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Research Article

Enterprise Collaborative Integrated Management System Based on IoT Cloud Technology

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With the advent of the white-hot competition environment at home and abroad, enterprises must continuously improve their management level to reduce operating costs, so as to achieve the purpose of improving operating efficiency, highlighting competitive advantages, and improving core competitiveness. The purpose of this research is to realize the sharing and collaboration mechanism of government resources, enterprise resources, and other resources in the digital ecological environment, so as to realize the transformation of enterprise productivity and production mode to a higher-end mode, and enhance the innovation ability of enterprises. On the basis of cloud computing theory and service computing theory, this research has carried out service model innovation, analysis, and design and realizes a service-oriented open collaborative sharing, multiorganization, multitenant, and dynamically scalable intelligent enterprise collaborative innovation cloud service platform. By selecting 20 valid scoring data, 80% of the scores are distributed in 3-5 points, indicating that the collaborative innovation cloud service platform for smart enterprises proposed in this paper realizes collaborative sharing among multiple organizations and multiple tenants. It highlights the matchmaking between enterprises and high-quality innovation resources, alleviates the uneven distribution of innovation resources, bridges the gap between various innovation entities, and provides a scalable and sustainable evolution of collaborative innovation cloud service environment.

1. Introduction

With the advent of the white-hot competition environment at home and abroad, enterprises must continuously improve their management level to reduce operating costs, so as to achieve the purpose of improving operating efficiency, highlighting competitive advantages, and improving core competitiveness. Changes in the size of the enterprise organization, the increase in branches, the refinement of departmental responsibilities, and the sharp increase in the number of personnel have also made the management and operation of the enterprise subject to time and space constraints [1, 2]. Obstacles increase, high-level decision-making is difficult, middle-level coordination is difficult, and bottom-level execution is difficult, resulting in a significant reduction in efficiency. The business upgrade brought about by the business transformation of the enterprise also makes the enterprise face a new state of collaboration. That is to say, according to the situation of the project or task, it may be necessary to build a temporary team, or to coordinate multiple key peoples in multiple departments at the same time, so as to achieve seamless collaboration in all aspects. This requires the data of the enterprise to be updated in real time to meet the needs of managers for resource allocation and task management.

The application of cloud computing can just be used as a base point. The advantages of no need to change the architecture, flexible deployment, high cost performance, and simple operation allow these startups to focus more on their core business. “Enterprise Internet +” and “Industrial Manufacturing 2025” are the strategic deployment of the country’s new generation of information technology development. The smart enterprise collaborative innovation cloud service platform uses the new generation of information technology, information infrastructure, and software service system model as the technical foundation to support the transformation of traditional enterprises to e-enterprises.

The innovation of this paper is (1) to propose a collaborative and shared cloud computing environment and computing model theory and method; (2) based on the cloud computing service model based on SOA architecture, combined with the enterprise cloud service theory, a smart enterprise cloud service architecture model is proposed; and (3) using software engineering methodology to model the demand and data of the collaborative innovation cloud service platform of smart enterprises, and analyze and design the system.

