Guangdong provincial financial IC card and mobile finance platform, including system components, interfaces, and business processes, is reconstructed from the described design and implementation (Li, 2017; GlobalPlatform, 2012).

Typical industry applications (metro, public transport, traffic penalty handling, SE-based mobile banking) are summarized as concrete instantiations of the specification and platform designs (Chen et al., 2017; Wang, 2017). Because the thesis documents both specification- and implementation-level details and cites national standards such as PBOC 1.0–3.0 and the financial mobile payment standard series, another researcher can reproduce this synthesis by following the same mapping from chapters to thematic sections and cross-checking against these standards (People's Bank of China, 1997, 2005, 2010, 2013).

3. Application Card Specification Design for Multi-Application Use

3.1 Public Transport and Utility Applications

The application card structure for financial IC cards in Guangdong is designed to support multiple public service applications—such as public transport and utilities—within a unified framework that complies with PBOC financial standards and provincial industrial requirements (People's Bank of China, 2013; Luo & Xie, 2019). For public transport, the card structure defines dedicated application identifiers, data elements, and transaction flows that support different card types (ordinary cards, senior cards, student cards) and flexible discount modes, while ensuring that fare calculation and transaction logging coexist safely with the core financial application (Zhao & Zhang, 2017; Wang, 2017). For utilities such as water, electricity, and gas, the specification reserves application spaces and data objects to support payment and consumption recording, sharing the same physical card and secure environment with financial and other industrial applications (Chen et al., 2017).

Industrial application data are stored using secure files with appropriate access conditions, separating public-service data from core financial data while retaining interoperability where needed (GlobalPlatform, 2012; Luo & Xie, 2019). Harmonizing application identifiers, file structures, and access control rules across industries reduces the risk of incompatible card profiles and supports future applications without requiring complete redesigns (Kuckertz, 2006).

3.2 Health and Resident Applications

The specification also defines structural design for financial IC cards carrying resident health applications that integrate medical insurance and hospital services on top of the financial base (Chen et al., 2017). Health applications must satisfy privacy and regulatory constraints while enabling card-based identification, medical record referencing, and medical expense payment in hospital environments (Luo & Xie, 2019). This is achieved through dedicated application spaces, secure storage of sensitive health identifiers, and controlled interaction with external hospital systems via POS or specialized terminals, so that the same card can function simultaneously as a payment card, citizen card, and health card (Chen et al., 2017; Zhao & Zhang, 2017).

4. Industry Application Key Systems and POS Docking Specifications

4.1 Industry Activation and Management Keys

To support secure multi-application deployment, the design introduces separate industry application activation keys and management keys, along with corresponding key systems and dispersion mechanisms (Li, 2017; Wang, 2017). The industry activation key system controls secure opening and activation of industrial applications on financial IC cards, defining how master keys are derived and dispersed to generate application-specific keys while preventing unauthorized activation (GlobalPlatform, 2012). The management key system handles lifecycle operations such as updating, suspending, or closing industrial applications, again using dispersed keys and standardized derivation rules to balance security with manageability across many organizations and terminals (Liu et al., 2017; Li, 2017).

These key systems provide a common security foundation for industrial applications across the province, reducing the need for each city or industry to define proprietary schemes and facilitating interoperability and centralized risk control (GlobalPlatform, 2012; People's Bank of China, 2015). The separation of activation and management roles, combined with explicit dispersion mechanisms, also supports role segregation and auditability, which are important for financial and public-service governance (Li, 2017).

4.2 POS Terminal Docking and Parameter Management

The POS docking specification ensures that terminals in different industries and regions interact consistently with financial IC cards and the provincial platform, covering blacklist download, parameter management, and transaction message formats (Zhao & Zhang, 2017; Chen et al., 2017). The design extends traditional financial POS specifications to support industrial blacklists and promotional activities, both of which are critical for public transport and other public services but were not fully supported in earlier standards (Luo & Xie, 2019). Platform parameter management defines how terminals

obtain and update operational parameters (tariffs, discount rules, application profiles) from the provincial platform, enabling coordinated changes across many terminals and organizations (Wang, 2017; Liu et al., 2017).

By standardizing POS behavior and its linkage to card applications and backend services, the docking specification closes gaps that previously prevented seamless cross-industry use of financial IC cards, especially in small and medium-sized cities that lacked mature industry application management systems (Zhao & Zhang, 2017). This unified design reduces local customization burdens, centralizes blacklist and parameter control, and supports rapid promotion of financial IC cards in new public-service fields (Luo & Xie, 2019).

