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Research on Designs of Modern Payment Systems in China

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Abstract: In this paper, we focus on the design of the modern payment system in China, especially the third-party payment systems. The reason for the flourishing the third-party payment systems including Alipay, WeChat is the demand of government and enterprise units for electronic transaction payment that has had a profound impact on the financial industry, then the traditional banking business model cannot meet the needs of online payment. We conduct research on the main third-party payment systems and solutions in the Chinese market, focusing on the payment system design and principle architecture. We analyze the key issues of the operation of the payment systems, and we also illustrate some possible suggestions in relation to the improvement of China's payment system. Because of the modern financial system characteristics in China, enterprise and institutions need to invest a lot of funds and implement advanced technologies to solve the increasing transaction volumes, lack of manpower, and funds. In terms of subsystem design, we present the access and internal subsystems that provide all types of services based on a full system. We also want to share the case of emphasizing the Alipay system architecture, the study still needs to be focused in detail. Our paper presents the accounting and financial processing design of Alipay. It involves two subsystems, internal and external. The external subsystem is a unilateral account to meet online performance requirements; the internal subsystem uses double-entry subsystems to meet financial needs. In order to compete with other payment service companies like WeChat, our study proves that Alipay payment application program implementation and service accounts on the platform are able to provide direct in-app payment service to users. In this paper, we highlight the feature due to the third-party online payment connection with the internet system with the bank and the service they offer is dependable and safe. The third-party online payment has a completely safe method, which transmits the encryption data from the internet bank system across the safety of the certificates, making sure the account transactions from the customer are safe and the digital signature. In this paper, the architecture design of Jingdong payment platform is emphasized as another powerful design of the payment system in China. The paper concludes that third-party modern systems help with contemporary solutions of financial smart collections, business transactions, networking, digitization, and multi-point distribution.

Keywords: Payment Systems, Payment Gateways, Financial Companies, Fintech

1. Introduction

China's banking system has undergone significant changes in the last two decades. As a result of the significant changes, China's banking system has gained more autonomy. There are several advanced payments systems such as Real-time gross settlement (RTGS), China's National Advanced Payment System (CNAPS) composed of the High-Value Payment System (HVPS), the Bulk-Entry Payment System (BEPS), and the Settlement Account Processing System (SAPS) [1].

However, the demand of government and enterprise units for electronic transaction payment has had a profound impact on the financial industry, and the traditional banking business model cannot meet the needs of online payment. For instance, traditional payment systems such as credit cards or

PayPal are simply not going to work in China.

In order to survive and gain a competitive advantage in the network economy environment, the banking industry has invested heavily in information technology and launched its own Internet financial services (including electronic services such as online banking and online payment), trying to provide customers with comprehensive Electronic trading platform and online payment clearing service [2].

Currently, the China's automatic payment systems have developed many interactive links among the money market bond market, and foreign exchange market. Specifically, Chinese mobile payment services benefit from third-party payment platforms, such as Alipay and WeChat pay [3].

For instance, features of Internet banking, its interactive links are:

1) Full realization of paperless transactions.

2) The service is convenient, fast, and efficient.

3) Low cost of use.

With the introduction of online banking in various banks, people find that it is not convenient enough to use online banking to conduct transactions on the Internet. The service is more cumbersome and rigid. Subject to various conditions, banks are not very active in dealing with such issues of Internet banking. The most difficult condition is that setting up mobile payments in China is one of the biggest problems when foreign companies enter China's online market. Therefore, third-party payment companies such as UnionPay, WeChat Pay, and Alipay penetrated into market (Figure 1).

Currently, these three main Chinese payment systems dominate the market. Therefore, we focus on the designs of these three modern payment systems, and their key designs of payment system operations.

Figure 1. *Third party payment in China.*

We also illustrate some possible suggestions for the improvement of China's payment system. Therefore, the third-party online payment as a modern payment system came out for the sake of resolve these issues.

2. Features of the Modern Systems

The original online payments have three main parties including the buyer, seller, and bank, now the third-party platform was joined in these three parties. Therefore, the payment process is described by four parties. The role of the third-party payment is like a bridge to decrease the expenditure from the service of bank, and remove the suspect of the transaction parties [4].