2. Related Work

The concept of interoperability has become a major challenge that must be considered when attempting to collaborate between enterprises and even within enterprises. In fact, a lack of interoperability can lead to problems, dysfunctions, slowdowns, or more generally, performance degradation that can lead to a drop in confidence among partners. Tayeb and Noureddine's research shows that of the existing methods to ensure interoperability, ontologies are the most commonly used. Ontologies are formal systems whose goal is to represent domain knowledge through mutually defined and structured concepts [3]. With the advent of Industry 4.0 and the Internet of Things (IoT), the need for electronic management is also becoming more widespread. In order to help small- and medium-sized enterprises take the first step towards the integration of Industry 4.0, it has become inevitable to implement enterprise collaboration system (ECS) in small- and medium-sized enterprises. Chiang et al. used SuccMail to examine the impact of external and internal support on the performance of ECS implementations. To achieve this, they took a questionnaire from ERP and modified it for ECS and used SPSS for correlation and multiple regressions [4]. However, when all supports are considered together, only some supports have significant and positive impact, so these supports can help SMEs implement ECS to improve performance. Collaboration is defined as the act of working with other people or organizations to create or achieve something. Collaboration exists in all organizations in some form, structured or unstructured, formal or informal. Organizations often do not consider existing collaboration practices when introducing new technologies. Bedford et al. take the form of a case study from a large international development organization. This case study describes the initial successful adoption of collaborative technology in the late 1990s and considers the reasons for its success [5]. Lück et al. proposed the design principles for business domain-specific electronic collaboration (BDSpec). This concept focuses on the integration of electronic collaboration into the core processes of a specific business domain and the corresponding transactional enterprise systems (ES) that support these core processes. These principles are based on research findings on collaborative support as a pilot area in product costing. In this area, they found a lack of integrated electronic collaboration to enable communication, coordination, and exchange of information directly related to core processes and their daily work procedures and data sources [6]. Today's ubiquitous technology is driving companies of all industries and sizes to transform their business models and make digital transformation a reality. Enterprise collaboration players are at the center of digital transformation, enabling real-world scenarios of productivity, scalability, agility, and resulting in an enhanced customer experience. Agrawal sees companies investing more in ensuring a seamless customer experience. Customers are no longer loyal to brands that offer products at competitive prices or significantly innovate; customers are more loyal to brands that they interact with regularly and provide a true omnichannel customer experience [7]. Singh et al. discover supplier-buyer relationships in the automotive and parts industry. More precisely, they examine the cooperative trade associations between all companies working in the automotive industry. They examine the extent of information sharing, trust, and collaboration in the business networks involved and attempt to determine which structures influence the establishment and expansion of channel member affiliations. In particular, whether the interactions among supply chain members are directly affected by these structures is explored and inferences drawn [8]. The research methodology has a cross-sectional design and is descriptive and exploratory. The massive data demands in modern communication networks mean that the traditional model of placing data processing, storage, and management at the core of the network is increasingly seen as inefficient, while the edge is where services need to be created and delivered. Bright's research suggests that multiaccess edge computing (MEC)—an extended definition of mobile edge computing originally envisioned by ETSI—proposes the creation of a satellite-type cloud computing environment by employing distributed data centers (cloudlets) at the network edge. Access to web APIs will allow application developers to create new applications and services closer to the point of use [9]. IoT is widely deployed in various fields of daily life through heterogeneous communication protocols. Shen et al. proposed a general architecture for IoT and designed a centralized controller that provides standardized interfaces for data acquisition, organization, and storage and support elastic and supportive computing. With these properties, different devices can coexist in a unified microcosm, and rich services can be developed and provided on demand to interoperate with physical devices [10].

3. Enterprise Collaboration Method of IoT Cloud Technology

3.1. Enterprise Collaborative Management. Collaborative management refers to a theory based on synergy to manage all management objects [11]. How to better realize the role of the whole, to allocate resources reasonably and effectively and to maximize the interests of the enterprise, is the main purpose of collaborative management. Applying the basic theory and management methods of collaborative management to various business management of an enterprise is what we often call enterprise collaborative management [12, 13], taking the enterprise as the main research object, and involving multiple organizations and departments inside and outside the enterprise in the research process, and researching innovative methods to bring together and synergize internal and external resources of the enterprise. In the case of the continuous development and change of the internal and external environment such as the market, combined with the overall development goals and strategies of the company, it is decomposed into various work links, so that the goals are consistent from top to bottom, so that resources can always be used and allocated reasonably. The essence of enterprise collaborative management is to achieve dynamic management cooperation of enterprises and achieve common goals to create maximum value.

Enterprise collaborative management has the following characteristics:

(1) Goal maximization: how to maximize the realization of enterprise synergy is the goal pursued by enterprise collaborative management, which is what we often say $1 + 1 > 2$. To achieve this goal, it is necessary to first understand and complete the management content of each subdepartment and straighten out the collaborative relationship between various departments, so as to smooth the collaboration process, so that the value created after collaboration is greater than the original value of each department

(2) Multipurpose: the synergy effect is not simply a straight line connecting every two points, but connecting each key point to each other to realize the supporting role of the entire plane, so as to achieve the goal of collaborative management

(3) Full synchronization: in the unified field of time and space, the various participating departments of collaborative management are closely linked together, so that the management process is more scientific, the management method is more reasonable, and the operation status is more orderly, which is another characteristic requirement of collaborative management [14–16]

With the development of the "Internet +" era background, social mobility and other changes have changed the working methods, working time and space, and working status of each of our enterprise workers. The collaborative management of enterprises increasingly reflects the demand for mobility.

