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A QoS optimization system for complex data cross-domain request based on neural blockchain structure

Lianbing Deng[1,2] · Daming Li[1,3] · Zhiming Cai[3] · Xiang Yao[1]

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Abstract

Various computing environments are constantly emerging which are using different technology platforms and security mechanisms from each other. The development of network technology makes cross-domain access between various systems necessary, which requires seamless information sharing and data exchange between systems, thus eliminating the phenomenon of information islands. With its unique consensus mechanism and compatible encryption algorithms, it has gradually attracted attention in various fields. Many people believe that blockchain technology is a revolution in Internet technology in the future, which is a huge innovation in information infrastructure technology as well. In order to ensure a high QoS of the data grid, the system needs to overcome many unstable factors of the network and the grid nodes. Resource (capability) reservation, copy deployment, buffer mechanism, parallel data transfer, and data storage and recovery are the main means to solve such problems. Above all, this paper proposed a QoS optimization system for complex data cross-domain request based on neural blockchain structure. Experimental results show that the proposed method has higher robustness and efficiency.

Keywords Neural network · Blockchain · Network structure · Cross-domain request for complex data

1 Introduction

From the earliest emergence of the concept of data center to the rapid development and widespread promotion, it has undergone several technological changes. Every revolution in data has given the data center a new impetus and new demands and challenges. The earliest data centers appeared in the early 1960s, and they were mainly used to store mainframes. Because of the high cost and complicated operation and maintenance of the system, the data center at that time was mainly used for military or scientific purposes. With the rapid development of information technology, data centers have gradually become popular. Since then, governments, enterprises, and organizations have begun to build their own data centers and provide various information services to internal or public [1, 2]. The demand for various information services has increased rapidly, and the size of data centers has continued to expand. In response to these demands, the performance of various hardware is rapidly increasing, and virtualization technology is beginning to be widely adopted in data centers. The technology at the time virtualized computing and storage resources to improve resource utilization efficiency. At the same time, different services were hosted on different virtual machines, which could isolate the business and prevented the influence of the business to a certain extent, thereby improving the scalability of the system. This period is called the virtual machine era.

Ian Foster mentioned that grid refers to a framework for providing flexible, secure, and collaborative resource sharing in a dynamic collection of multiple individuals, organizations, and resources. That is to say, grid computing is concerned with coordinating resource sharing and collaborative problem-solving in a dynamic, multi-agency

✉ Daming Li
dmli@cityu.mo

[1] The Post-Doctoral Research Center, Zhuhai Da Hengqin Science and Technology Development Co., Ltd, Hengqin, China

[2] Huazhong University of Science and Technology, Wuhan, China

[3] Macau Big Data Research Centre for Urban Governance, City University of Macau, Macau, China

virtual organization. Grid is a strategic infrastructure used for high-performance computing and information services, and high-performance computing and data-intensive processing have become the foundation for large-scale distributed applications. Along with the rapid increase in the amount of information, many large-scale data-intensive tasks put forward higher requirements for data processing capabilities. Specifically, the current data center needs are changing as follows:

1. The dramatic increase in business demand has led to a significant increase in the number of traditional data center resources, and the size of the data center has increased significantly as well.
2. Traditional data center resources are shared by a small number of services, so data centers need to provide a wider variety of services. Each service has a growing demand for resources, so for shared resources, isolated requirements are introduced to prevent the interaction between various services and to guarantee the quality of service for each service.
3. Traditional data centers have little change in the load of services due to the small number of users. As the number of users increases, only static expansion of the resources of the business is required to meet the demand. Therefore, in order to cope with the frequent changes of services and optimize the power consumption and performance of the system, services often need dynamic migration and dynamically adjust the resources of the service according to the needs of the service.
4. Traditional data centers are small in scale, so faults can be quickly located and eliminated in the event of a failure, and as the size of the data center grows dramatically, failures might occur more frequently. In order to cope with this situation, it is necessary to monitor the status of various resources in the data center to quickly locate and troubleshoot and prevent service interruption or service quality degradation. In addition, the trending of resource usage in the data center and the expansion of the system also require monitoring data as a basis.
5. Traditional data centers are usually operated independently. The traffic between virtual machines is inside a data center, so there is no need for cross-data centers. In order to meet the needs of users in different geographical locations, the same service often needs cross-domain integration of resources to dynamically adjust services according to the distribution of services in various places to achieve load balancing. In addition, for disaster recovery, data cross-domain access is also an inevitable requirement.

So far, in order to achieve interoperability between services, the following technologies had emerged.

Name	Protocol	Interface definition	Service search method
COM/DCOM	ORPC	MIDL	System registry
CORBA	GIOP	IDL	Naming service
J2EE	JRMP	JAVA	JNDI
WEB SERVICES	SOAP	WSDL	UDDI

Data grids are centered around data management, so data are their most important resource. Data shields heterogeneous storage media and data resources from the underlying physical environment, providing common and reliable data services for upper-layer applications. The focus of the data grid is on the processing of massive amounts of data. Chervenak believed that data grids primarily deal with distributed data-intensive applications where an infrastructure was needed to provide data access, transport, and update of the infrastructure and services stored on each node [3, 4] (Fig. 1).

At present, some research work has begun to pay attention to QoS adaptive management of complex systems. Adaptive QoS management in the operational phase usually adopts a closed-loop control model, that is, the current output QoS of the system is used as the input of the controller, and the control quantity is obtained through feedback to adjust the unreasonable situation of the distribution of internal resources of the system to meet the QOS management objectives. For some application scenarios where data performance is not a high demand, QoS management in the operation phase can be regarded as a planning problem, that is, QoS adaptive maintenance.

In the field of communication networks, the degree of standardization is high, and most of the QoS design and

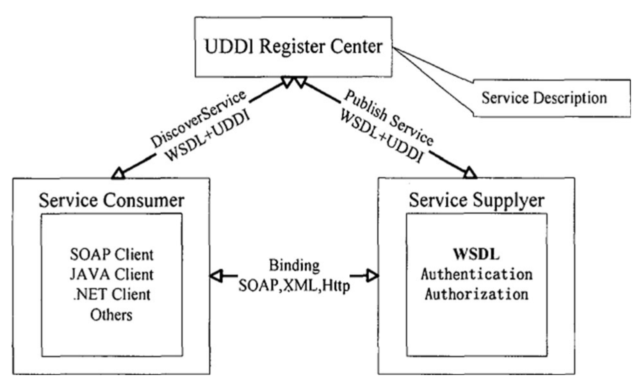


Fig. 1 Service model for data access

management related to communication networks have standards and specifications for reference. Common QoS parameters include bandwidth, delay, jitter, and packet loss rate. However, the QoS of data systems has a relatively higher complexity and dynamics. The complexity of the internal structure of data access is high, and the update of devices and technologies is relatively frequent, which makes the QoS parameters related to the basic resources need to consider more factors. The application layer entity presents a large difference considering business requirements of the different enterprises or organizations, which makes the QoS parameters related to the application layer have higher dynamics, so it is not easy to establish a general model.

