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The Application of Cloud Computing in Financial Shared Services: Implementation Strategies and Benefit Assessment

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Abstract Problems such as dispersed financial data, low processing efficiency, and prominent security risks are becoming more and more prominent, and enterprises urgently need to build a unified and efficient financial management system. This study constructs a financial shared service system based on cloud computing technology, adopts a security architecture combining blockchain and threshold proxy re-encryption, and designs three core modules, namely, a financial sharing basic support platform, a financial sharing center platform, and a fund management platform. The study realizes data security sharing through the TDPR-BC scheme, and applies principal component analysis to comprehensively evaluate the economic benefits of enterprises. The results show that in terms of encryption performance, this paper's method exhibits better time efficiency compared with the dynamic change of user rights algorithm and the Bloom Filter algorithm; in the security test, when the amount of financial data reaches 20,000 items, this paper's method has only 9 data cracked while the other two methods have 81 and 96 data cracked, respectively; in the evaluation of the enterprise's benefits, an industry in the 2021 after applying cloud computing financial shared service the comprehensive score reaches 2.35, ranked first, compared with 0.56 in 2020 there is a significant improvement. The study shows that cloud computing technology can effectively improve the security and processing efficiency of financial shared services, create significant economic value for enterprises, promote the digital transformation of financial management, and provide important technical support for the construction of a modern financial management system.

Index Terms Cloud computing technology, financial shared services, blockchain, threshold proxy re-encryption, principal component analysis, digital transformation

I. Introduction

Under the background of economic global integration, Chinese enterprises continue to expand the scale, the emergence of many large-scale enterprises and multinational groups, while the high difficulty of financial management, high cost and other issues arise, so that the enterprise management and development is in trouble [1], [2]. Many large enterprise groups in order to improve financial efficiency, reduce financial processing costs, began to establish and implement financial shared service center, according to the market response, the implementation effect is more significant [3], [4]. With the development of science and technology, the financial shared service center constructed on the basis of cloud computing technology has been emphasized.

Cloud computing as an emerging technology element, not only can increase efficiency and speed up the financial operation and management, but also can provide technical support for the wide application of the company's financial cloud [5]. After the integration of cloud computing as a new technological element, the relevant financial software can be constantly updated and upgraded, the form of the financial department can be changed, and the organizational structure of the company can be innovated, which helps the company to achieve strategic transformation and upgrading [6]-[9]. At the same time, the company's business processes, personnel management, organizational structure and other aspects of the reengineering, some of the duplication, scattered business will be centralized in the shared center and scale of processing [10], [11]. This can enhance the company's understanding of the actual operating conditions of the subsidiaries and branches, improve the company's ability to operate and control, and lay the foundation for the company to carry out refined management and obtain more economic returns [12]-[14]. Of course, in order to make the enterprise financial shared services more in line with the actual requirements of enterprise development, to build a more intelligent and efficient financial shared service system, as well as to ensure the safety of financial information, which is an urgent issue to face the transformation and development of enterprises [15], [16].

Adopting a combination of theoretical analysis and empirical research, this study first constructs a financial shared service architecture system based on cloud computing technology, and designs a three-layer architecture model containing a financial sharing foundation support platform, a financial sharing center platform, and a fund management platform. In terms of security, the TDPR-BC scheme based on blockchain and threshold proxy re-encryption is proposed to ensure the security and integrity of financial data in the sharing process. In terms of benefit evaluation, the principal component analysis method is used to construct a comprehensive evaluation index system, and the implementation effect of cloud computing financial shared services is verified by analyzing the 12-year financial data of an industry. By comparing and analyzing the encryption performance and security performance of different algorithms, the technical advantages and practical value of this research proposal are evaluated to provide theoretical guidance and practical reference for the implementation of cloud computing financial shared services in enterprises.

II. Implementation strategies for the use of cloud computing technology in financial shared services

II. A. Cloud Computing Technology Overview

II. A. 1) Basic Concepts of Cloud Computing

Cloud computing is an Internet-based computing model that provides services such as on-demand computing resources, storage resources, and applications over a network, allowing shared computing resources (e.g., servers, storage, databases, networks, software applications, and services) to be accessed and utilized on an on-demand, elastic basis without the need to directly manage the underlying hardware. Cloud computing distributes computing tasks across a large number of distributed computing machines rather than relying on a single computing device, enabling the sharing and efficient use of computing resources, the cloud computing architecture is shown in Figure 1.