3.2. Cloud Computing Mobile Work Platform. The mobile work platform takes internal communication and sharing within the enterprise as the core. Through enterprise social networks and social enterprise applications, it builds a safe and private socialized workspace to help enterprises improve communication efficiency, strengthen teamwork, promote sharing among all employees, and achieve efficient collaboration. Cloud computing simply means that the software and hardware resources and data required by enterprises can be placed on the network, and at any time and place, they can be connected to each other by using different IT equipment to achieve data access, computing, etc. [17]. The hierarchical division of cloud computing services can be divided into three layers, from bottom to top, IaaS (infrastructure as a service) hardware resource management service, PaaS (platform as a service) software resource management service, and SaaS (software as a service) application software service. Private cloud is a type of cloud computing that efficiently controls data, security, and service quality. It is generally built for enterprises or institutions for their own use. Other products similar to mobile OA currently mainly adopt the design and operation and maintenance ideas of traditional software and have not established a platform ecosystem. They mainly rely on manufacturers to update products themselves, which cannot meet the needs of users in the era of rapid iteration in the mobile Internet era [18].

3.3. Key Technologies of the Internet of Things. The Internet of Things can be divided into three levels: perception, network, and service application in terms of architecture. The three-tier architecture of the Internet of Things is shown in Figure 1.

As shown in Figure 1, the perception layer completes the acquisition of entity information, that is, collects entity information through various sensing devices; the network layer completes the transmission, fusion, and processing of information and transmits the collected data to the Internet through the communication network; the service application layer refers to the combination with industry needs to achieve a wide range of intelligence. The principle of IoT technology is shown in Figure 2.

As shown in Figure 2, there are many types of key technologies in the modern Internet of Things, mainly including the following aspects:

(1) Network and communication technology

Wireless network technologies mainly include infrared, ZigBee, WiFi, and Bluetooth, and different types of information can be transmitted by using this wireless network technology [19]. Among them, Bluetooth has the characteristics of small size, low cost, and low power consumption, and it can realize a variety of wireless connection methods [20]. It is a highly reliable data transmission network platform composed of multiple wireless modules, and each module can exchange data with each other. Through the interconnection of multiple modules, the communication distance between data can be extended accordingly.

(2) Wireless sensor network

The wireless sensor network is composed of many onsite detection sensor nodes, and they are deployed in the place that needs to be monitored. A self-organizing network system is built through wireless communication technology, and the relevant information of the place is finally obtained. These nodes integrate the signal processing module and the