1. In communication network systems, the same control mechanisms are typically employed for many network elements. Data access systems often contain many complex layers, so the impact of the underlying hardware, operating system, and middleware cannot be ignored when considering the performance of an application or service. The data access system itself is implemented in a multi-tier architecture, such as the data layer, the business logic layer, and the presentation layer.
2. The workload of data access systems is more complex and difficult to predict.
3. Managing the performance of an application or service in a data access system requires consideration of numerous resources, such as server resources, software resources (threads), and power consumption. Among the many resources, only the resource items that cause the bottleneck effect can be adjusted to most effectively adjust the performance of the application or service.

2 Data grid resources and QoS

2.1 Access to data grid resources

A grid is a combination of resources and services that can be logically and physically categorized. The physical layer includes servers, computers, storage systems, software, distributed systems, and network bandwidth. Logical resources are the capabilities that these physical resources can provide, including storage, transmission, computing, and information services. By effectively managing these resources, the grid provides users with high-quality computing, storage, and information query services [5–7].

The grid can be divided into three basic levels, namely, the application service layer, the middleware layer, and the physical resource layer. In addition to information resources, the underlying resources in the data grid are mainly physical resources, that is, various types of storage devices, computer nodes, and basic networks. The middleware layer has different types, which are responsible for security management, resource management, and data management. The application level mainly provides specific services and functions for users in different fields for specific practical applications [14–17].

The implementation mechanism of single-table query online aggregation cannot be directly applied to the online aggregation of multi-table join queries, because the results of the connection after random sampling from each table are related, not completely random. The estimated total aggregation of a single table is all the tuples in the table. The full table scan can obtain the sample size and sample layer size of each layer. Compared to single-table queries, the estimated total of multi-table joins is a subset of join results or the Cartesian products, and its hierarchical sample creation is much more complicated. MC-OLA uses Markov chain to model the connection, converts the connection process into random walks on multiple tables, and performs hierarchical sampling from the data at the start of the walk. The online aggregation updates the results at a fixed frequency, and the sample size N of each extraction can be calculated according to the update frequency [18–20].

During the system operation phase, QoS fluctuates with the user's request rate and system failure. For managers and users, it is expected that the QoS management mechanism can adaptively compensate the dynamic load of the system during operation, thereby keeping the QoS of the system within a reasonable range. Therefore, the adaptive mechanism becomes the focus of the QoS management problem in the operational phase. The method of adjusting the resource allocation may not care about the specific service request type, which needs to control the resource allocation by means of the feedback amount of the QoS outputted by the system, however, and therefore usually has a certain time lag. The way to schedule system workloads does not require modification of the allocation of existing base resources, which requires a clear understanding of specific business logic and processes, nevertheless. Generally, the system QoS adaptive management mechanism is implemented by online adaptive adjustment resource allocation [21–23].

2.2 Service-oriented data authentication authorization framework

Currently, interactions between web services mostly use the SSL protocol and standard HTTP security technologies to meet security requirements. Using SSL to ensure the security of data transmission, this method can be easily ported to network services, using HTTPS protocol to ensure the security of SOAP messages, and implementing SOAP/HTTPS is relatively simple. While this approach can quickly establish a security solution, it has some limitations.

1. HTTPS provides a peer-to-peer security policy. One of the characteristics of network service applications is that messages need to pass through some intermediate routers during the delivery process, because each intermediary router may process the message body. Although HTTPS can ensure that SOAP messages are secure between nodes, SOAP information is vulnerable to attacks within the nodes.
2. HTTPS does not provide security at the message level. Messages are only safe during transmission, and once they reach the end, they are no longer secure.
3. HTTPS allocates a pair of shared keys to both sides of the transmission for message addition and subtraction which does not use digital signature technology when delivering messages, so it does not have the ability to resist denial [19].
4. HTTPS provides the security of the transport layer, so it is impossible to encrypt some of the elements of the message.

Cross-domain interaction is the trend of software development today, but it also leads to a series of problems, in which the securities of messages and the authentication and authorization between services are a prominent problem when each service interacts. If the data nodes can correctly verify the SOAP message, the attribute certificate can solve the problem of permission check.

2.3 Grid QoS framework

For the CPU, QoS can refer to the speed of operation it provides. For storage devices, QoS can refer to the storage capacity, reliability, transmission speed, etc., that it can provide. As one of the important contents of grid technology research, QoS is becoming the focus of current domestic and international grid research. QoS in the data grid not only includes traditional network QoS, but also can be further expanded, such as high bandwidth, large storage capacity, high security, and reliability [24].

The World Wide Web Consortium defines a service as: “The service provider completes a set of tasks that deliver the desired end-result to the service consumer. The end result usually changes the state of the user, which changes the state of the provider as well. Or both parties have changed.” This shows that users are most concerned about whether their services can be satisfied. In order to meet the service requests submitted by users, the grid system should be based on system resources with certain quality of service. The grid physical resource layer is transparent to the user, and the system must be able to decompose the abbreviated QoS request into specific QoS parameters of each sub-service [8, 9]. Since the QoS requirements at the user level are not uniform with the QoS that the resources can provide, it is necessary to map the user-level QoS with the QoS of the underlying resources to enable them to match. Service-level QoS is the link between the two. User-level QoS includes: speed, reliability, service cost, and service acceptance.

2.4 Identity authentication for data cross-domain access

Validation of the validity of the certificate requires consideration of a complete set of detection mechanisms, usually including the following aspects.

1. A trusted signature CA, and the signature is verified. This prevents the user’s digital certificate from being a fake digital certificate; namely, the certificate was not issued by the designated CA.
2. Good integrity: That is, the digital signature on the certificate is consistent with the digest value calculated by the signature CA’s public key and the certificate hash algorithm.
3. The validity period of the time: The time the certificate is used must be within the specified start time and end time.
4. The certificate has not been revoked. The verification system first needs to obtain the latest CRL and check whether the serial number of the user certificate is in the CRL list, thereby determining whether the certificate is revoked.

When the Web service exists in a heterogeneous distributed environment, it is difficult to authenticate the user. When a Web service invokes another Web service, how to implement identity authentication of the Web service in such a cross-domain environment is a core issue for implementing cross-domain access.

3 Blockchain structure and complex data access

3.1 Blockchain

In recent years, the research and development and application of blockchain technology have attracted great attention from academic and industrial circles. Many people believe that blockchain technology is a revolution in the future of Internet technology and a huge innovation in information infrastructure technology. The main feature of blockchain technology is decentralization. In summary, the blockchain is an Internet-based distributed ledger technology. Since the books are shared by many parties, the blockchain guarantees the unchangeable modification of the books.

Blockchain technology is a database technology based on mathematical algorithms to generate trust, which is essentially an Internet communication protocol. The application advantages it has can be summarized as follows: Decentralized structures can save a lot of intermediary costs compared to centralized structures. The mathematical trust mechanism can solve the core defects of today's communication and transaction, and the programmable attributes facilitate the implementation of the agreement without supervision.