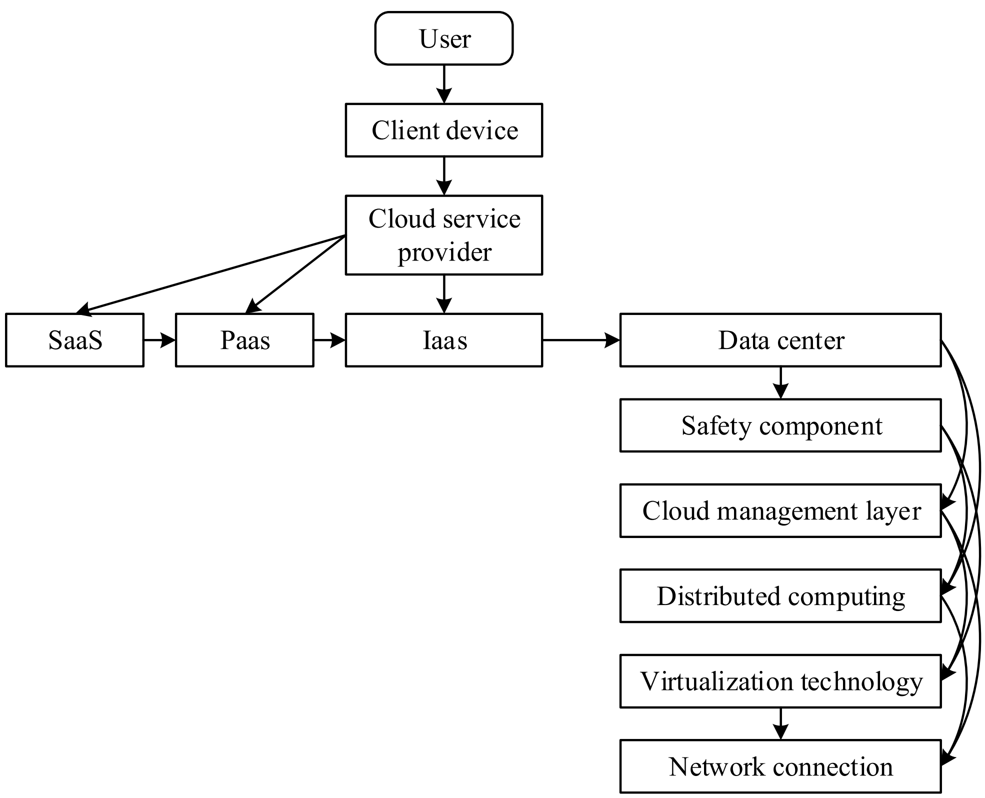

Figure 1: Cloud Computing architecture diagram

II. A. 2) Technical Principles of Cloud Computing

The technical principles of cloud computing mainly include virtualization technology, distributed computing, parallel processing and automated management. Among them, virtualization technology can realize flexible distribution and optimal utilization of computing resources. Distributed computing and parallel processing can decompose large-scale computing tasks into multiple subtasks, which can be processed simultaneously on multiple computers to improve computing efficiency.

II. A. 3) Service Models for Cloud Computing

The service model of cloud computing mainly includes Infrastructure as a Service (Iaa S), Platform as a Service (Paa S), and Software as a Service (Saa S).Iaa S provides infrastructure services such as computing resources, storage resources, and network resources.PaaS provides platform services such as development platforms, databases, and middleware.SaaS provides software services such as online application software, data storage, and collaboration tools. SaaS provides software services such as online application software, data storage and collaboration tools, etc., which are selected and combined according to the user's needs in order to realize flexible cloud computing applications.

II. B.Financial services shared platform design

II. B. 1) Design of the main functional modules of the financial sharing platform

The construction of the platform will mainly consist of three modules: the financial sharing basic support platform, the financial sharing center platform, and the fund management platform [17].

Firstly, it is necessary to unify the standards and data to build the basic support platform. The basic support platform contains financial standard data management, coding, integration, cleaning, sharing and governance of financial standard data. By adopting the advanced financial standard data management system, it can realize the functions of creating, editing, importing, checking and approving the financial standard data, and it can realize effective integration with other application systems and external Internet data to provide a solid foundation for the enterprise's operation and decision-making.

Secondly, it concentrates and integrates easy-to-standardize financial services and builds a financial sharing center platform. Through the redesign and standardization of processes, the reimbursement, accounting and settlement businesses of units at all levels will be centralized and integrated into one organization and platform to improve the efficiency and competitiveness of the enterprise, and to achieve improved quality of financial information, increased employee satisfaction and the realization of the Group's control objectives. The financial sharing center platform will consist of subsystems such as reporting management, electronic ticket folder, financial reporting, accounting accounting, accounting e-file, transaction management, business travel settlement and procurement settlement.

Thirdly, we will establish a group treasury and build a fund management system in order to strengthen the ex ante risk warning and ex post risk prevention to ensure the sustainable development of the enterprise. Through the front-end reporting module, it accepts a variety of fund settlement demands, while the back-end establishes links with financial companies, banks and other financial institutions, so that online fund settlement can be realized. Setting up the pending payment pool and payment pool in the payment platform, completing the fund payment through the direct connection between banks and enterprises, ensuring the compliance of fund control and enhancing the payment efficiency through the unified settlement management. It strengthens real-time analysis and monitoring, prevents capital risks and optimizes decision-making tools.

II. B. 2) Construction of major functional modules

(1) The construction of the financial infrastructure support platform is divided into the following three main steps.

a) Build a cloud platform

Building a cloud platform adopts cloud-native, distributed architecture and multi-cloud deployment of public, private and hybrid clouds, which enables the business system to be flexibly split and interconnected and deployed according to the enterprise's geographical distribution and data center construction planning. When the initial platform architecture is carried out, standard specifications are formulated at the business level, and the technical aspects are extended and integrated through API interfaces, which can provide a basis for solving the problems of personalized business in a unified and centralized system environment.

b) Conduct financial standardized data management

The first step to improve management is to design and implement a standardized system. The standardized system should include: a unified financial standard data system, a unified accounting system, a unified system of economic transactions, a unified system of accounting rules and a unified system of accounting processes. Financial standard data management involves accounting standards for accounting matters, form standards carried by the reporting system, process standards carried by the workflow, role standards carried by the system management, interface standards carried by the support platform and so on.

c) Construction of Financial Sharing Basic Support Platform

Cloud computing-based financial sharing services will be realized through two parts: cloud and client. In the cloud, the cloud computing server can provide us with a platform which can connect to the Internet, run various applications, provide application support, and storage [18]. We can fully utilize the multiple functions provided by the application services and upgrade and improve them according to the needs of the company. And through the effective integration of basic, financial and decision-making data, more comprehensive mining and analysis.