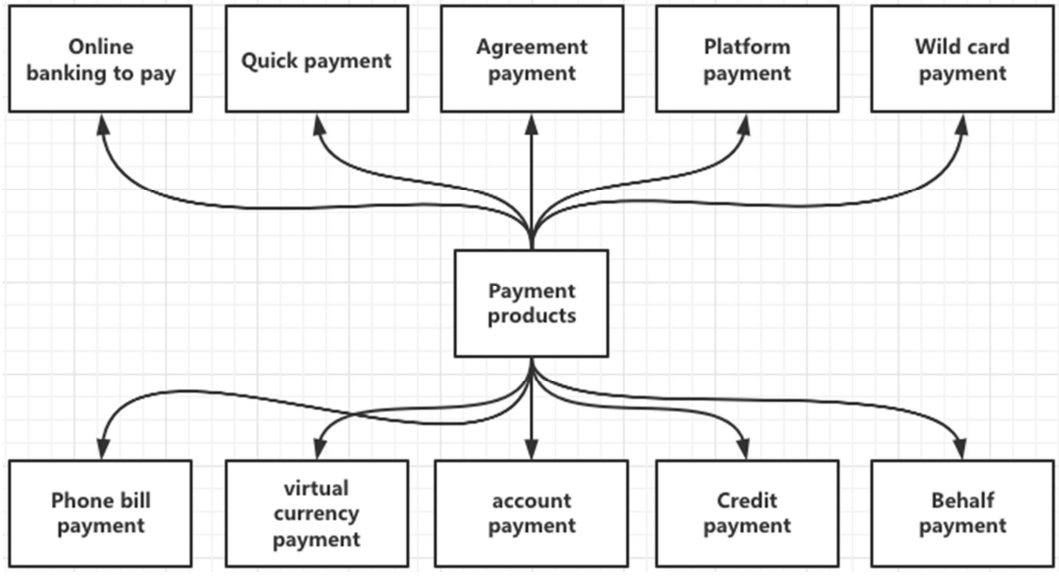

Figure 2. *Common payment products in China.*

The interfaces provided by banks and third-party payment channels to external systems are often packaged into payment products (Figure 2). Due to the third-party online payment connection with the internet system with the bank and the service they offer is dependable and safe. The third-party online payment has a completely safe method, which transmits the encryption data from the internet bank system across the safety of the certificates, making sure the account transactions from the customer are safe and the digital signature [4, 5].

Now that there are already powerful payment systems like UnionPay, VISA, and Alipay that provide payment and settlement capabilities for government and enterprise units. The different parties for these payment systems provide the unity methods for capital flow for three business activities, logistics, and information flow due to the transaction from different parties will be integrated [4].

However, still there are several major risks in modern payment systems. With the increasing number of people using the third-party online platform to deposit lots of money, there is no specific regulation for restricting the amount of money, and it may cause risks including cash and liquidity risks, legal risks, operation risks, as well as credit risks. For instance, some third-party online payment platform offers illicit channels in order to get cash from the credit card, due to not all the third-party online payment platform working with the real transaction. On account of the competition from other industries, the operators and users from third-party online payment platforms are up against liquidity risk. If the third-party online payment didn't send the money to the seller which kept their deposit in the expected time and the lack the inflow, the seller will face liquidity risk [4, 5].

In addition to the risk features, there are several beneficial features. The third-party online payment as an intermediary agent, depending on the commercial bank, becomes the credit intermediary between the two sides, establishing a favorable credit environment, and promoting the development of the e-business. And it also increases the scope of business for the commercial bank, accelerates innovation, expanding the business from B2B to B2C and C2C. And it also reduces the cost for the bank [5].

In addition, from the perspective of business development, adopting the above-mentioned solution may encounter the following problems [6].

1) Disaster recovery: If there is a problem with the third-party payment or banking system, it may cause the access party system to be unusable.
2) Fund security: All funds flow through a third party. If there is a problem with a certain link, it may lead to funding security issues.
3) Data security: All accounting data is stored in a third party. If there is an abnormal situation in the third party, important data may be lost or leaked.
4) Inconvenient for management and control: It is impossible to do deeper customized development, resulting in the inability to carry out certain business scenarios.
5) High handling fee: The channel usage fee will be charged for the capital flow through the three-party platform, and the docking party has no bargaining power.
6) Missing payment scenarios: For example, some bank cards or channels are not supported.

To sum up, it is very necessary and urgent for large and medium-sized government and enterprise units to establish their own payment systems [6].

3. Process, Requirements Overview

Here, the whole system working process is described based on the demand of a state-owned enterprise "telecom company call bill payment system". The basic functions that need to be provided in the system [3, 5].

1) User query and create payment order.
2) The user submits the order to the payment system of the telecommunications company, and the payment system of the telecommunications company checks the order. If there is no problem, the payment interface is called to execute the payment.
3) The payment system checks the validity of the parameters, especially the validity of the signature.
4) Select the appropriate acquirer according to the payment method selected by the user and the system payment routing settings. Note: Common payment methods include various banks, UnionPay, VISA, Master Card, Alipay, WeChat Pay, etc.
5) Call the acquiring interface to execute the payment.
6) After the payment is successful, the acquirer transfers the money to the account of the telecommunications company, and the telecommunications company completes the write-off.

For other non-functional requirements, we involve the followings:

Performance: How to meet performance requirements, especially when there are a large number of requests?

Reliability: The payment system has its own unique reliability requirements according to different business scenarios.

Ease of use: There are too many steps in the payment, which will lead to user complaints and criticism.

Scalability: With the ever-increasing payment scenarios, how to quickly meet customer needs, scalability is also a challenge for payment system design [6].

Scalability: For business growth, promotional activities are a must. Promotional activities will bring burst traffic. The best solution to solve the impact of burst traffic on system performance is to add machines. [5, 6].

The above analyzes the basic functions that the payment system should support from the perspective of process and concept.

4. On Design of Financial Payment Systems

Each company designs different payment systems according to its business and different stages of company development. The typical payment system architectures of Internet companies are described in the literature [7].

4.1. Alipay-Financial Company Payment System Design

The strongest Alipay system in China's industry, the overall architecture design of Alipay's payment system (Figure 1).