From a technical point of view, the blockchain is a distributed database system built on a peer-to-peer network, using an asymmetric encryption algorithm to encrypt each block. From the perspective of currency, the distributed shared ledger system of the blockchain digital currency system, the accounting transaction information of a period of time is encrypted and packaged into a block, and the blocks are sequentially connected to form a ledger system.

From the perspective of the Internet economy, blockchain is a distributed management system that manages all kinds of Internet assets in cyberspace. The registration, storage, and transaction of any digital and intelligent assets are encrypted and packaged into blocks for a period of time, and the blocks are connected to form a distributed asset management system.

Blockchains can be divided into public chains, private chains, and federated chains based on usage rights and authentication methods. The public chain means that all participating nodes are freely connected to the network according to the system rules, and the nodes participate in the blockchain organization structure through the consensus mechanism. The public chain promotes decentralization to build a support platform for global value networks [10, 11] (Fig. 2).

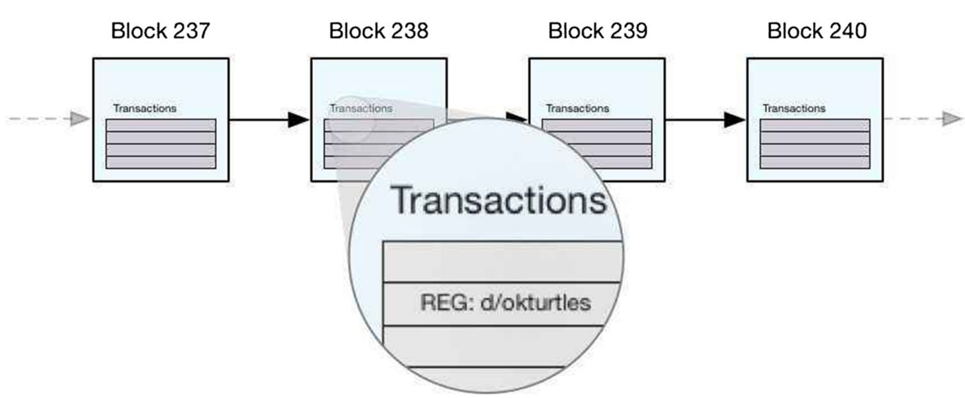
From a theoretical and demand perspective, the blockchain system can create very rich services and products. Because the blockchain will allow humans to collaborate on a large scale in a trust-free manner without geographical restriction. If the blockchain 1.0 refers to currency, that is, the application of cash-related encrypted digital currency, such as currency, transfer, remittance and digital payment systems. Then, blockchain 2.0 refers to contracts, such as stocks, bonds, futures, loans, smart assets, and smart contracts, and other broader nonmonetary applications (Fig. 3).

The concept of blockchain is a collection of multiple technologies that solve three problems in terms of technology:

1. How to store data completely and traceably.
2. How to build a democratic network that allows people participating in.
3. How to ensure that the blockchain network operates safely.

The security of cryptography is usually defined as the encrypted information which cannot be decrypted for a considerable period of time. But with the advent of new mathematical algorithms and the further development of quantum computer technology, encrypted information may be decrypted in a shorter period of time. Then, blockchain technology based on cryptographic algorithms will lose security, and the security of blockchain technology will become weaker. Taking Bitcoin as an example, according to the core source code analysis of Bitcoin, as of May 14, 2015, 50% of the source code was written by three programmers. Therefore, the control of the Bitcoin blockchain is in fact in the hands of a small number of programmers, which is also a warning for the application of commercial banks. This source code writer and related code information are also potential security risks (Fig. 4).