(2) Financial core function realization

a) Accounting management

Accounts reporting shall be constructed in accordance with the Group's unified standards and specifications, taking into account the individual needs of each unit's financial management. At the same time, the construction of cell phone applications shall be carried out to provide conditions for business personnel to report accounts through flexible ways of reporting information collection and two terminals, PC and mobile.

b) Electronic ticket folder

Establish an electronic billfold system to upload and store electronic invoices. Employees directly capture the electronic images of invoices when filling out account reports, and add invoices in various ways such as manual entry, OCR recognition, scanning, and uploading of PDF files through the electronic ticket folder system, so as to provide structured storage of the original bills. Paperless office is implemented in the Group with online application, approval and payment to avoid problems such as loss of paper documents.

c) Accounting

In order to ensure the unity of the group, the accounting subsystem should follow the unified subjects and standards, and should be migrated and integrated on the basis of the existing financial accounting system of each unit. To build a single account for the whole group, to use uniform accounting standards throughout the group, to unify the caliber of accounting data, and to improve the quality of accounting data.

d) Financial Reporting

According to the object of financial reporting, it can be divided into external disclosure reports, such as those required by SASAC and other external regulatory bodies. As well as internal management reports, mainly used for internal management of the Group. Among them, financial statements are the core content of financial reports.

e) Images and electronic files

In accordance with national laws, regulations and standards, accounting e-files are stored in electronic media to record accounts, general ledgers, ledgers, journals, bank statements, statements and accounting reports. The adoption of a financial sharing platform allows for online inquiry and management of the files. Through the implementation of electronic file management, the Group is able to store all documents centrally in a more efficient manner, thus making full use of its advantages in terms of technology, channels and resource management.

f) Current Management

The details of the transactions contain information such as business matters, amount, date and business personnel. In order to better manage the company's financial situation, a perfect file system can be set up for recording personal current accounts with employees, as well as the current accounts of units that have business dealings with the company. Record, analyze, inquiry, credit rating, account canceling and inventory cycle management of financial transaction information, generate each customer's current statement, and regularly reconcile the management of correspondence with the correspondent unit.

(3) Funds management platform: treasury system

The fund management function of the platform is realized through the treasury system. The member units coordinate the fund arrangement according to the fund budget of the unit, form the fund plan in a certain cycle, and after approval and summarization, form the weekly, monthly and annual cycle fund plan of the Group Company. After completing the capital plan, it is submitted to the leaders for approval. After approval, the capital plan is issued and provided to the finance company as the basis for the implementation of payment by the finance company, realizing the supervision of the payment of funds to each member unit of the group, and then the group carries out the implementation analysis of the implementation of the capital plan.

III. Financial shared services security encryption program design

III. A. System architecture

The blockchain and threshold proxy based re-encryption data sharing architecture is shown in Fig. 2. In this paper, the scheme contains six entities: DO, DU, RMS, RES, KGC, and SSP. DO owns the private data, which is the data that needs to be shared securely, and DU refers to the organization or application that needs to use the private data. The blockchain network is the cornerstone of the system, the RMS is responsible for receiving the data access request from the DUs, and then verifies the access rights of the DUs through the access control policy on the blockchain, and then splits the re-encryption key uploaded by the DOs into multiple segments and distributes them to the re-encryption servers. When RES uses proxy re-encryption for ciphertext sharing, it combines the threshold secret sharing scheme and proxy re-encryption scheme to split the re-encryption key into multiple segments, and one RES receives only a part of the re-encryption key, and RES converts the ciphertext of the metadata and returns the result to the RMS. The SSPs usually need to be shared with data occupying a large amount of space, and they need to upload the private data to the third-party SSPs for storing.

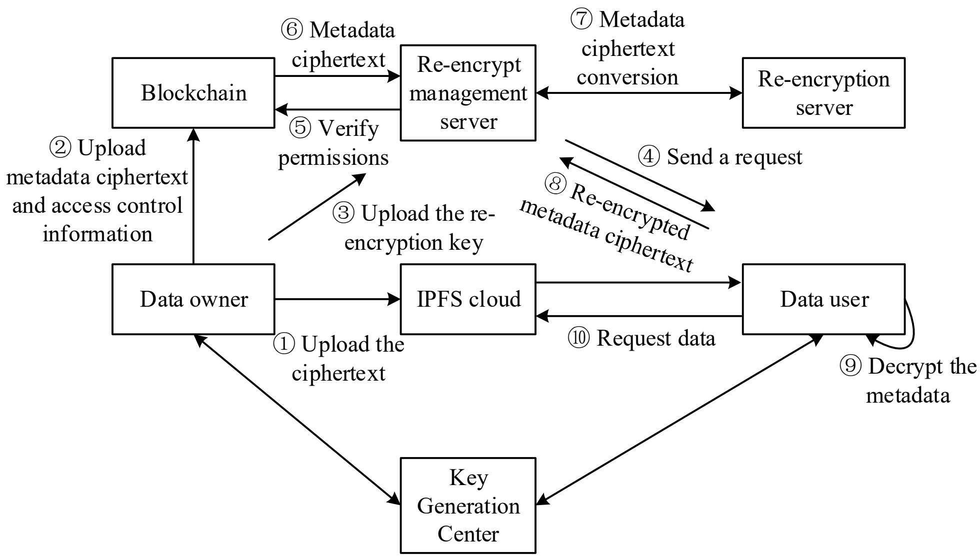

Figure 2: The block chain and the threshold agent reencrypt the data sharing architecture