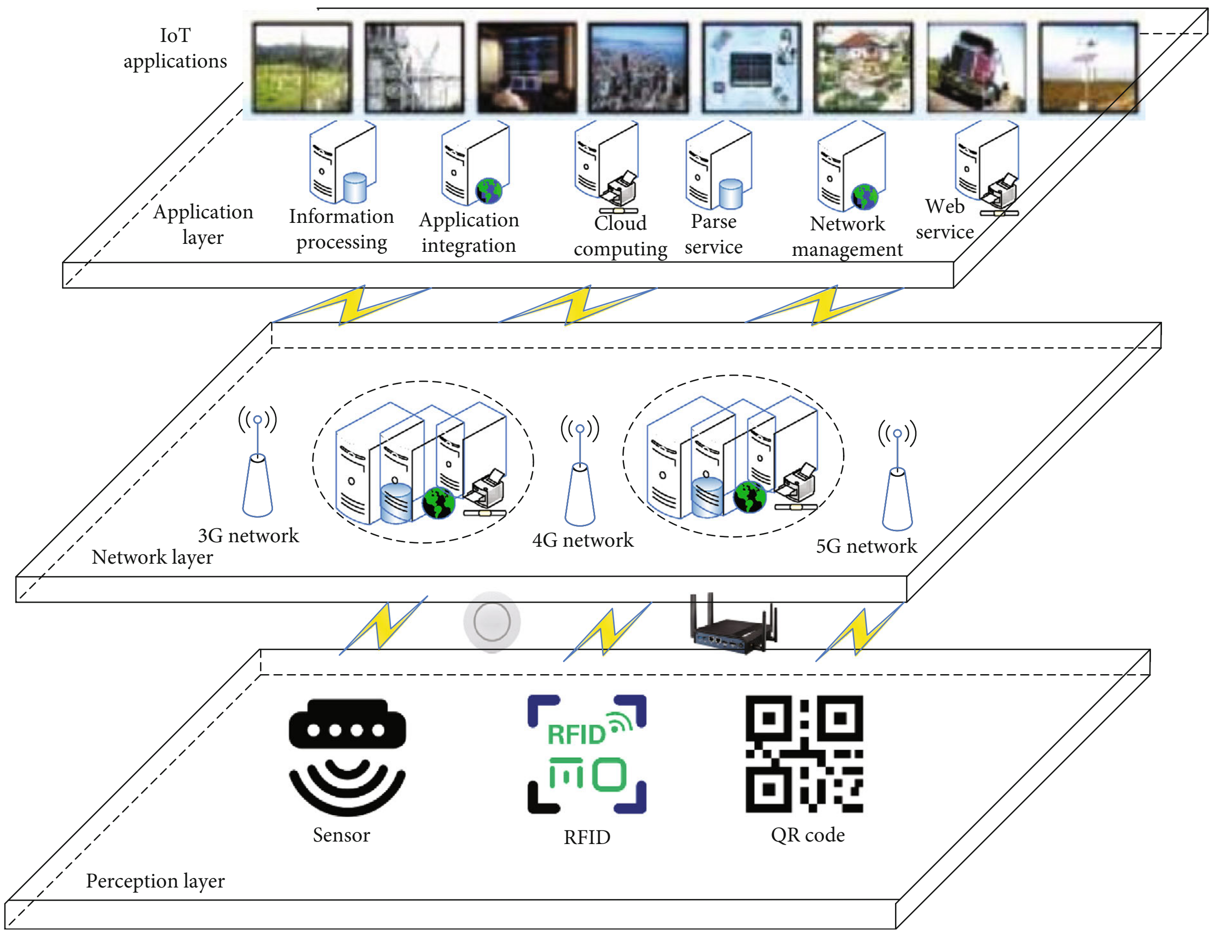


Figure 1: The three-tier architecture of the Internet of Things.

signal transmission module to form a regional network system. The sensor can measure the surrounding information, so that each node cooperates with each other, and realizes the target object detection by exchanging local data [21].

(3) Radiofrequency identification (RFID) technology

RFID technology is one of the key technologies in the Internet of Things. Its working principle is to tune the transmitted signal into a specific electromagnetic field and spread its information to the surrounding [22]. The signal strength vector of the tag to be located measured by the AP is $S = (S_1, S_2, \cdots, S_n)$, and the signal strength vector of the reference tag measured by the AP is $\theta = (\theta_1, \theta_2, \cdots, \theta_n)$. It is easy to obtain that the Euclidean distance between the kth reference label and each label to be tested. It is used to express the relative signal strength value between the reference label and the label to be tested, such as

$$Q_k = \sqrt{\sum_{j=1}^{n} (\theta_i - S_i)}, k = 1, 2, \cdots m. \quad (1)$$

The m Euclidean distances can geometrically form a set of vectors. As,

$$Q = (Q_1, Q_2, \cdots Q_m). \quad (2)$$

Then, according to the K-nearest neighbor algorithm, the values in Q are arranged in ascending order, and the first k values are selected and multiplied by the weighting coefficient w to obtain the weighted sum of the position coordinates. The expression is

$$(m, n) = \sum_{j=1}^{K} w_j (m_j, n_j). \quad (3)$$

Among them, the weighting coefficient w is calculated by experience, and the mathematical expression is as

$$\frac{w = Q_j^2}{\sum_{j=1}{}^{K} Q_j^2}. \quad (4)$$

The filtering method has low computational cost, fast processing speed, and remarkable effect. The mean value μ