Fig. 2 Structure of blockchain



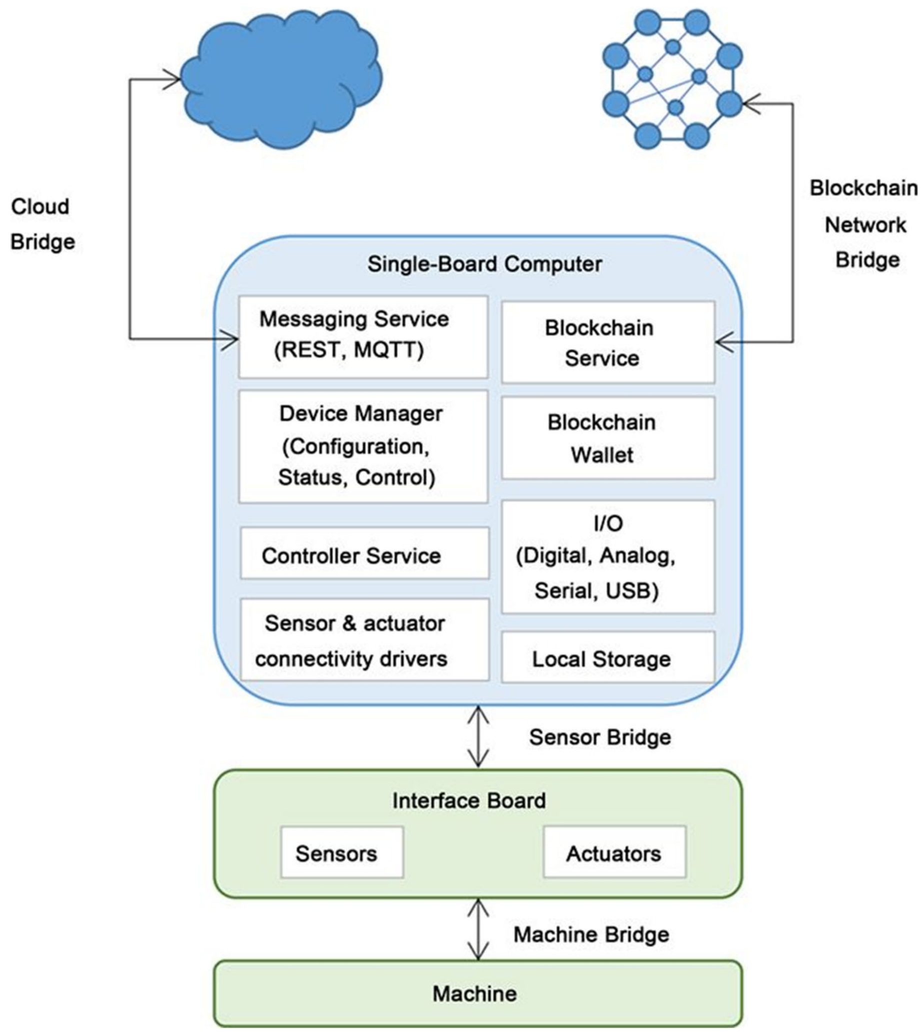


Fig. 3 Cloud Bridge and blockchain network bridge

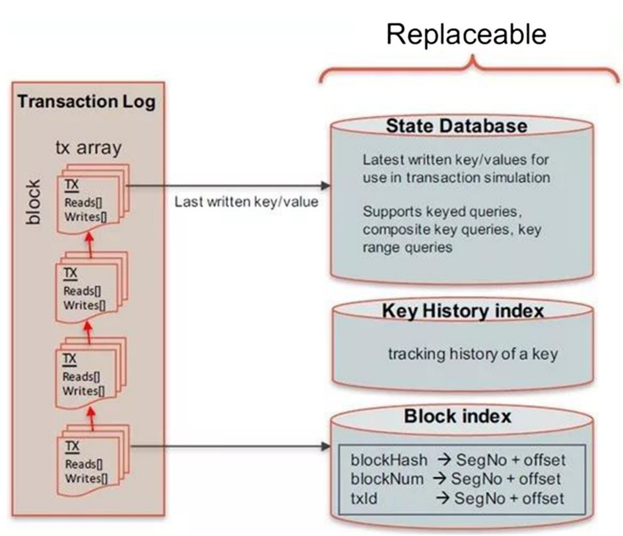


Fig. 4 Blockchain

3.2 Blockchain technology handles large-scale information updates and storage

At present, the total number of platform nodes based on blockchain technology is still small. Once the blockchain technology is extended to a large-scale trading environment, its compressive capacity is still doubtful. For example, in a process of blockchain transaction, it takes about 10 min per Bitcoin transaction. For small e-commerce transactions through the network, such processing speed will obviously lose many customers. A "broadcast storm" may occur when the size of a node in the network increases. From 2014 to 2015, the capacity of the blockchain network increased from 14 GB to 25 GB. Such a large capacity requires high network bandwidth for transaction users, which greatly affects its wide application. In addition, transparent data and information in blockchain networks are considered to facilitate regulation and tracking. However, as data sizes increase, chained data structures and large amounts of content prevent us from obtaining useful information in a limited amount of time.

Due to the recent rise of blockchain technology and the independent research and development of various institutions, the current blockchain system lacks uniform technical standards, and even large projects such as superbooks still have no uniform standards. In terms of storage, communication, transmission, and network security, the blockchain network has not yet formed a mature solution. Many experiments only use small-scale data for testing, and there is no uniform scenario and prototype as the test standard.

3.3 The size and mechanism of blockchain

From the perspective of industrial development, the main industrial sectors involved in the blockchain are software and information technology services. Most blockchain technology providers can provide related software products and information technology services such as system integration. As an emerging basic and cutting-edge technology, blockchain is the integration of multiple technologies. Its core technologies mainly include consensus mechanism, P2P network transmission technology, distributed data storage, and asymmetric encryption algorithms.

The consensus mechanism of blockchain technology is the strategy and method for all participating nodes in the blockchain system to agree. The participating nodes establish a consensus on the sequence of events and current status of the entire network transaction record and perform trusted value exchange without knowing the basic information of the other party. The establishment of a consensus mechanism has greatly reduced the friction cost in the value exchange process, which has great application value in the era of sharing economy.

A P2P network is a common organizational structure in a communication network. In a P2P network, all nodes have free access to the network and have the same network rights. The blockchain system uses P2P network transmission technology to connect various nodes in the network and forms a decentralized distributed system.

Blockchains generally need to build a distributed architecture based on open sources and decentralized protocols. Based on the structural system, the value exchange information can be sent to the entire network through the distributed network, and then, the information data content is determined. The block data can be generated after the time stamp is set, and then distributed to each node through distributed transmission to realize distributed storage.

The basis of the ownership verification mechanism in the blockchain system is the asymmetric encryption algorithm to ensure the credibility and security of the database. Asymmetric encryption algorithm refers to the process of encrypting and decrypting data and storage using public and private keys.

The public key is visible throughout the network; thus, any participating node can encrypt the information with the public key, while the private key is known only to the information owner. The information encrypted by the public key can only be decrypted using the private key. Public key cryptography guarantees the authenticity and integrity of the information, and private key decryption ensures the security of the information.

4 Neural-based blockchain

4.1 Pulsed neural network

Artificial neural networks are simulations of biological neural networks. The input and output of traditional artificial neural networks are analog quantities. These analog quantities can be interpreted biologically as the frequency at which a neuron releases a pulse over a certain period of time, namely, pulse frequency coding. In 1986, Rumelhart et al. proposed a back-propagation algorithm for artificial neural networks. The proposed algorithm has set off a research boom in neural networks in machine learning. Boosting and logistic regression methods can be regarded as learning models with one hidden node or no hidden nodes, which is called shallow machine learning model. Shallow learning models usually need to obtain good sample features by artificial methods and then identify and predict them [13]. Therefore, the effectiveness of the method is largely restricted by feature extraction. After the neural network is proposed, its combined algorithm with pattern recognition is applied to the experiments of image processing and signal acquisition [12].

For pulsed neural networks, research has shown that: Organisms can respond quickly to external stimuli because the information transmission of biological neural networks depends on specific pulse moments. Pulse time is a more efficient coding method than slow frequency coding. Compared with traditional neural networks based on the frequency coding, pulsed neural networks have more powerful computing power, so this algorithm can arbitrarily approximate nonlinear functions and also simulate biological neural network signals. Also, we should consider the data access methodologies. (1) Adaptability is one of the major advantages of the hierarchical technology. In development practice, internal structure can be divided from multiple levels, so as to encourage developers to optimize and upgrade the internal structure more scientifically and greatly improve computational efficiency and accuracy. (2) Hierarchical technology can develop software hierarchically, so when developing some new functions, it only needs to upgrade and optimize similar functional levels and does not need to redevelop the functions. (3) The middle connection is playing the extremely vital role in the computer lamination, and it mainly is the connection different laminations in order to form the systematic complete main body. The research discovered that, the middle structure reasonable establishment, it may urge the software security, the stability to then obtain the promotion, each level compatibility obtains the enhancement, the computer run breakdown appearance probability reduces greatly, the operational performance obviously optimized.

Due to the limitations of deep learning itself, researchers have found that deep learning is difficult to achieve true artificial intelligence. As the best agent in nature, the biological brain is the most important reference for artificial intelligence research. In this context, the USA first launched the BRAIN initiative in 2013. Subsequently, the European Union and Japan launched the Human brain project and the Brain/Minds project.

In brain-like scientific research, pulsed neural networks occupy the core position, and its low power consumption and high performance are also new breakthroughs in the implementation of artificial intelligence technology. With the development of brain science programs, pulsed neural networks are increasingly becoming the focus of research.

In recent years, pulsed neural networks have been increasingly used in practical engineering due to the computational ability of pulse neurons and the continuous improvement in learning algorithms.

Compared to traditional neuron models, pulsed neuron models have lower power consumption, so they are more suitable for parallel computing. Chips based on pulsed neural networks accelerate parallel computing, the most typical of which is the TrueNorth chip developed by IBM.