III. B. Blockchain in the system

In this paper, the blockchain is mainly used for storing metadata and access rights verification information, which are protected by the strong security of the blockchain. In the blockchain module, the smart contract is a crucial component, the interaction between the scheme and the blockchain is accomplished through the smart contract.

III. C. Programmatic realization

The overall TDPR-BC scheme consists of the following five steps:

(1) System initialization. Call algorithm level functions Setup and KeyGen to generate public parameters, public and private keys, hash functions, etc.

(2) Data encryption and uploading. DO call the algorithm level function Encryption to encrypt the shared data. Generate metadata, authorization list, call algorithm level function MeEncrpytion to encrypt metadata, upload shared data cipher to SSP, upload metadata cipher.

(3) Re-encryption key generation. DO generates the corresponding re-encryption key according to the public key as well as the private key of DU, and uploads the re-encryption key to RMS.

(4) Ciphertext re-encryption. After receiving the access request from DU, RMS calls the algorithm level function RkKeyGen to generate multi-segment re-encryption key, sends it to the corresponding re-encryption server RES, calls the algorithm level function ReEncrpytion, and finally gets the re-encrypted ciphertext.

(5) Data decryption. The DU calls the algorithm level function MeDecryption to decrypt the received re-encrypted ciphertext, obtains the metadata plaintext, and calls the algorithm level function Decryption to obtain the shared privacy data according to the storage location of the privacy data in the metadata and the symmetric key.

The functions involved in the above five steps are described as follows:

a) System initialization Setup.

$(1^a, U) \rightarrow SS$: selects the security parameter 1^a as input, and outputs the public parameter SS. Users can use SS to generate their own public and private keys.SS is generated as follows:

This initialization algorithm takes as input the security parameter α , selects a large prime q of 1 α bit, and outputs the bilinear mapping $e: G_1 \times G_1 \rightarrow G_2$, where G_1, G_2 is the cyclic group of the order of q and q are prime numbers. Choose 1 randomly generated element $g \in G_1$ and compute $F = e(g, g)$. Define 4 hash functions: $H_1: \{0,1\}^* \rightarrow G_1, H_2: \{0,1\}^* \rightarrow G_1, H_3: G_2 \rightarrow \{0,1\}^{l_b q}, H_4: \{0,1\}^* \rightarrow G_1$.

Run the parameter generation algorithm to obtain common parameters:

$$Params = (G_1, G_2, H_0, H_1, H_2, H_3, g, F, e, q) \tag{1}$$

b) Generate public-private key pair KeyGen.

$(SS) \to (sk_{DO}, pk_{DO}, sk_{DU}, pk_{DU})$: Based on the existing public parameters, DO and DU generate their own public-private key pairs respectively. DU randomly chooses $\gamma \in F_q^*$ as the private key and calculates the public key $pk_{DU} = g^{\gamma}$. DO randomly selects $\delta \in F_q^*$ as the private key and calculates the public key $pk_{DO} = g^{\delta}$.

c) Data Encryption Encrpytion.

$(SEK, Data) \to CT$: the private data to be encrypted is encrypted using symmetric encryption, and SEK is the encryption key. For the selection of symmetric encryption algorithms, the most commonly used AES is directly selected, and the encrypted ciphertext CT is uploaded to the SSP for storage.

$$CT = encrypt(Data, SEK) \tag{2}$$

d) Metadata Encryption MeEncrpytion.

$(M, PK_{\mathrm{DO}}, SS) \to CT_M$: for the metadata M related to the privacy data, it is encrypted using the DO's public key with asymmetric encryption to improve reliability. The metadata M mainly contains the symmetric key SEK used for the encryption of the privacy data, the hash digest used for integrity verification, etc.

$$CT_M = Enc(M, PK_{DO}) = (MF^l, g^{l\delta}) \tag{3}$$

where $F = e(g, g)$ and l is a random coefficient.

e) Generate the re-encryption key RkKeyGen.

$$(SK_{DO}, PK_{DU}, n, t) \to \{rk^i_{DO\to DU}\}_{i\in[0,n-1]} : n \tag{4}$$

denotes that the re-encryption key is split into n segments and t is the threshold value. In addition the generation of the re-encryption key requires the private key of the DO and the public key of the DU:

$$rk_{DO\to DU} = g^{\gamma/\delta} \tag{5}$$

Recover Keys Formula:

$$F(x) = \left\{ \sum_{i=1}^{t} \left(y_i \prod_{1\le j\le t, j\ne i} (x - x_j) \left(\prod_{1\le j\le t, j\ne i} (x_j - x_i) \right)^{-1} \right) \right\} \mathrm{mod}(p) \tag{6}$$

Take $x=0$ and substitute to find $F(0)$ which is the final key to be recovered. Each proxy node holds only a portion of the re-encryption key:

$$\begin{aligned} &ReEncrypt(rk^1_{DO\to DU}, M) \to C_{\gamma_1} \\ &ReEncrypt(rk^2_{DO\to DU}, M) \to C_{\gamma_2} \\ &ReEncrypt(rk^3_{DO\to DU}, M) \to C_{\gamma_3} \\ &\qquad \vdots \\ &ReEncrypt(rk^n_{DO\to DU}, M) \to C_{\gamma_n} \end{aligned} \tag{7}$$

f) Ciphertext Re-Encryption ReEncrpytion.