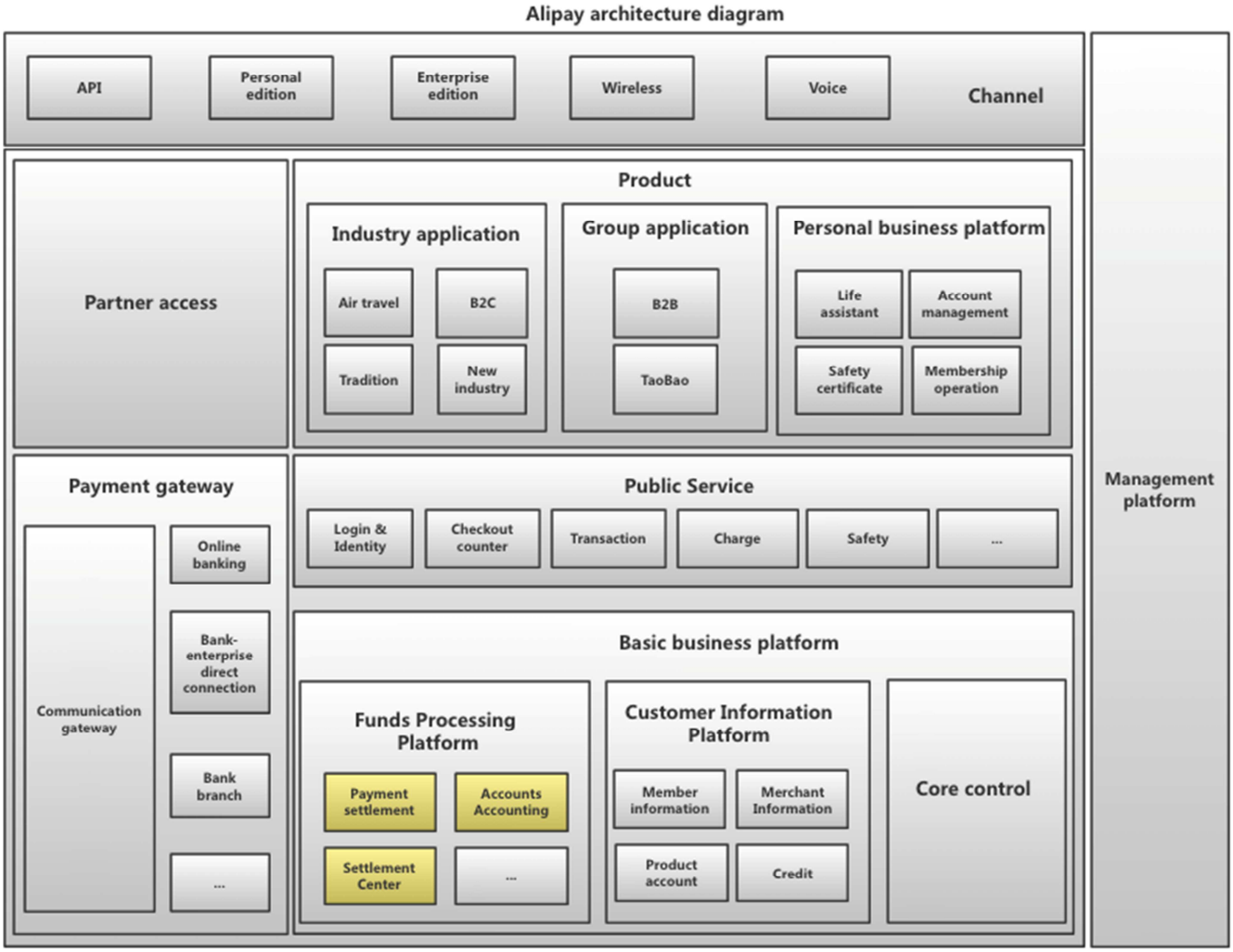

Figure 3. *Alipay architecture diagram.*

In terms of subsystem design, this figure shows that access and internal subsystems provide all types of services based on a full system. However, the Alipay system architecture document still needs to be studied in detail. Figure 2 presents the accounting and financial processing design of Alipay. It involves two subsystems, internal and external. The external subsystem is a unilateral account to meet online performance requirements; the internal subsystem uses double-entry subsystems to meet financial needs (Figure 2). In order to compete with other payment services companies like WeChat, Alipay payment application program implementation, service accounts on the platform are able to provide direct in-app payment service to users. Alipay offers payment services for both online and offline purchases. Customers are allowed to either pay for products on web pages or pay in-store by scanning the QR codes of products provided by offline retailers. Tencent said the opening of its WeChat Pay to business came earlier than expected. According to the different characteristics of Alipay and WeChat Pay, and the market share changing that described above, we believe that the factors influencing Alipay and WeChat Pay adoption intention are different. In figure 1, we know that although there are various kinds of third-party mobile payment service providers, Alipay still occupied more than half of the market share and their market share has changed a lot [7]. We believe that the factors influencing Alipay and WeChat Pay are different, and also will be different from other mobile payment providers.

In Alipay, the external interface adopts a unified parameter method, refer to the APP request parameter description. Interface parameters are divided into three layers: public parameters, business parameters, and business extension parameters (Figure 1). Among them, the public parameters are common to each request through the management platform.

Business-related parameters are spliced on business content through specific rules. Finally, generate a signature with the parameter and put it in the sign field. Unlike Alipay, WeChat Pay uses XML format for message transmission. In its interface document description, there is a detailed description of the XML message format [7]. The signature string is also used to ensure the security of the interface, and the signature result is placed under the signed tag. Flexible transaction processing, using the message mechanism (MQ)

to achieve cross-system transaction processing, avoiding performance problems caused by database locks.