4.2 Neuron model

In pulsed neural networks, the state of a neuron is determined by the membrane potential and the activation threshold. The membrane potential of neurons is determined by the postsynaptic potential from the upper neurons. The postsynaptic potentials are divided into excitation and inhibition, which are recorded as EPSP and IPSP, respectively. Among them, EPSP will increase the membrane potential of neurons, and IPSP will reduce the membrane potential of neurons. When the membrane potential of a neuron rises to the activation threshold, the neuron produces a spike that is passed through the axons of the neuron to the next neuron.

The process of transmitting pulses along the synapse takes a certain amount of time, which is called synaptic delay. The pulsed neuron activation process is shown in Fig. 5.

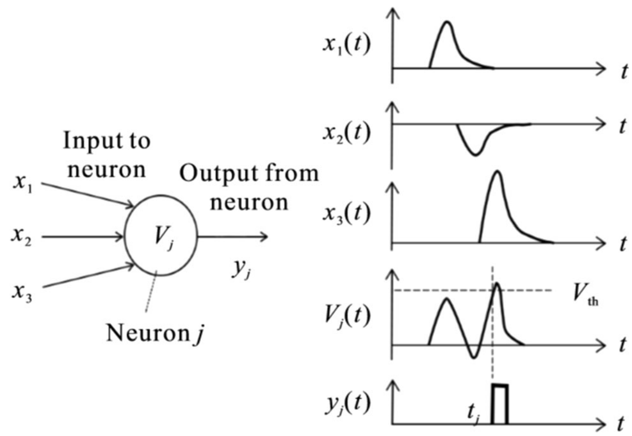


Fig. 5 Activation process of pulsed neurons

Pulsed neurons can be classified into four categories in terms of the model mechanism:

1. Membrane potential model based on current input and output
2. Natural information input model
3. Pharmacological stimulation model
4. Hierarchical instant memory model

4.3 Convolutional neural networks

According to the characteristics of the input information, the convolutional neural network designs the neurons into three dimensions: width, height, and depth. For example, if the input image size is 32 × 32 × 3 (rgb), then the input neurons also have a dimension of 32 × 32 × 3. The structure of CNN is shown as follows (Fig. 6).

Convolutional neural networks usually contain the following layers.

1. Convolutional layer. Each convolutional layer in a convolutional neural network consists of several convolutional units, and the parameters of each convolutional unit are optimized by a back-propagation algorithm. The purpose of the convolution operation is to extract different features of the input. The first layer of convolutional layer may only extract some low-level features such as edges, lines, and corners.

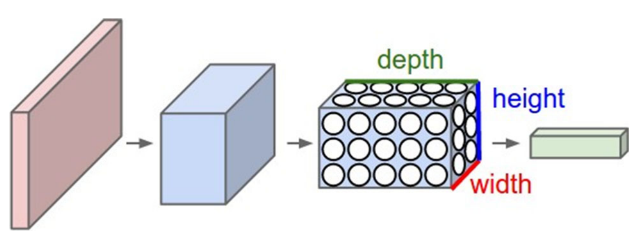


Fig. 6 Structure of CNN

Multi-layered networks can iteratively extract more complex features from low-level features.

2. Rectified linear units layer (ReLU layer). The activation function of nerves in this layer uses a linear rectification function.
3. Pooling layer. Usually, after the convolutional layer, a feature with a large dimension is obtained, and the feature is divided into several regions, and the maximum value or the average value is extracted to obtain a new feature with a small dimension.
4. Fully connected layer. Combine all local features into global features to calculate the score for each of the last classes.

4.4 Hodgkin–Huxley model

This model can describe changes in neuronal membrane potential and quantitatively describe changes in neuronal membrane voltage and current. The specific form of the Hodgkin–Huxley model is represented by the following differential equation group:

$$I_{\mathrm{ext}} = C_m \frac{\mathrm{d}V_m}{\mathrm{d}t} + I_{\mathrm{Na}} + I_{\mathrm{L}} + I_{\mathrm{K}} \tag{1}$$

$$I_{\mathrm{NA}} = \overline{g_{\mathrm{Na}}}\,\mathrm{m}^3\,h(V_m - V_{\mathrm{Na}}) \tag{2}$$

$$I_{\mathrm{K}} = \overline{g_{\mathrm{K}}}n^3(V_m - V_{\mathrm{K}}) \tag{3}$$

$$I_{\mathrm{L}} = \overline{g_{\mathrm{L}}}(V_m - V_{\mathrm{L}}) \tag{4}$$

where V_{Na}, $V_{\mathrm{K},}$ and V_{L} represent balanced potential of sodium ion channel current, potassium channel current, and leakage current, respectively; $\overline{g_{\mathrm{Na}}}, \overline{g_{\mathrm{K}}}$, and $\overline{g_{\mathrm{L}}}$ represent corresponding maximum conductance; m, n, and h are sodium ion channel activation variables, potassium channel activation variables, and sodium channel inhibition variables, respectively.

$$\frac{\mathrm{d}m}{\mathrm{d}t} = \alpha_m(V_m)(1-m) - \beta_m(V_m)m \tag{5}$$

$$\frac{\mathrm{d}n}{\mathrm{d}t} = \alpha_n(V_m)(1-n) - \beta_n(V_m)n \tag{6}$$

$$\frac{\mathrm{d}h}{\mathrm{d}t} = \alpha_h(V_m)(1-h) - \beta_h(V_m)h \tag{7}$$

$\alpha_*(V_m)$ and $\beta_*(V_m)$ are the conversion rates of the opening and closing of each ion channel, respectively, which are related to the membrane potential.

$$\alpha_m(V_m) = \frac{0.1(25 - V_m)}{\exp((25 - V_m)/10) - 1} \tag{8}$$

$$\alpha_n(V_m) = \frac{0.01(10 - V_m)}{\exp((10 - V_m)/10) - 1} \tag{9}$$

$$\alpha_h(V_m) = 0.07\exp(-V_m/20) \tag{10}$$

$$\beta_m(V_m) = 4\exp(-V_m/18) \tag{11}$$

$$\beta_n(V_m) = 0.125\exp(-V_m/80) \tag{12}$$

$$\beta_h(V_m) = \frac{1}{\exp((80 - V_m)/10) + 1} \tag{13}$$

In the classic Hodgkin–Huxley model, the values of the parameters are shown in Table 1.

4.5 Impulse response model

The spike response model is a generalization of the integral fire model. The state of the neurons in this model is only described by the membrane potential. The model uses three different kernel functions to represent the effects of external input and self-activation states on the membrane potential. The state of the neuron membrane potential at time t is calculated as follows:

$$\begin{aligned} V_m(t) = \eta(t - \hat{t}_i) + \sum_j w_{ij} \sum_j \varepsilon_{ij}(t - \hat{t}_i, t - t_j^{(f)}) \\ + \int_0^\infty \kappa(t - \hat{y}_i, s) I_{\mathrm{ext}}(t - s)\mathrm{d}s \end{aligned} \tag{14}$$

The information received by the pulsed neurons is a pulse time series, so the original analog data need to be encoded as a pulse time series to be input into the pulsed neural network. Sparse coding is another common type of coding that encodes receptive fields derived from biological neurons. The output value of the function represents the activation of the set of neurons. The larger the function value, the earlier the activation time, and the smaller the time value of the encoding (Fig. 7).