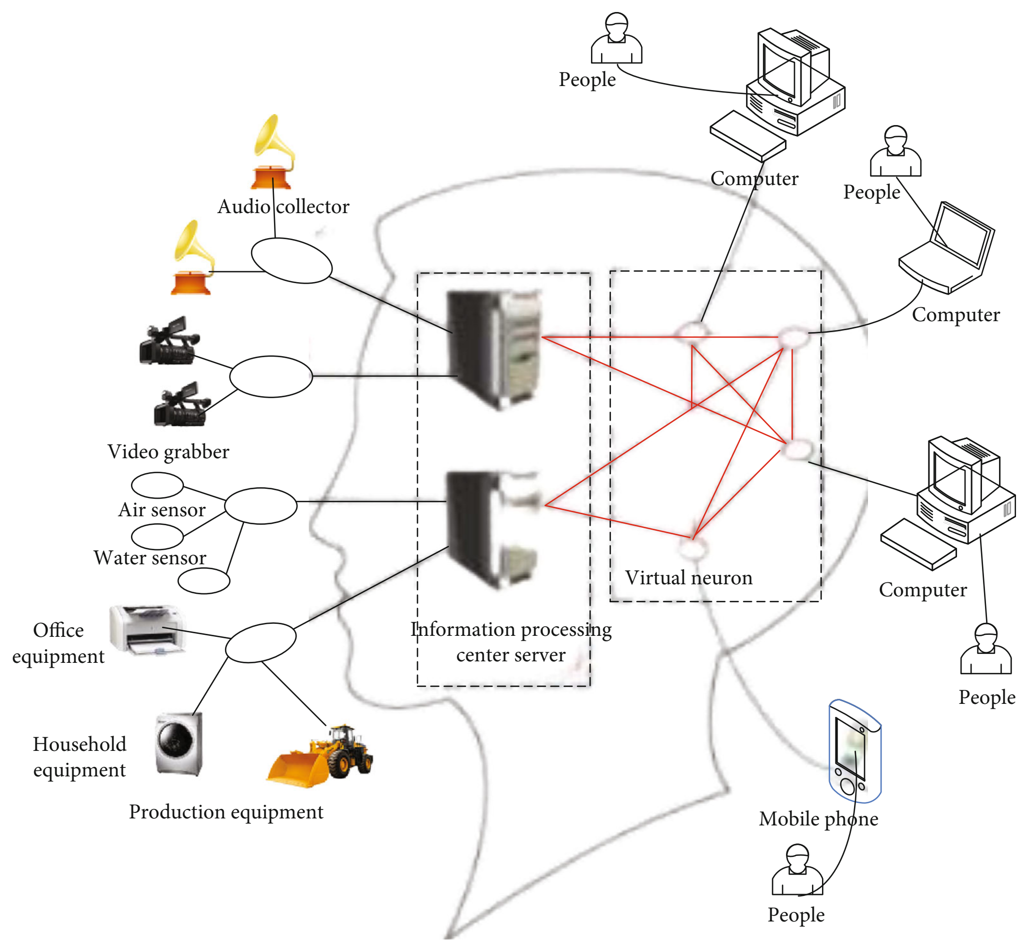


Figure 2: The principle of IoT technology.

and the standard deviation σ of the signal samples are calculated as formulas (5) and (6), where k represents the total number of samples, and RSSI_n is the nth sample.

$$\frac{\mu = 1}{k} \sum_{n=1}^{k} \mathrm{RSSI}_n, \tag{5}$$

$$\sigma = \sqrt{\frac{1}{k} \sum_{n=1}^{k}} \left(\mathrm{RSSI}_n - \mu\right)^2. \tag{6}$$

The filtered signal strength can be obtained by accepting data in the range of $(\mu - 0.5\sigma, \mu + \sigma)$. Under normal circumstances, the actual received power value will decrease due to environmental interference, reflection interference, and other reasons during the signal propagation process. Therefore, the left acceptance area is reduced here to offset the effect of the small RSSI value. Finally, the mean value μ_n and the original variance σ_n are calculated as the fingerprint information G of the reference label and stored in the fingerprint database. G is as

$$G_n = \left(a_n, b_n, \mu_1, \mu_2, \cdots, \mu_k, \sigma_1, \sigma_2, \cdots \sigma_k\right). \tag{7}$$

Among them, $n(1, m)$, $k\,(1, l)$. After obtaining the fingerprint information of all reference tags on all APs, a complete offline fingerprint database is established.

In the classic LANDMARC positioning algorithm, the KNN algorithm is usually used in the online positioning stage, and the coordinate information is estimated by selecting the appropriate K value and selecting the first k minimum values in the vector E. The algorithm steps are as follows:

(1) Determine three reference label coordinates (x_1, y_1), (x_2, y_2), and (x_3, y_3), and an additional fourth reference label coordinate (x_4, y_4)

(2) Calculate the distance between (x_1, y_1) and the other two reference points, denoted as $d12$, $d13$, and $d14$, respectively, and select 4/5 of the maximum value as the radius and denote it as $R1$. Similarly, find $R2$ $R3$ symmetrically, such as

$$R_1 = \mathrm{Max}\ (d_1 i) = \mathrm{Max}\ \sqrt{(x_1 - x_i)^2 - (y_1 - y_i)^2}, i = 1, 2, 3 \tag{8}$$