After the RMS sends the ciphertext conversion request, the particular RES starts to perform the re-encryption process. According to equation (7), let:

$$k_i = \prod_{1\le j\le t, j\ne i} (x - x_j) \left(\prod_{1\le j\le i, j\ne i} (x_j - x_i) \right)^{-1} \tag{8}$$

According to Eq. (5), each RES can compute the re-encrypted ciphertext CT'_M with the re-encryption key:

$$e(g^{l\delta}, (rk_i)^{k_i}) = e(g^{l\delta}, g^{[k_i \cdot y_i]}) = F^{l\delta[k_i \cdot y_i]} \tag{9}$$

$$CT'_{M_i} = (MF^l, F^{l\delta[k_i * y_i]}) \tag{10}$$

When t out of n RESs have completed the ciphertext conversion, i.e., after the RMS collects t copies of the completed re-encrypted ciphertext, it can recover the re-encrypted ciphertext $CT_M^{'}$, and return the result to the data requestor DU, which then decrypts it to derive the original plaintext through its own private key, according to Eq. (9):

$$\sum_{i=1}^{t} F^{l\delta[k_i \cdot y_i]} = F^{l\delta\sum_{i=1}^{t}[k_i \cdot y_i]} \tag{11}$$

Again, based on Eqs. (6) to (8), it follows that

$$F^{l\delta\sum_{i=1}^{t}[k_i \cdot y_i]} = F^{l\delta\cdot\gamma/\delta} = F^{l\gamma} \tag{12}$$

$$CT_M^{'} = (MF^{l}, F^{l\gamma})(\bmod q) \tag{13}$$

At this point the re-encryption ciphertext $CT_M^{'}$ can be decrypted by the DU's own private key.

g) Decrypt the metadata ciphertext MeDecryption.

After DU gets the re-encrypted ciphertext of the metadata ciphertext, it decrypts it by its own private key SK_{DU} to obtain the metadata plaintext, according to Eq. (13), it is known that the DU's private key is γ, there are:

$$MF^{l} / F^{l\gamma/SK_{DU}} = MF^{l} / F^{l\gamma/\gamma} = M \tag{14}$$

h) Decryption of privacy data.

After decrypting the metadata, obtain the symmetric key SEK, decrypt the private data ciphertext through the key to obtain the original plaintext, and determine the data integrity through the data digest, which is contained in the metadata.

$$Data = dec(SEK, CT) \tag{15}$$

III. D. Threshold proxy re-encryption mechanism

The threshold agent re-encryption mechanism is shown in Fig. 3,and some key parts of it are described in detail below.

(1)DO generates the re-encryption key $RK_{DO\to DU}$ and then sends the generated re-encryption key to RMS, which is responsible for splitting the re-encryption key and then sends the re-encryption key $RK_{DO\to DU}^{i}$ to multiple RESs to re-encrypt the metadata ciphertext.

(2) Each RES re-encrypts the metadata ciphertext on the blockchain according to the received re-encryption key.RES first finds the corresponding metadata ciphertext CT_M on the blockchain, and then completes the ciphertext conversion using the re-encryption key $RK_{DO\to DU}^{i}, i = 1, 2, \cdots, n$.

(3) The RES that completes the ciphertext conversion request signs the ciphertext CT_M^{i} and returns the conversion result to the RMS.

(4) RMS collects and verifies the received re-encrypted ciphertext CT_M^{i}, if RMS collects t of the verified re-encrypted ciphertext, it will merge the collected re-encrypted ciphertext of t into the new ciphertext $CT_M^{'}$, and then the data user receives $CT_M^{'}$ and completes the decryption process, and the threshold proxy re-encryption process is completed.