For continuously sampled signals, the AER (address event representation) code is a simple and efficient way of encoding. Specifically, for the continuously sampled signal, whether or not a pulse is generated at the moment is determined based on the difference between the values of the adjacent two samples, which is specifically expressed as follows.

Table 1 Parameters of Hodgkin–Huxley model

Parameters	Value	Unit
C_m	1.0	μF/cm^2
$\overline{g_{Na}}$	120	ms/cm^2
$\overline{g_K}$	36	ms/cm^2
$\overline{g_L}$	0.3	ms/cm^2
V_{Na}	115	mV
V_{K}	− 12	mV
V_{L}	10.6	mV

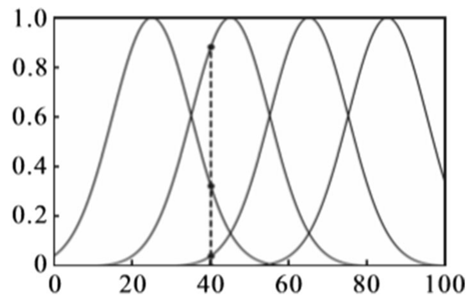


Fig. 7 Sparse coding

$$s(t) = \begin{cases} 1, & u(t) - u(t-1) \geq \text{threshold} \\ 0 & \text{Otherwise} \end{cases} \tag{15}$$

The structure of the pulsed neural network is similar to that of the traditional neural network and can be divided into static structure and dynamic structure. The static structure means that the number of neurons and the number of layers are constant, and only the weights and other parameters are changed, including the multi-layered feedforward network structure and the cyclic network structure. Dynamic structure means that the number and connection of neurons in the network can be dynamically adjusted. The typical representative is the evolutionary pulse neural network.

The input layer of the multi-layered feedforward pulse neural network is the coding layer, and the hidden layer uses the pulsed neurons. To ensure that there are enough pulsed neurons to be activated, the mode of connection between neurons is usually a multi-synaptic connection. Different delays need to be set on each synapse to ensure the stability of the pulsed neural network. The structure of the multi-layered feedforward neural network is as follows (Fig. 8).

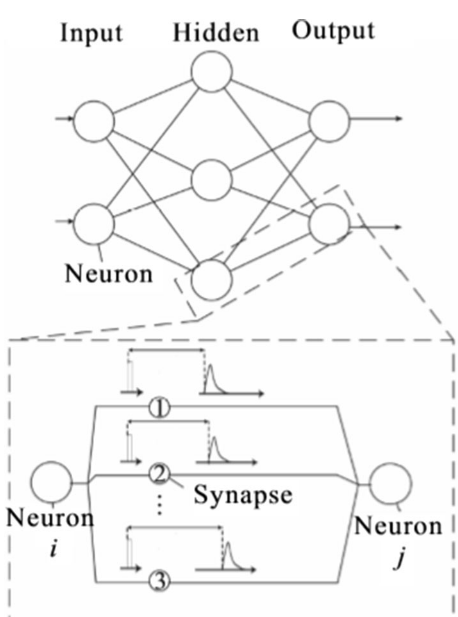


Fig. 8 Feedforward pulse neural network

In the proposed model, this structure is considered. During operation, each node in the P2P network competes to acquire the right to then establish a new block by performing an authorization certification mechanism, stores the transaction data generated in the period to the block, and connects the block to the block main chain, and therefore, block chain structure follows the listed steps. (1) According to the global sensing characteristics of the private chain, the node that first obtains all the required data in the whole network is regarded as the node that establishes the new block. At the same time, in order to ensure the security of data, this paper realizes the fast verification of data blocks by comparing and verifying the feature values and index values. (2) According to the prediction model based on the extreme learning machine, the predicted value of each sample point in the next moment from the data source is predicted. (3) Appropriate network is the basis of block chain operation. In order to get rid of the special central node and hierarchical structure in the network, all nodes need to be given the same status, so that each node can undertake the functions of network routing and data block verification, so P2P network is the most suitable network structure.

5 Experiment and analysis

5.1 Experiment 1

Select 4–6 ordinary PC nodes to install the IIS server, and deploy the data according to the storage model. The client is a normal PC in the education network. The data are "complex data domain request QoS.wmv," the file size is 142 M, and the storage model p = 1 is set.

Since the tests were conducted at different times, considering the dynamics of the network, the three results of the experiment were statistically analyzed (Fig. 9; Table 2).

The data in the table are processed to form 9. It can be seen that the performance of PTBM and CLBA observed at the same time is very different. Due to network instability, CLBA transmission time is slightly smaller than PTBM, while in the second observation, PTBM transmission time is slightly smaller than CLBA.

The raw data are processed using a storage model and stored in each node. In each case, one node is unavailable and data are transferred from other nodes. The download speed of each node is 40–150 k/byte (Fig. 10).

Fig. 9 ToT

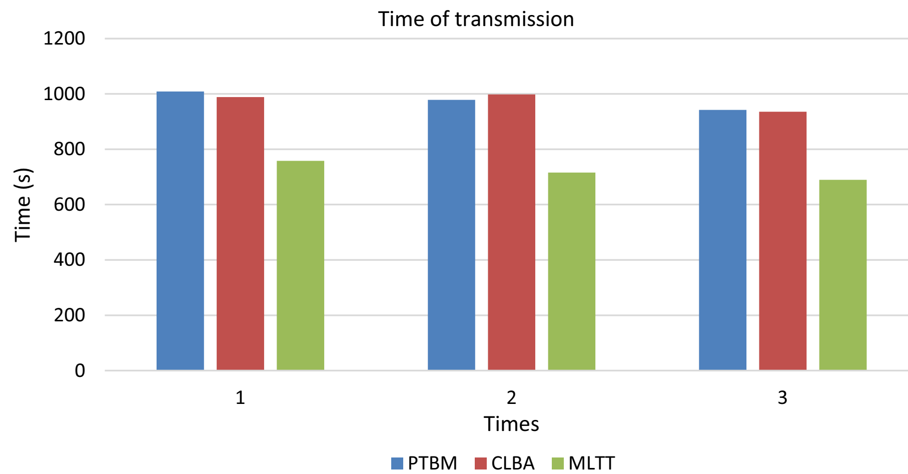
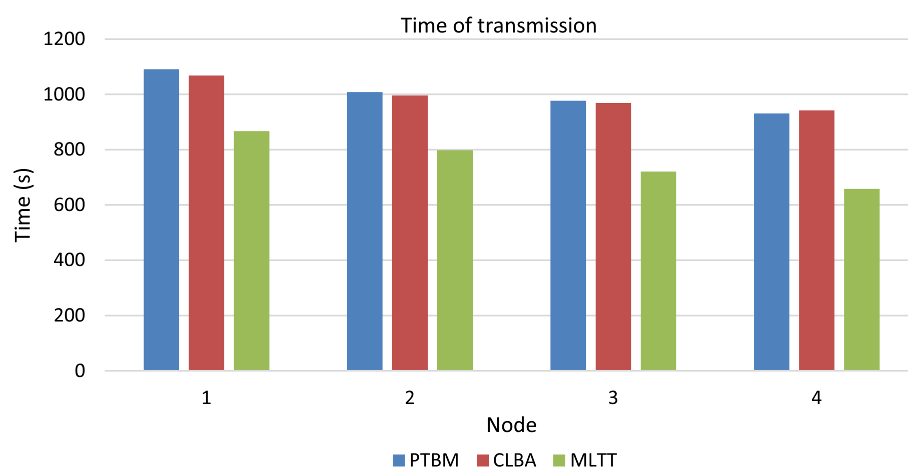