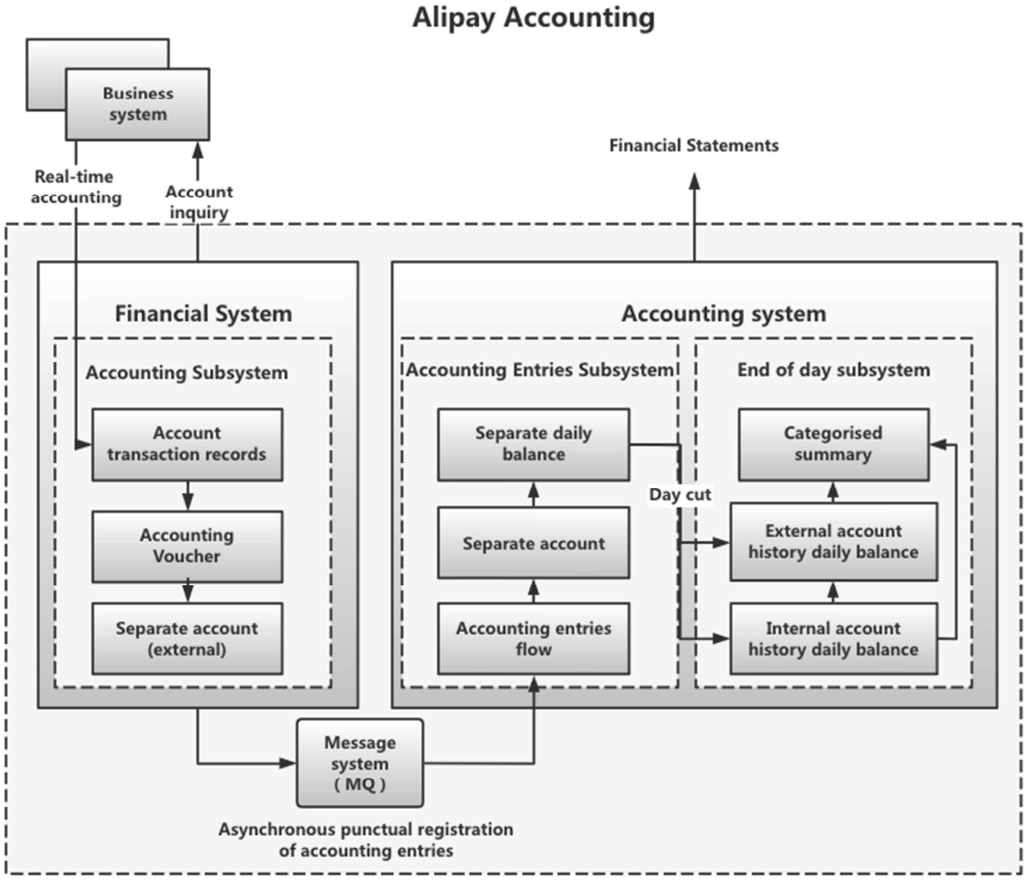

Figure 4. *Alipay Accounting.*

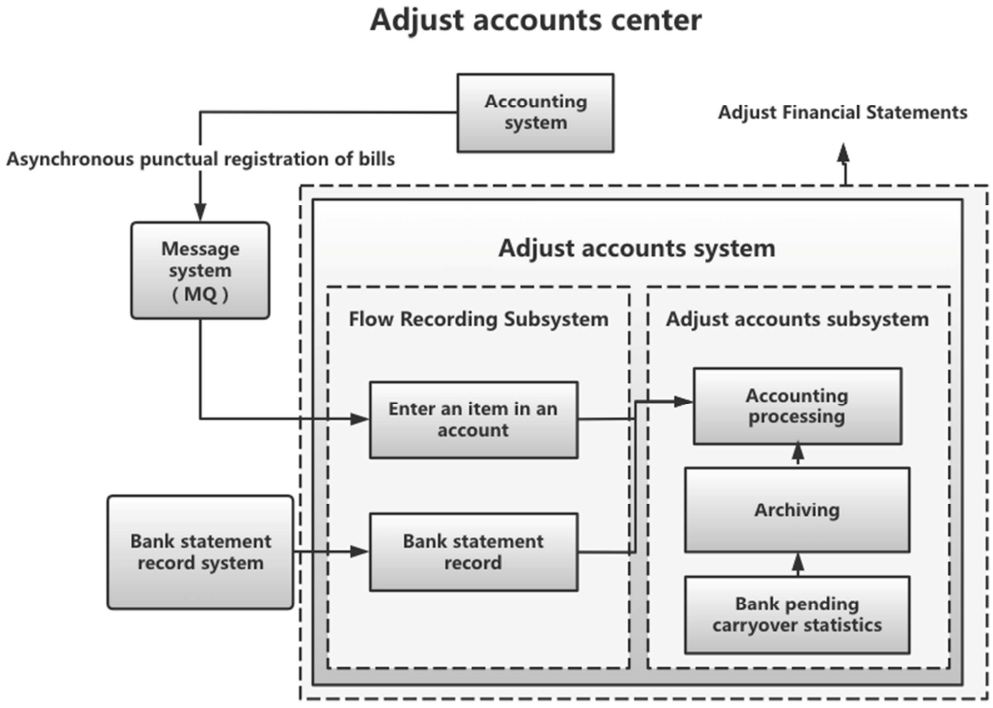

Figure 5. *Alipay Adjust Accounts Center.*

Alipay has mobile Apps and users can make a transaction through the mobile Apps directly or scan the QR code using their phone online/offline. When using the Apps, users need to register an account number first and bind a bank card

through the bank statement record system.

The transaction process is very easy to handle since users only need to enter the password and the transaction will be finished. Alipay has multi-functions online/offline shopping, repaying for credit cards, recharging for SIM cards, calling and paying for a taxi, ordering a train ticket, paying for electricity/water bills, etc. Alipay has a communication function [7, 8].

There is an extensive study in third-party mobile payment has been conducted to understand how a relatively successful third party mobile payment ecosystem is created and sustained through the cooperation of various actors by adopting Alipay wallet [9]. While firms like Alipay, such as JDPay which possess an online shopping mall, can provide preferential policy to attract more users. For example, the users can get a chance to use a discount coupon if they choose to use JDPay of JD system [7].