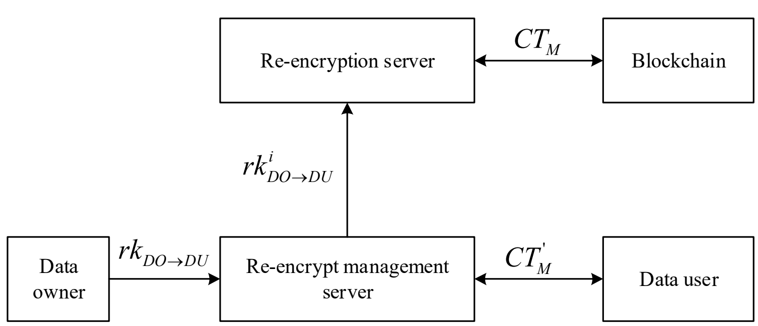

Figure 3: Threshold proxy re-encryption mechanism

III. E. Financial Shared Services Security Analysis and Research

In the experiment, 50 groups of financial data of an enterprise are randomly selected to determine the data privacy performance by comparing the status of encrypted data under the method of this paper, the dynamic change of user rights algorithm and the Bloom Filter algorithm. In order to compare the efficiency of data sharing of the three algorithms, the time required for encryption and decryption is taken as an evaluation index, and the encryption and decryption times of different algorithms are obtained respectively when the number of ciphertext attributes is the same, and the comparison of encryption times of different algorithms is shown in Fig. 4. The comparison of encryption time of different algorithms is shown in Fig. 4 and decryption time of different algorithms is shown in Fig. 5. As shown in Fig. 4 and Fig. 5, the decryption time of all algorithms is smaller than the encryption time. The methods in this paper show good time performance in both encryption and decryption processes, taking less time, and the time required does not increase significantly with the increase in the number of ciphertext attributes. This is because the proxy re-encryption process is simple and does not waste a lot of waiting time of the user.

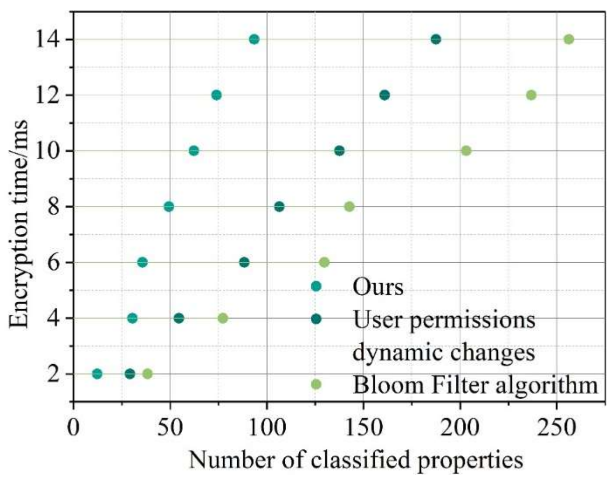

Figure 4: Different algorithm encryption time contrast

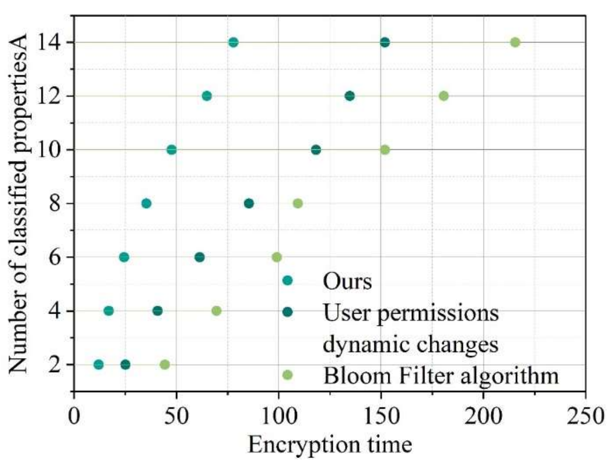

Figure 5: Different algorithm decryption time comparison

Assuming that the experimental environment is the same, under the security protection of the above three methods, different amounts of financial data are shared, and the number of data cracked is used as an indicator to obtain the success rate of different algorithms for secure sharing, and the number of data cracked by different algorithms is shown in Table 1. As can be seen from Table 1, when the total amount of data is 500, all three algorithms have no cracked data, and all of them can realize secure sharing. With the continuous increase of sample data, the method of this paper still maintains a low number of cracked articles, while the other two methods crack the number of rapidly increasing, the sharing success rate gradually decreases. On the one hand, because the proposed heavy encryption algorithm can guarantee the data security, on the other hand, the data sharing contract is formulated to provide a double guarantee for the secure sharing of data, which improves the sharing success rate.

Table 1: Different algorithms data cracking number

Number of financial data	This method	User permissions dynamic changes	Bloom Filter algorithm
500	0	0	0
1000	2	8	7
2000	1	14	25
5000	5	45	68
10000	8	61	78
20000	9	81	96

IV. Benefit Analysis of Cloud Computing Technology in Financial Shared Services

IV. A. Principal Component Analysis

Principal Component Analysis, which in essence is a special case of Factor Analysis, is a method of converting a set of possibly correlated variables into a set of linearly uncorrelated variables by means of orthogonal transformation, and the converted set of variables is referred to as the principal components. It is assumed that a certain degree of correlation often exists between the original n variables, accordingly, through the method of linear combination, a new variable will be calculated as a new composite indicator on the basis of retaining as much information as possible about the original variables, and this new variable is the principal component. When principal component one is not able to represent the main content of the original variable, principal component two, principal component three, etc. can be extracted by linear combination until it can represent most of the content of the original variable. In general, the number of principal component factors is smaller than the number of original variables, so it can be quickly reduced by principal component analysis, and simplifies the linear regression equation and retains the information of the original variables [19].