Table 2 Time of transmission (ToT)

Data category	PTBM			CLBA			MLTT		
Frequency	1	2	3	1	2	3	1	2	3
ToT	1008.5	988.7	758.1	978.5	998.1	715.6	942.1	935.8	689.5

Fig. 10 Impact of system load on acceptance rate



5.2 Experiment 2

In this section, we mainly test the effect of establishing/removing the hop count of the optical path on establishing/removing the optical path delay. This paper tests the optical paths of 2 hops, 3 hops, and 4 hops, respectively. The test results obtained are shown in Tables 3 and 4.

The optical path establishment time and the hop count show a good linear relationship. For each additional hop, the setup delay is increased by approximately 3000 ms. The removal time is generally increasing. For each additional hop, the removal delay is increased by approximately 1500 ms. Analysis and evidence show that this is caused by the blocking call of the CORBA interface, which only provides the call interface for establishing/removing a single cross-connection. When multiple requests to establish/remove a cross-connection are sent, these requests can only be executed in a sequential blocking manner. The next

Table 3 Data path creation delay

Data path	Maximum delay	Minimum delay	Average	Mean square error
2	8820	5832	6385	524
3	9114	7869	8426	284
4	12,365	10,856	11,335	535

Table 4 Data path deletion delay

Data path	Maximum delay	Minimum delay	Average	Mean square error
2	4198	3520	3752	196
3	5102	3198	3652	398
4	7886	6398	7065	358

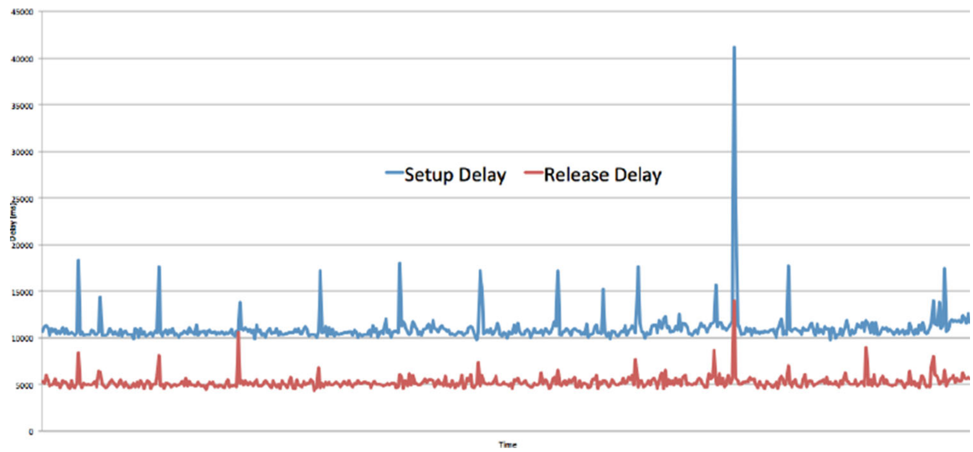


Fig. 11 Screenshots of long-time data path creation/deletion testing

Table 5 Long-time data path creation delay with 5-s interval

Time (h)	Burst interval (ms)	Maximum delay (ms)	Minimum delay (ms)	Average (ms)	Mean square error (ms)
1–2	5/5	20,450	10,087	11,498	1652
3-4	5/5	36,521	10,350	11,786	1985

Table 6 Long-time data path deletion delay with 5-s interval

Time (h)	Burst interval (s)	Maximum delay (ms)	Minimum delay (ms)	Average (ms)	Mean square error (ms)
1–2	5/5	14,865	6085	7068	865
3–4	5/5	25,047	6287	7174	1287s

request can only be continued if the previous request to establish/remove the cross-connection is completed and returned. Therefore, the time to establish/remove the cross-connect is substantially linear with the number of hops.

This paper performed long-term performance tests on the setup/removal of optical paths to verify their reliabilities (Fig. 11; Tables 5, 6).

We use Wireshark to capture the processing time of data cross-domain requests, as shown in Fig. 12. We can see that the CORBA uses the GIOP protocol message. By capturing the network messages of various complete operating procedures, by extracting the timestamps in the messages and performing related calculations, a very accurate OptoVisor processing time can be obtained (Table 7).

Stack chart of system network traffic and bar chart of system healthy conditions are shown as follows (Figs. 13, 14).

After verifying the effectiveness of the algorithm, it is necessary to conduct a feasibility experiment on the algorithm. In order to verify proposed algorithm is able to figure out the QoS global optimal service chain, we did the following experiment. The exhaustive method used in the experiment is to list the optimal solutions for all executable service flows and to verify the probability of having optimal results in these solutions. For experimental validation purposes, the statistical algorithm cycles 200 times

Fig. 12 Trace captured with Wireshark

Table 7 Numerical results of different operations

Network fragmentation	Operating delay (ms)		
	Topology acquisition	Establish data path	Delete data path
Virtual network 1	1.877	6.258	6.752
Virtual network 2	1.987	8.368	6.289
Virtual network 3	2.685	7.985	8.610