In Alipay, there are several limitations, for example, when items are dropped in a purely data-driven manner, the meaning of the constructs may change. In this case, revalidating the trimmed scales with new data can be argued to increase the validity of the scales. In addition to the Alipay above-mentioned limitation, we suggest considering an additional study is the conceptualization of trust [7, 9].

4.2. JD Financial Platform Company System Design

The architecture design of Jingdong payment platform is another powerful design of the payment system in China (Figure 6). In addition to the formal architecture, studies tend to focus on the key areas of natural language processing, computer vision, and machine learning. The system constantly enhances the power of the most important parts of JD's business, such as search and personalization.

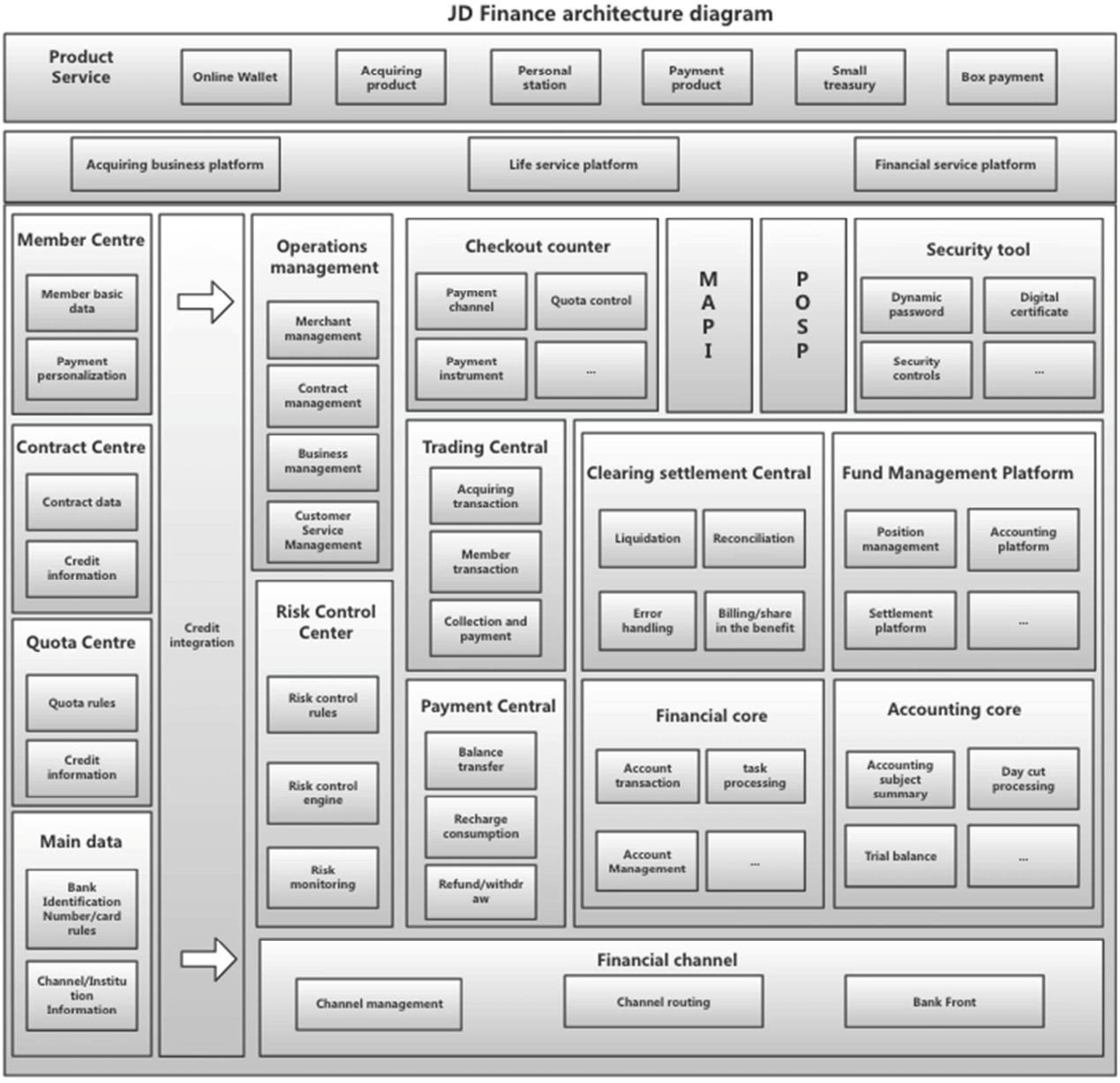

Figure 6. *JD Finance architecture diagram.*

JD Finance was developed on the basis of the acquisition of China bank Payments, and later introduced talents from Alipay, so it was greatly influenced by these two companies in terms of structure [7]. As far as payment systems are concerned, information is relatively scarce. Mature commercial systems on the market involve capital security issues and generally adopt the method of prohibiting external communication to prevent core system information from leaking. These architecture documents are all from Internet public information. Whether the architecture truly reflects the actual system situation needs to be judged by oneself. Based on these documents, we analyze the proper software architecture of the payment system [8].

5. On a Typical Payment System Design

According to the design documents of various payment platforms and bank gateways, and we extract the following modules based on the design elements [9].