First of all, the data are standardized, and the eigenvalues λ are obtained according to the relationship matrix of the variables, and the first $\lambda \geq I$ of the first t principal components are taken, making:

$$\frac{\sum_{i=1}^{t}\lambda_i}{\sum_{i=1}^{10}\lambda_i} \geq \alpha, 0 < \alpha \leq 1, 1 \leq t < 10 \tag{16}$$

Again, based on the knowledge of mathematical statistics, the principal components are:

$$Y_n = a_1 X_1 + a_2 X_2 + a_3 X_3 + a_4 X_4 + \ldots\ldots + a_n X_n \tag{17}$$

After determining t principal components, then the composite indexes for company performance evaluation can be obtained from equations (16) and (17):

$$Y = \frac{\lambda_j}{\sum_{i=1}^{t}\lambda_i}Y_1 + \frac{\lambda_2}{\sum_{i=1}^{t}\lambda_i}Y_2 + \frac{\lambda_3}{\sum_{i=1}^{t}\lambda_i}Y_3 + \ldots\ldots + \frac{\lambda_t}{\sum_{i=1}^{t}\lambda_i}Y_t \tag{18}$$

Before conducting an empirical study on, this paper uses the Z-score method to standardize the data of the original variables.

The process is shown in equations (19) to (22).

$$X_1 = \frac{x_1 - \mu_1}{S_1} \tag{19}$$

$$X_2 = \frac{x_2 - \mu_2}{S_2} \tag{20}$$

$$X_3 = \frac{x_3 - \mu_3}{S_3} \tag{21}$$

$$X_n = \frac{x_n - \mu_n}{S_n} \tag{22}$$

where, μ - the expected value of the variable x, S - the value of the product-difference correlation of the corresponding variable, $n-1,2,3,4,......$

IV. B. Comprehensive evaluation by principal component analysis

IV. B. 1) Selection of indicators

In this section, the data of 12 years of an industry is selected as the research sample, and the original data is obtained based on the financial indicators published in the financial statements of an industry in each year. According to the four aspects of enterprise profitability, solvency, operating ability and growth ability, six financial indicators of an industry are selected as raw indicators, which are operating income (x1), gross profit margin of sales (x2), total return on assets (x3), total asset turnover (x4), current ratio (x5), and asset-liability ratio (x6). The raw data are shown in Table 2, the operating income, gross sales margin and total assets compensation ratio can reflect the profitability of the enterprise, the total assets turnover ratio reflects the operating ability of the enterprise, and the current ratio and assets and liabilities ratio reflect the solvency of the enterprise. After selecting the original indexes, the standardization process is carried out first, and the comprehensive evaluation system about the economic efficiency of the enterprise is established by applying the principal component analysis method to analyze the final comprehensive score, and the research is carried out from both qualitative and quantitative aspects.

Table 2: Raw data

Year	X1	X2	X3	X4	X5	X6
2012	12299	21.67	-0.84	0.43	0.39	147.75
2013	12078	18.56	-11.31	0.52	0.27	175.12
2014	12891	21.25	1.64	0.44	1.85	41.55
2015	18302	8.77	0.31	0.44	1.97	39.26
2016	5502	11.16	-11.36	0.13	2.58	41.1
2017	4735	5.28	-18.19	0.14	2.23	44.68
2018	4216	12.94	10.34	0.12	1.93	54.69
2019	5847	16.09	-6.86	0.16	2.36	50.34
2020	19560	9.89	1.64	0.51	3.09	39.96
2021	34572	6.17	1.92	1.03	4.3	32.35
2022	34280	5.57	0.94	0.985	2.634	44.57
2023	35387	4.2	0.76	1.008	3.278	37.33

IV. B. 2) Normalization of raw data

As different variables often units and the degree of variation may be different, and thus in order to eliminate the effect of the range of variation, the data need to be standardized to make them comparable, the original data in Table 1 will be standardized, the indicators standardized data as shown in Table 3.

Table 3: Index standardized data

Year	X1	X2	X3	X4	X5	X6
2012	-0.3642	1.6829	0.221	-0.054	-1.6555	1.8134
2013	-0.3791	1.0335	-1.1689	0.0619	-1.7461	2.4027
2014	-0.3115	1.478	0.6426	-0.2572	-0.3421	-0.4365
2015	0.1394	-0.3289	0.5445	-0.1701	-0.2153	-0.495
2016	-0.9284	-0.0993	-1.1018	-1.0129	0.316	-0.4618
2017	-0.9923	-0.9628	-1.7756	-1.0127	-0.0175	-0.3773
2018	-1.0352	0.0527	1.7398	-1.0995	-0.2514	-0.1702
2019	-0.8959	0.6754	-0.8242	-1.0129	0.0731	-0.268
2020	0.242	-0.4283	0.4219	0.1205	0.757	-0.467
2021	1.4922	-1.1227	0.6285	1.6308	1.8283	-0.6419
2022	1.4718	-0.9642	0.3503	1.4134	0.3286	-0.3683
2023	1.5592	-1.0183	0.3222	1.3923	0.9263	-0.05306

IV. B. 3) Selection of principal components

Based on the matrix of correlation coefficients, the eigenroots and cumulative variance contributions are derived, and the eigenvalues and variance contributions are shown in Table 4. The eigenvectors are shown in Table 5. The number of principal components is generally determined based on the cumulative variance contribution ratio, and the larger the cumulative variance contribution ratio is, the higher the degree of explaining the original data through the selected few principal components. As can be seen from the table, the principal components of the first two explain 79.384% of the total variance, indicating that the first two principal components can be used to replace the original six original variables. The first principal component has larger coefficients in the 1st, 4th and 5th indicators, indicating a strong correlation with the business income, total asset turnover and current ratio of the enterprise. The coefficients of the second principal component are larger in the 4th and 6th indicators, indicating a strong correlation with total asset turnover and gearing ratio. The variance of the first principal component and the second principal component is 3.355 and 1.408 respectively.The variance contribution ratio of each principal component can be obtained by principal component analysis through SPSS, and it is used as the weight to construct a new comprehensive evaluation function.