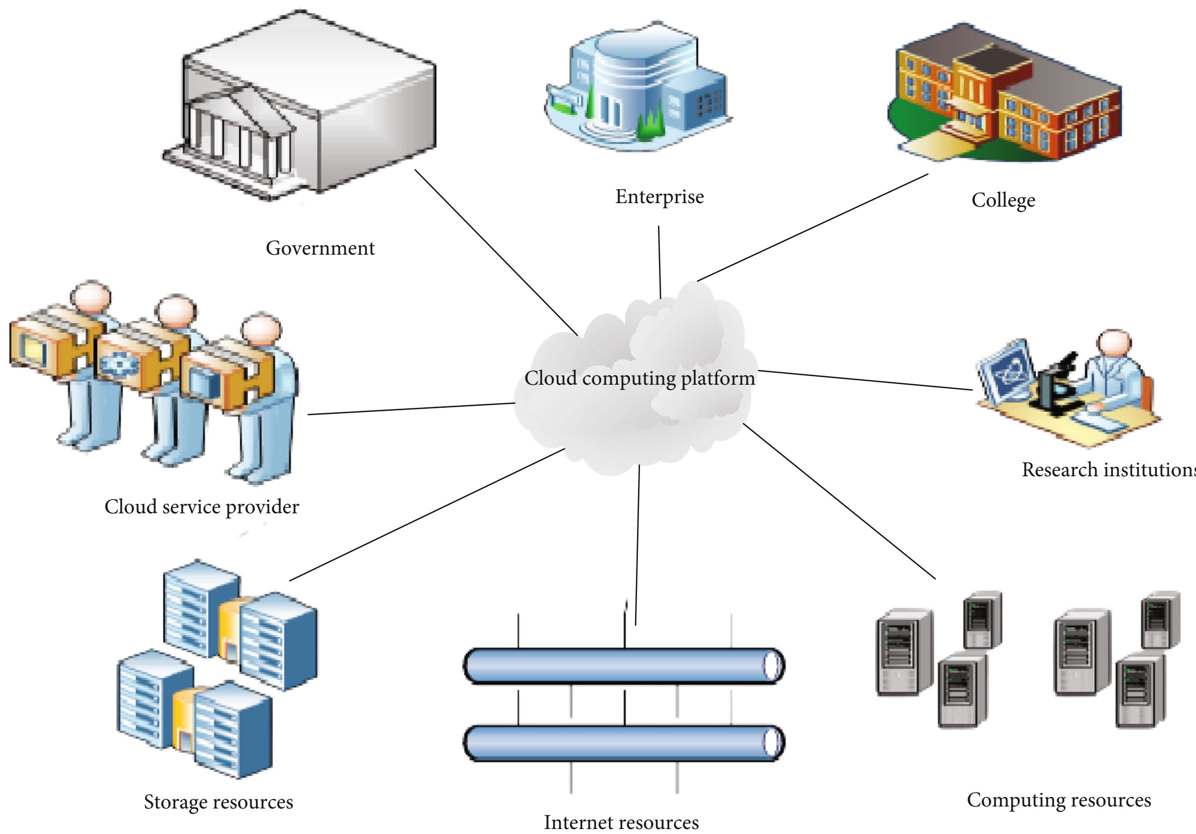


FIGURE 3: Digital ecological model of smart enterprise collaborative innovation.

(3) Obviously, the coordinate formula of the three circles are as

$$(x-x_i)^2 + (y-y_i)^2 = R_i, i = 1, 2, 3 \tag{9}$$

The conditions to be satisfied are as in

$$\sqrt{(x_1-x_2)^2} + (y_1-y_2)^2 \leq R_1 + R_2, \sqrt{(x_2-x_3)^2} + \cdot (y_2-y_3)^2 \leq R_2 + R_3, \sqrt{(x_1-x_3)^2} + (y_1-y_3)^2 \leq R_1 + R_3. \tag{10}$$

If the above three formulas are not satisfied, then the following is obtained:

$$\frac{\text{Avg\_}x = x_1 + x_2 + x_3}{3,} \tag{11}$$

$$\frac{\text{Avg\_}y = y_1 + y_2 + y_3}{3.} \tag{12}$$

When formula (11) is established, it is proved that the three circles intersect in pairs.

3.4. Establishment of the Order Parameter Formula of the Cooperative System

4. Technical Collaboration

Technical collaboration is the basic element and foundation of collaboration in modern logistics systems. The overcoming of key technologies, the standardization of interfaces, and the unification of data formats will make technical collaboration possible [23]. The technical coordination depends not only on the inherent properties of the hardware but also on the stability and real-time performance of the software system.

Let the system synergy efficiency be y and the service synergy factor be x. x is the function of time t. the initial state synergy efficiency of the system y_i, the equilibrium synergy efficiency, β is the slope of the system from the initial state to the equilibrium state, that is, $dy/dx = \beta$, have

$$y = \begin{cases} y_0\,(x=0), \\ \beta x\,(0 < x < x_0), \\ y_i\,(x_i < x). \end{cases} \tag{13}$$