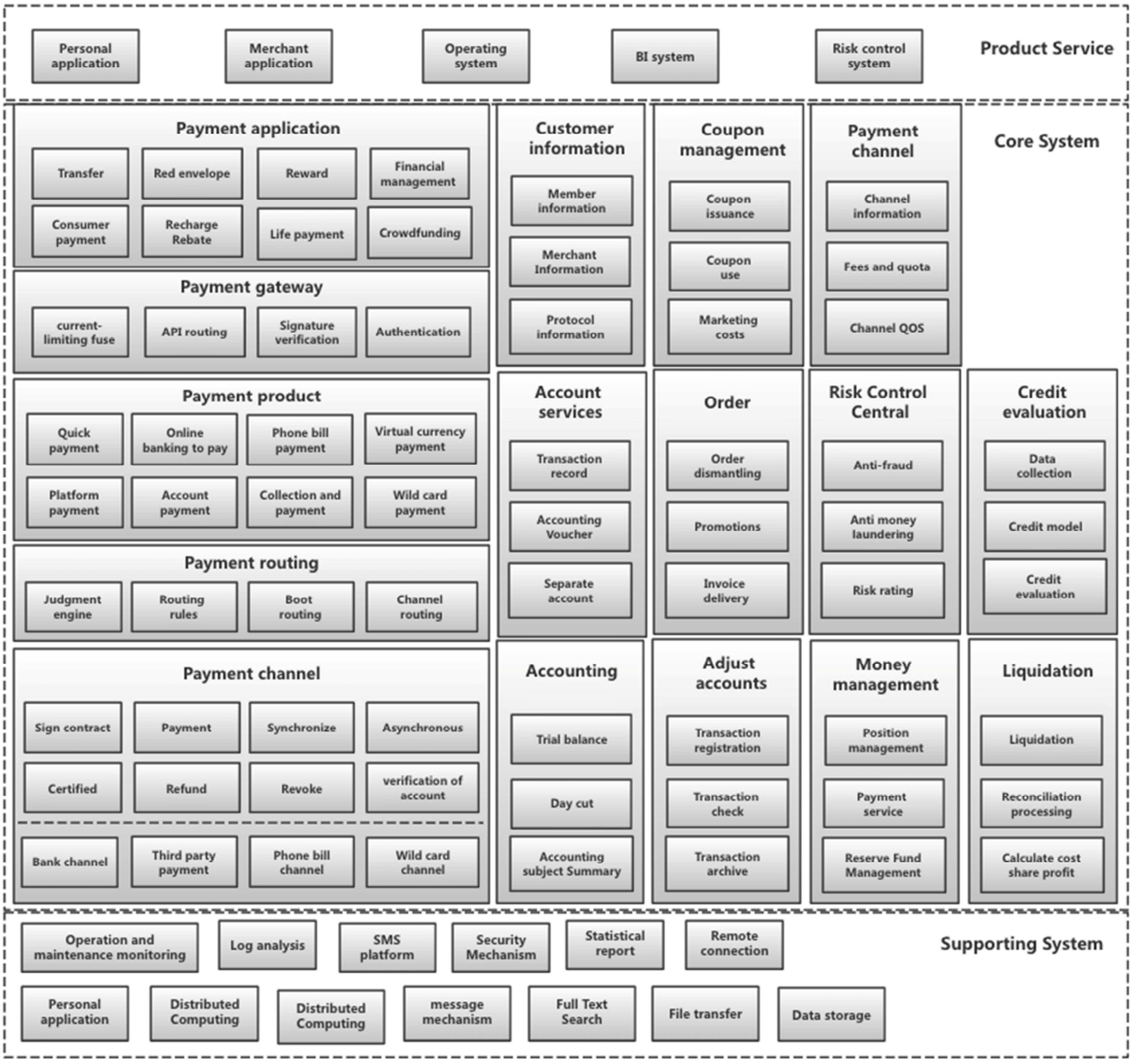

Figure 7. *Payment system architecture diagram.*

The payment system is structurally divided into three layers including the support layer, core layer, and product layer (Figure 7).

The basic software package and infrastructure of the support layer are used to support the core system, including the operation and maintenance monitoring system, log analysis system, etc. The core module of the payment system is divided into two parts: the payment core module and the

payment service module.

The product layer is used to access end users, merchants, and operation managers through the combination of services provided by the core layer.

5.1. Core Architecture Design

The supporting system is the infrastructure provided by a company for the operation of the payment system (Figure 7). It mainly includes the following subsystems [9]:

1) Operation and maintenance monitoring: The payment system will inevitably be affected by various internal and external interferences during its operation, such as fiber optics being cut off, hackers attacking, databases being deleted by mistake, bugs in the online system, etc. The operation and maintenance personnel must Respond to these unexpected events at first time, and can't keep an eye on them 24 hours a day. This requires an operation and maintenance monitoring system to assist.
2) Log analysis: The log is an important basis for statistical analysis and operation and maintenance monitoring of the payment system. Companies need to provide infrastructure to support the unified collection and analysis of logs.
3) SMS platform: SMS plays an important role in the payment system: identity verification, secure login, password retrieval, and alarm monitoring all require the support of SMS.
4) Safety mechanism: Safety is the lifeline of payment. SSL, certificate system, anti-swipe interface, etc. are all necessary facilities for payment.
5) Statistical report: The visual display of payment data is the basis for the company to make decisions.

Remote connection management, distributed computing, message mechanism, full-text search, file transfer, data storage, machine learning, etc. are all basic software necessary for building large-scale systems.

5.2. Payment Service Area

The payment core system refers to the core process for users to perform payment (Figure 7) including:

1) The user initiates the payment process from the payment application. Then the payment application invokes the corresponding payment product to transfer payment according to the application, and the payment tools selected by the user.
2) Third party payment system performs the payment channel processes based on payment tools, channel rates, and interface stability to implement payment to perform the payment operation, and finally transfer the funds.