Table 4: Feature value and variance contribution

Total variance interpretation						
Constituent	Initial eigenvalue			Extracting the load of the load		
	Total	Percentage of variance	Cumulative%	Total	Percentage of variance	Cumulative%
1	3.355	55.917	55.917	3.355	55.917	55.917
2	1.408	23.467	79.384	1.408	23.467	79.384
3	0.918	15.300	94.684			
4	0.227	3.783	98.467			
5	0.09	1.500	99.967			
6	0.002	0.033	100			

Table 5: Eigenvector

Component matrix		
	Constituent	
	1	2
X1	0.84	0.512
X2	-0.819	0.332
X3	0.39	0.351
X4	0.746	0.636
X5	0.89	-0.361
X6	-0.698	0.63

In this paper, principal component analysis is used to first transform the initial six self-selected variables into two principal components that are not related to each other, so that the two principal components finally selected can represent the basic valid information of the original data, and the formula for the calculation of the comprehensive performance evaluation score Y is obtained by weighting the two principal component scores with the corresponding variance contribution ratio. The standardized data are reduced to the original variables in SPSS, and after transforming-calculating the variables-entering the mathematical expressions, a multiple linear regression function is constructed to derive the comprehensive score for each year:

$Y=3.355/(3.355+1.408)\times Z1+1.408/(3.355+1.408)\times Z2$

The above formula can be used to calculate the comprehensive score for each year of enterprise economic efficiency of an industry from 2012 to 2023, and the comprehensive score ranking for each year is shown in Table 6. Because the raw data were standardized when the principal component analysis was performed, the results obtained are both positive and negative. A positive number indicates that it is greater than the average. If it is negative, it indicates that it is less than the average. According to the above table, it can be seen that an industry from 2012 to 2019, the evaluation of the economic efficiency of the previous period is poor, except for 2015, the comprehensive score is negative, it is presumed that its business performance is poor, the reason is that an industry in those years the market competitiveness of the market is declining, and by the impact of rising raw material prices, the company's procurement costs are gradually rising, resulting in a decline in the profit of the main business of the enterprise year by year, and then the operating efficiency of the business is poor.

In 2020 the score is 0.56, it can be seen that the business performance of the enterprise has improved greatly compared with the previous years, the reason is that a certain industry in 2020 the application of cloud computing technology based on the strategy of financial shared services, and at the same time the implementation of diversification strategy, carried out a variety of products such as chemicals, coal, glycol and other products of the trading business, to achieve the increase in operating income and operating cash flow, and in the previous period there is no such project occurs. This in turn affected the economic efficiency of the enterprise.

The evaluation of economic performance from 2021 to 2023 was better, with positive overall scores, presuming better economic performance. However, compared with 2021, there is a slight decrease, the performance in the past two years has a downward trend, and the gross profit margin of the main business is unstable, so it should appropriately adjust and optimize its business strategy and strengthen the control of risks.

Table 6: Annual overall scoring rankings

Year	Z1	Z2	Y	Ranking
2012	-2.44	1.82	-1.13	11
2013	-2.6	1.64	-1.35	12
2014	-0.74	0.2	-0.49	9
2015	0.32	-0.15	0.21	5
2016	-0.69	-1.64	-0.99	8
2017	-0.64	-1.92	-1.07	7
2018	-0.58	-0.49	-0.58	6
2019	-1.13	-1.14	-1.13	10
2020	0.99	-0.31	0.56	4
2021	3.16	0.52	2.35	1
2022	2.04	0.87	1.68	3
2023	2.48	0.65	1.9	2

V. Conclusion

In this paper, the application of cloud computing technology in financial shared services has achieved significant results, providing strong support for the digital transformation of enterprise financial management. The research effectively solves the security risk problem in financial data sharing by constructing a security architecture based on blockchain and threshold proxy re-encryption. In the algorithm performance test, the method proposed in this paper performs well in dealing with large-scale financial data, and the number of cracks is only 8 when the amount of data is 10,000, which is significantly lower than that of 61 and 78 in the traditional method, and the security performance is significantly improved. In terms of encryption efficiency, the method can maintain a short processing time even when the number of ciphertext attributes grows, reflecting good scalability.

The three-tier architecture design of the financial shared service platform realizes the standardization and intensive management of business processes, and improves the standardization and efficiency of financial processing through the unified financial standard data system, accounting account system and accounting rule system. An industrial case study shows that after the application of cloud computing financial shared services in 2020, the enterprise's comprehensive score turned from a negative value in the previous period to a positive value of 0.56, and its business performance was significantly improved. The comprehensive score in 2021 was further improved to 2.35 and ranked No. 1, indicating that the cloud computing technology has had a positive impact on the economic performance of the enterprise.

Cloud computing financial shared services create significant economic value for enterprises by integrating decentralized financial resources, reducing operating costs and improving data processing efficiency. This technical solution provides an important technical path for building a modern financial management system, promotes the development of financial management in the direction of intelligence and standardization, and has important theoretical significance and practical value.

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