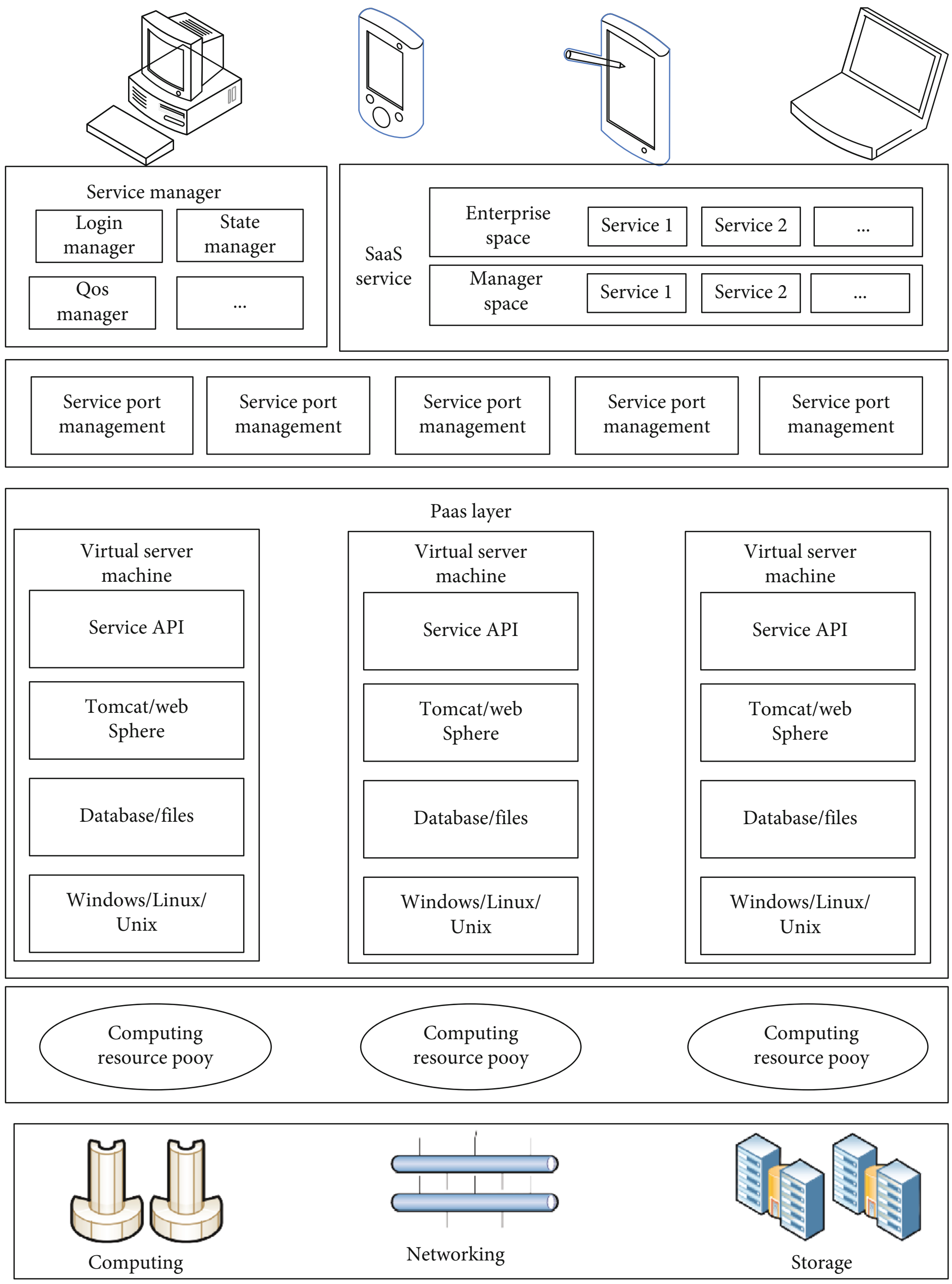


FIGURE 4: Smart enterprise collaborative innovation cloud service architecture model.

Suppose the system synergy efficiency is S, the management department synergy factor is w, and S is a function of w, so formula (13) becomes

$$s(w) = \begin{cases} S_0\,(w = 0), \\ \beta w + S_0\,(0 < w < w_0), \\ S_i\,(w_i < w). \end{cases} \tag{14}$$

5. Information Collaboration

The efficient coordination of information is the key to system coordination. Once information is blocked or lost, the system efficiency will drop rapidly [24, 25]. Therefore, when building an information system, information processing, fusion, exchange, and other links determine the fluency of information, thereby affecting the efficiency of information collaboration. Let the system synergy efficiency be y, the information synergy factor be x, and x