The service system is divided into a basic service management system, capital system, risk control, and credit system [10].

The payment basic management system provides basic business functions that support the operation of the online payment system including:

1) Customer information management: including the management of real-name identities, basic information, and agreements of users and merchants;
2) Coupon management: management of the process of making, issuing, and using coupons, vouchers, and discount coupons;
3) Payment channel management: management of channel interface, configuration parameters, fees, limits, and QOS (Figure 7);

The account service system manages account information, transaction records, accounting vouchers, etc. The ordering system implements payment orders, invoices, and promotions, and the fund system controls fund verification, scheduling, and management system that generates financial accounting.

The risk control system is an essential basic function of the payment system. Risk-free payment systems provide advanced anti risks functions developed on the basis of risk control techniques, for example, Jingdong Baitiao, Huabei as successful examples.

6. Technical Difficulties and Solutions

In payment systems, the connection between the payment gateway and the payment channel is the core function. Among them, the payment gateway can be the principal interface for providing external services, the fund operations require channel support need to be distributed to the corresponding channel modules through the gateway. However, there are gateway functions that are difficult to adjust. The payment channel module receives the gateway's request and calls the channel interface to perform fund operations. The reason is that the interface and transmission method of each channel is different, therefore, the role of the payment gateway works similarly to the decoration wrapper in the design pattern. The function of the gateway is to provide a common interface for the business, and some public operations that interact with the channel will also be placed in the gateway [11].

6.1. Payment Design Area

In general, the main difficulty and risky payment processes involve the following processes [12]:

1) The merchant-side application initiates a payment request from the server side. For instance, once a user pushes on the "Pay Now" button from his mobile phone, the merchant's server first generates an order, then the payment request executes the payment.
2) The payment request is sent to the payment (API) gateway. API gateway performs basic processing including QPS controls, signature verification, etc., and then channels are established based on the corresponding payment request for online banking, express, foreign card, etc.
3) The payment product preprocesses the user request, including performing parameter verification, finding a suitable payment channel according to the payment

route, evaluating transaction risks, generating an order, calling the channel to execute the payment, responding to the channel result and notifying the merchant of the transaction result side.

4) The payment channel executes the payment that is encapsulated through the front of the payment channel. The front of the payment channel provides an interface with the payment channel, and that interface completes the final payment operation. The interface is also related to the external gateway parameters. The interface design describes the above interface processes through payment platforms in the industry [13].

Another difficult area can be described by the interconnection among payment gateway, payment routing, and payment product. The system has divisions of responsibilities among payment gateways, payment products, and payment channels as follows [14]:

1) Payment products are divided by according to payment ability.
2) Payment products provide functions that are independent of payment channels and related to the payment process.
3) In each payment product, the public functions are implemented on the payment gateway. According to the interconnections, the main functions are implemented on the payment gateway [15]. The main functions are the followings, mainly API routing, routing interfaces for safety with fusing, current limiting, and isolation.

6.2. Signature Design Area

Signature verification function that signs the interface parameters and verifies their signatures. This is the most important part to prevent the unguaranteed interfaces from being stolen and tampered with. The sign parameters that need to be used in this area are the parameters to be signed [15]. If a unified signature rule is adopted for each interface, it can be implemented at the gateway layer. The verification function confirms whether the payer, payee, and channel that have permission to perform the current operation.

6.2.1. Signature Mechanism

Signature mechanism is described by the following strings to be signed:

```
string[] parameters={
"service=mer_cancel",
"charset=utf-8",
"mer_id=9996",
"version=4.0",
"res_format=HTML",
"order_id=123456789",
"mer_date=20110101",
"amount=500"
};
```

Sort each value in the array in order from a to z, if the same first letter is encountered, look at the second letter, and so on.

After the sorting is complete, connect all the array values with the "&" character, such as:

amount=500&charset=utf-8&mer_date=20110101&mer_id=9996&order_id=123456789&res_format=HTML&service=mer_cancel&version=4.0

This string is the string to be signed.

6.2.2. RSA Signature

When signing, the private key and the public key are required to join in the signature together. These two keys are generated by the client through OPENSSL. When signing, what the customer needs to use is the customer's private key and the public key of the gateway platform [16].

To sign on request, after getting the string to be signed in the request, put the string to be signed together with the client's private key into the signature function of RSA to perform the signature operation, so as to obtain the signature result string [17, 18].

To verify the signature when the notification returns, after obtaining the string to be signed when the notification returns, put the string to be signed, the public key provided by the gateway platform, and the value of the parameter sign in the notification return parameter of the gateway platform into the RSA signature function for the asymmetric Signature operation to determine whether the signature is verified [19].

6.2.3. Signature API Method Description

To generate signature, public static String sign (String dataString) throws SignEncException [19]. In our research, the following input and output functions are used:

Input parameter: String, which is the string to be signed.

Output parameter: String, which is the signature string.

Throwing an exception: SignEncException, a subclass of Exception, indicating that the signature failed, and the calling method needs to be caught or thrown.

In signature data verification [19], public static boolean verify (String dataString, String signString) throws SignEncException: In our case, the following finctions are used:

Input parameters: dataString, which is the string to be signed, and signString is the signature string.

Output parameters: boolean, which is the verification result, true means the verification is passed, and false means it fails.

Throwing an exception: SignEncException, a subclass of Exception, indicating that the verification failed, and the calling method needs to be caught or thrown.