5. Provincial Financial IC Card and Mobile Finance Platform Architecture

5.1 Overall Architecture and Functions

Building on unified card, key, and POS specifications, Guangdong constructed a provincial financial IC card and mobile finance platform characterized by openness, security, and interoperability (Li, 2017; Hu Wei, 2024). The architecture comprises card management, industry application management, key management, settlement and clearing, and interfaces to national mobile financial public service platforms, all aligned with China's financial mobile payment standards (People's Bank of China, 2015; Liu et al., 2017). The platform connects heterogeneous systems operated by banks, industry operators, and service providers, providing a common technical and business foundation for financial and industrial applications (Wang, 2017).

Functionally, the platform supports industry registration, application loading and lifecycle management, key exchange, and IC card application services such as industrial card data queries and updates (Hu Wei, 2024). It also integrates a mobile finance sub-platform (SPTSM) that manages secure elements in mobile terminals, including application publication, download, instantiation, personalization, locking/unlocking, deletion, and application provider management in line with TSM and secure element standards (GlobalPlatform, 2012; People's Bank of China, 2015).

5.2 Business Processes and Lifecycle Management

The platform formalizes business processes such as industry registration, client application download, key exchange, and IC card application services, ensuring that all actors interact via standardized, auditable workflows (Hu Wei, 2024). These processes align with national financial and mobile payment standards and are designed to be reusable templates that other provinces can adopt with localized parameter adjustments (People's Bank of China, 2013, 2015). Explicit linkage between process design

and underlying card, key, and POS specifications helps prevent misalignments that can cause integration failures or security weaknesses (Li, 2017; GlobalPlatform, 2012).

6. Typical Industry Applications

6.1 Metro and Public Transport Sub-Platforms

The metro application uses financial IC cards and mobile financial IC cards as carriers for subway fare collection, solving problems of secure storage and transmission of industrial data such as entry–exit records, fares, and discounts (Chen et al., 2017; Wang, 2017). The implementation optimizes transaction processes and tapping speeds, enabling first-time use of common financial IC cards and mobile financial IC cards in subway scenarios in China while maintaining coexistence with other industrial and financial applications (Hu Wei, 2024).

A public transport industry sub-platform supports bus applications across the province, including small and medium-sized cities that previously lacked industry application management systems (Luo & Xie, 2019). It manages multiple card types (ordinary, senior, student), flexible discounts, and backend services for various operators, all based on the unified card and POS specifications and provincial platform architecture (Zhao & Zhang, 2017; Chen et al., 2017).

6.2 Traffic Penalty Handling and SE-Based Mobile Banking

The traffic police penalty application extends financial IC card use to law-enforcement scenarios by securely storing and transmitting driver and driving license information and enabling payment and processing of traffic offenses on common financial IC cards open to all banks (Hu Wei, 2024). This demonstrates how industrial information beyond typical payment or transport domains can be encapsulated within the same multi-application framework while preserving security and interoperability (Luo & Xie, 2019).

The platform also supports SE-based mobile banking by integrating financial IC card logic into mobile intelligent terminals via secure elements and TSM-managed lifecycle operations (Liu et al., 2017; Chen Yanli, 2017). Using the SPTSM sub-platform, banks and application providers can publish, download, and manage mobile financial applications on secure elements, enabling mobile banking and payment services with hardware-backed security and compatibility with existing financial IC card acceptance environments (People’s Bank of China, 2015; Wang, 2017).

7. Reproducibility and Blueprint Value

Because the Guangdong implementation is documented in terms of card specifications, key systems, POS docking standards, platform architecture, and business processes, it serves as a reproducible blueprint for other regions seeking similar multi-application ecosystems (Hu Wei, 2024). The design explicitly references national standards (PBOC series, mobile payment standards) and international frameworks (GlobalPlatform, TSM), which are versioned and publicly specified, facilitating independent verification and adaptation (People's Bank of China, 1997, 2005, 2010, 2013, 2015; GlobalPlatform, 2012). Extending this blueprint to future digital currency and secure hardware wallet deployments will mainly involve reusing these architectural patterns and aligning them with emerging digital currency specifications (Li, 2017; Liu et al., 2017).

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