Fig. 13 Stack chart of system network traffic

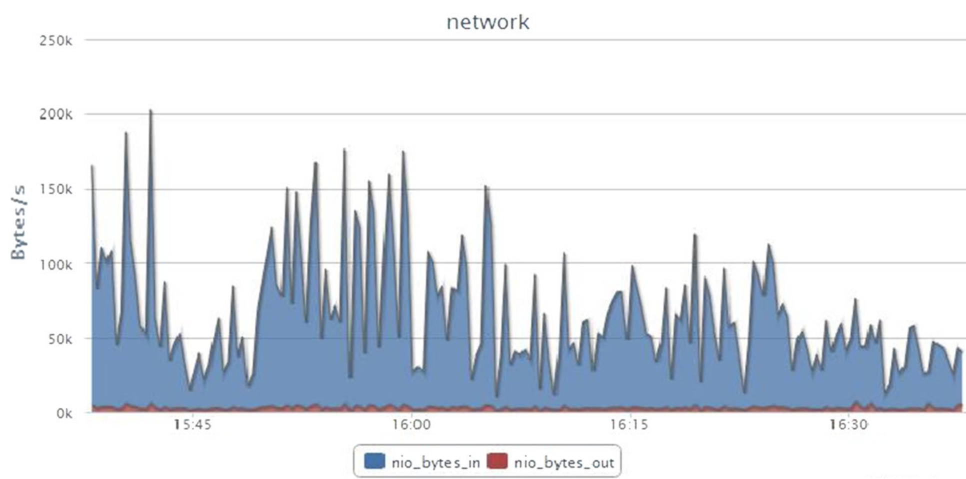
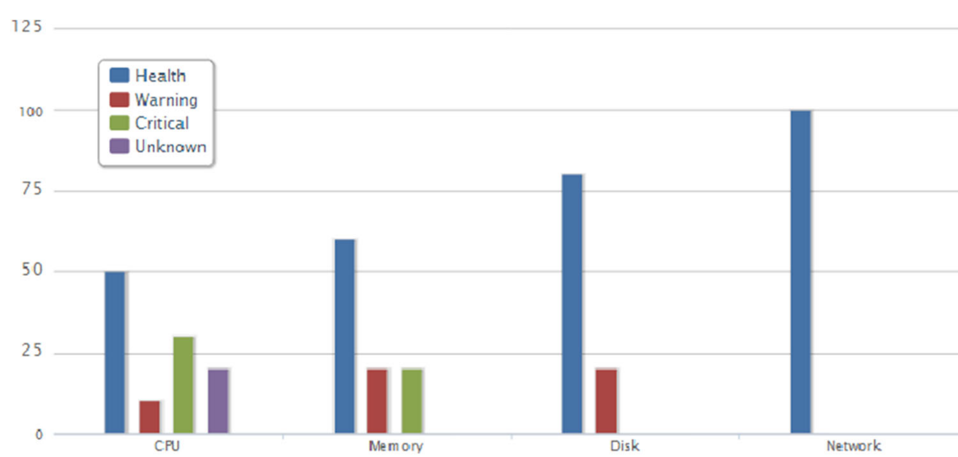
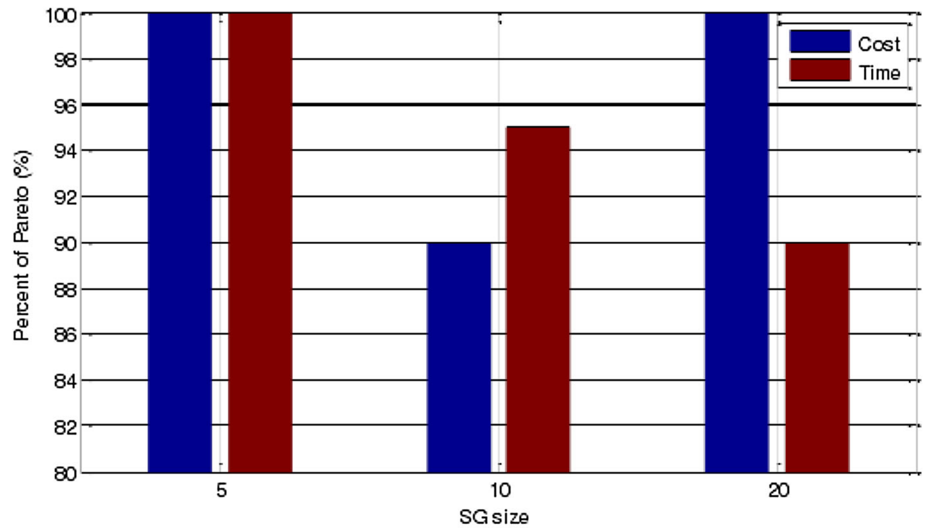
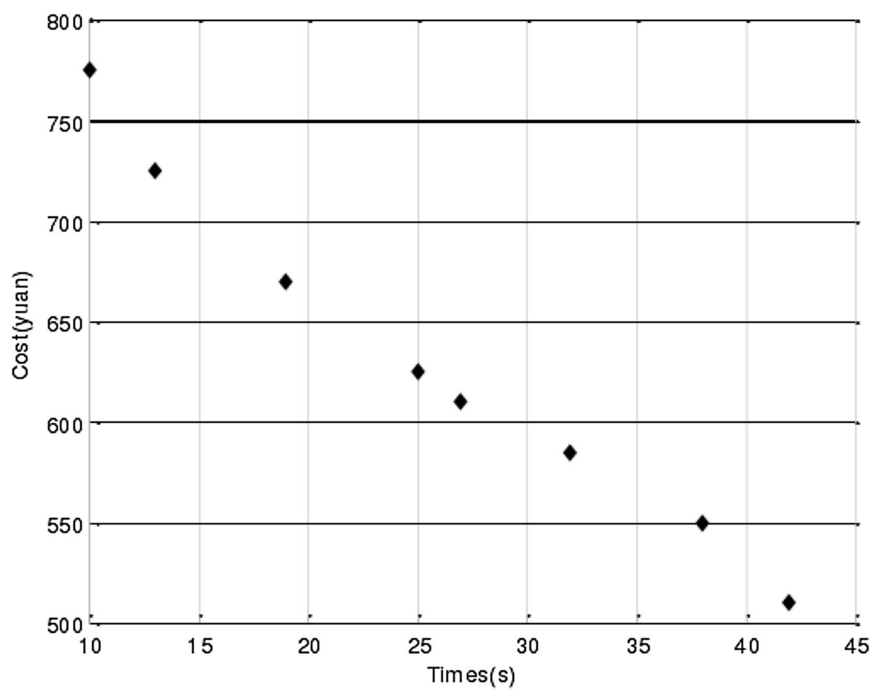


Fig. 14 Bar chart of system healthy condition





(a) Proportion of global optimal solutions



(b) QoS optimization solution

Fig. 15 Results of QoS optimization

the percentage of performance and overhead global optimal results, shown as follows (Fig. 15).

The various indicators of QoS are mutually influential and mutually constrained. We can only find the optimal solution according to the specific needs of users.

6 Conclusion

At present, computer networks in different environments have been developed, which makes it necessary to cross-domain data access between systems. This requires seamless communication and information sharing between systems, thus eliminating huge information islands. Providing extraordinary quality of service is a basic feature of data grids. It is of great practical significance to ensure that data services have high QoS while taking into account resource optimization. The loose coupling, reusability, easy combination, and virtual dynamic optimization of network services bring great challenges to traditional quality service assurance technology. In a dynamic and complex network service environment, the QoS assessment of service portfolio has become an important direction to ensure service quality. This paper proposes a QoS optimization system for complex data cross-domain request based on neural blockchain structure. This paper analyzes and tests the correctness and feasibility of various mechanisms from both theoretical and experimental aspects and achieves good results. The proposed algorithm achieves the goal of guaranteeing QoS and resource optimization.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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