7. Conclusion

The payment system is mainly divided into three principal layers including the support layer, core layer, and product layer. Within this principle design, the architecture of the payment platform is described based on the microservice architecture. In this paper, we focus on Alipay system, its main design, and architecture. Because of the modern financial systems in China, enterprise and institutions need to invest a lot of funds and implement advanced technologies to solve the increasing of transaction volumes, lack of

manpower, and funds. In this study, we especially focus on the third-party modern systems, especially Alipay that implements advanced solutions of financial smart collections, business transactions, networking, digitization, and multi-point distribution unto a market.

To conclude our research, we emphasize that the key area of a platform is the payment system area that provides payment services to internal and external systems, especially the transaction system for the contract signing, payment, refund, recharge, transfer, contract termination, etc. In addition, we conclude that the third-party system process of implementation level is basically similar to each other including placing an order, canceling an order, returning an order, and checking an order. However, in Alipay, each operation implementation includes 7 steps of parameter verification, payment routing, order generation, risk assessment, calling channel services, updating orders, and sending messages. Some more complex payment channel services, also involves asynchronous and synchronous notification processing.

In the study, the following functions are the riskiest functions in payment products: risk control interception, payment routing, parameter verification, and payment process that generate transaction records, execute payment, notifications, and other operations through landing channels. Alipay provides services to all parts of China, then it will be launched as a payment product to provide services to the outside world. The solution of the operation of the payment systems illustrates some possible suggestions in relation to the improvement of China's payment system.

References

[1] Sappideen, Razeen & He, Ling, “The Payment System in China”, 2009.

[2] S. Li, "Research on the Design of Electronic Payment System of Financial Company," 2021 2nd International Conference on E-Commerce and Internet Technology (ECIT), 2021, pp. 91-94, doi: 10.1109/ECIT52743.2021.00027.

[3] Huang J, “How mobile payment is changing the world”, Digitalcommons.wou.edu/computer science_student pubs. pp. 3–21, 2017.

[4] Zhao, X. Sun, Y. 2012. A Study of Third-party Online Payment: Risk Control and Supervision Analysis. University of Shanghai for Science andTechnology [accessed 7 April 2017].

[5] Wang, L. The impacts of third-party online payment solutions on banks. China national knowledge Interne, 2016.

[6] F. Wan, J. Li, N. Ma, X. He, Y. Cao and H. Yang, "Research and Design of E-commerce Payment System," 2017 International Conference on Computer Technology, Electronics and Communication (ICCTEC), 2017, pp. 1294-1297, doi: 10.1109/ICCTEC.2017.00283.

[7] Mu, H.-L., & Lee, Y.-C. (2017). Examining the Influencing Factors of Third-Party Mobile Payment Adoption: A Comparative Study of Alipay and WeChat Pay. The Journal of Information Systems, 26 (4), 247–284. https://doi.org/10.5859/KAIS.2017.26.4.247

[8] Zhu Xuefeng, Design and implementation of electronic commercial draft management information system, Fujian: Xiamen University, 2015.

[9] Guo, J., Bouwman, H., “An Ecosystem View on Third-party Mobile Payment Providers, A Case Study of Alipay wallet,” info, Vol. 18, No. 5, 2016, pp. 56-78. L.

[10] Yingli, "Design and Implementation of QR Code Payment in Power Self-service Payment Terminal," 2021 6th International Symposium on Computer and Information Processing Technology (ISCIPT), 2021, pp. 432-435, doi: 10.1109/ISCIPT53667.2021.00093.

[11] J. Su H W, Zou D B, Yuan Y, Wen X L, and Chen J, Research on QR Code Technology in the Field of Public Transport Payment, Issue 12, Information Technology and Informatization, 2017, pp. 139-142.

[12] J. Guo J Q, Analysis on the Application of Two-Dimensional Code in Electricity Mobile Payment Terminal, Issue 24. Communication world, 2014, pp. 1 85-186.

[13] J. Lin H, Su H W, Xie Z D, Li J T, and Lu Y J, Application of QR Code Payment in One Card Self-service Card Selling and Recharging Terminal System, Issue 1. Electronic Technology and Software Engineering, 2019, pp. 97-98.

[14] J. Xu C B, Research on the payment application of "Internet +" mode QR code payment in rail transit AFC system, Issue 3. Electronic test, 2020, pp. 62-63.

[15] V. Sethaput and S. Adsavakulchai, "E-Payment and It’s Effects on Cash in Thailand," 2021 9th International Electrical Engineering Congress (iEECON), 2021, pp. 460-463, doi: 10.1109/iEECON51072.2021.9440063.

[16] C. Shuran and Y. Xiaoling, "A New Public Transport Payment Method Based on NFC and QR Code," 2020 IEEE 5th International Conference on Intelligent Transportation Engineering (ICITE), 2020, pp. 240-244, doi: 10.1109/ICITE50838.2020.9231356.

[17] L. Ahmad, R. Al-Sabha and A. Al-Haj, "Design and Implementation of a Secure QR Payment System Based on Visual Cryptography," 2021 7th International Conference on Information Management (ICIM), 2021, pp. 40-44, doi: 10.1109/ICIM52229.2021.9417129.

[18] Fei Shuai, Juan You and Zhensong Li, "Research on symmetric key-based mobile payment protocol security," 2010 IEEE International Conference on Information Theory and Information Security, 2010, pp. 340-344, doi: 10.1109/ICITIS.2010.5689606.

[19] D. S. Islamiati, D. Agata and A. R. Anom Besari, "Design and Implementation of Various Payment System for Product Transaction in Mobile Application," 2019 International Electronics Symposium (IES), 2019, pp. 287-292, doi: 10.1109/ELECSYM.2019.8901643.