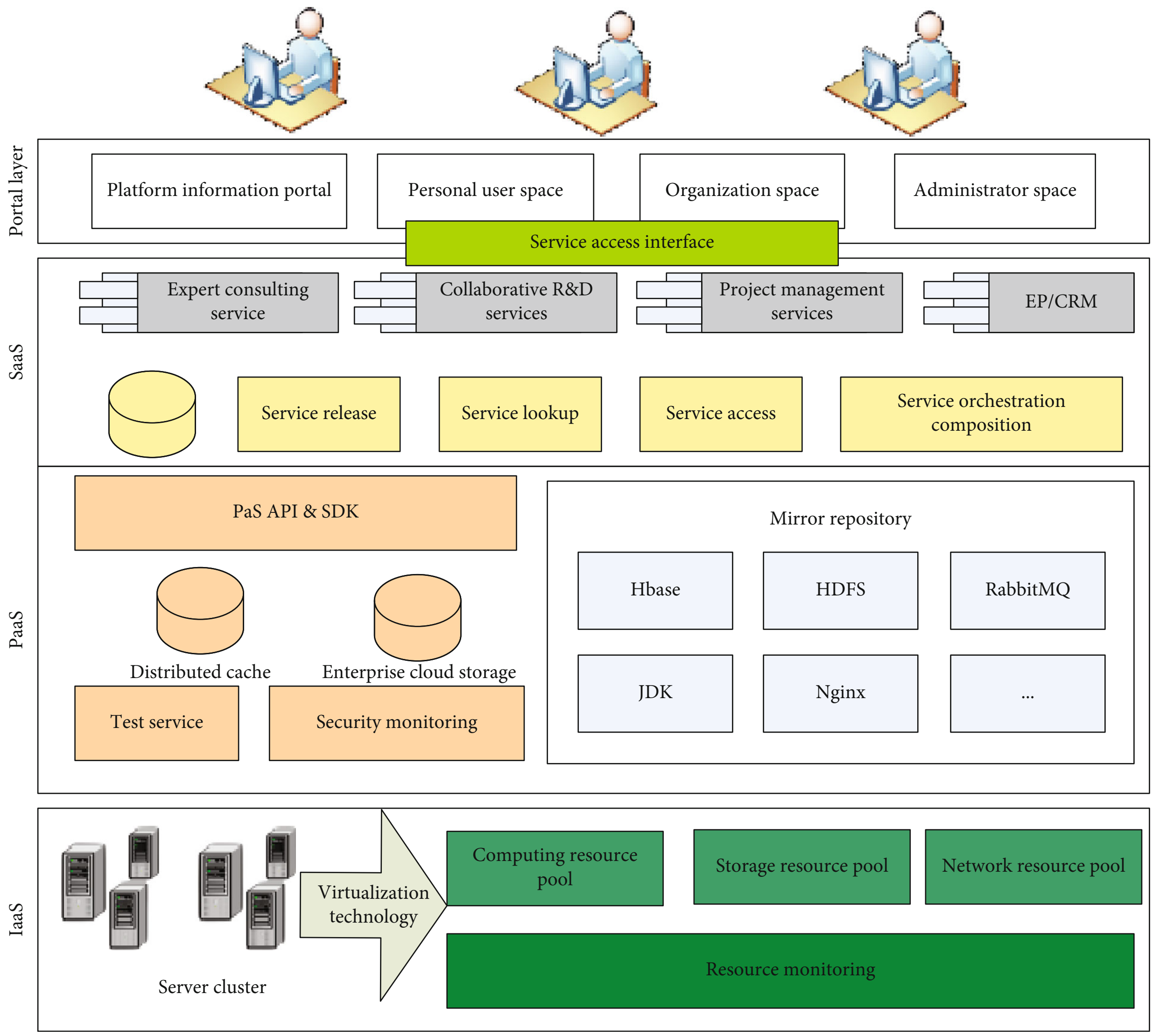


Figure 5: Smart enterprise collaborative innovation cloud service platform architecture.

be a function of time t, the system initial state synergy efficiency y_0, we have

$$y = bx^2 + y_0, b > 0. \tag{15}$$

Suppose the system synergy efficiency is S, the information synergy factor is σ, and S is a function of δ, so formula (15) becomes

$$S(n) = bn^2 + S_0, b > 0. \tag{16}$$

6. Service Collaboration

Service collaboration refers to the influence of the entire external environment such as upstream and downstream manufacturers, governments, consumers, and partners outside the system on the system itself, as well as the collaborative operation between the subsystems of the logistics system platform [26, 27]. The purpose of service collaboration is to shorten the information transmission time and increase information efficiency, minimize the bullwhip effect, and thus reduce production costs and logistics costs. Let the system synergy efficiency be y, the service synergy factor be x, and x be a function of time t, the system initial state synergy efficiency y_0, balance synergy efficiency y_i, we have

$$y = \begin{cases} y_0\ (x = 0), \\ \ln\,(x + 1) + y_0\ (0 < x < x_0), \\ y_i\ (x_i < x). \end{cases} \tag{17}$$

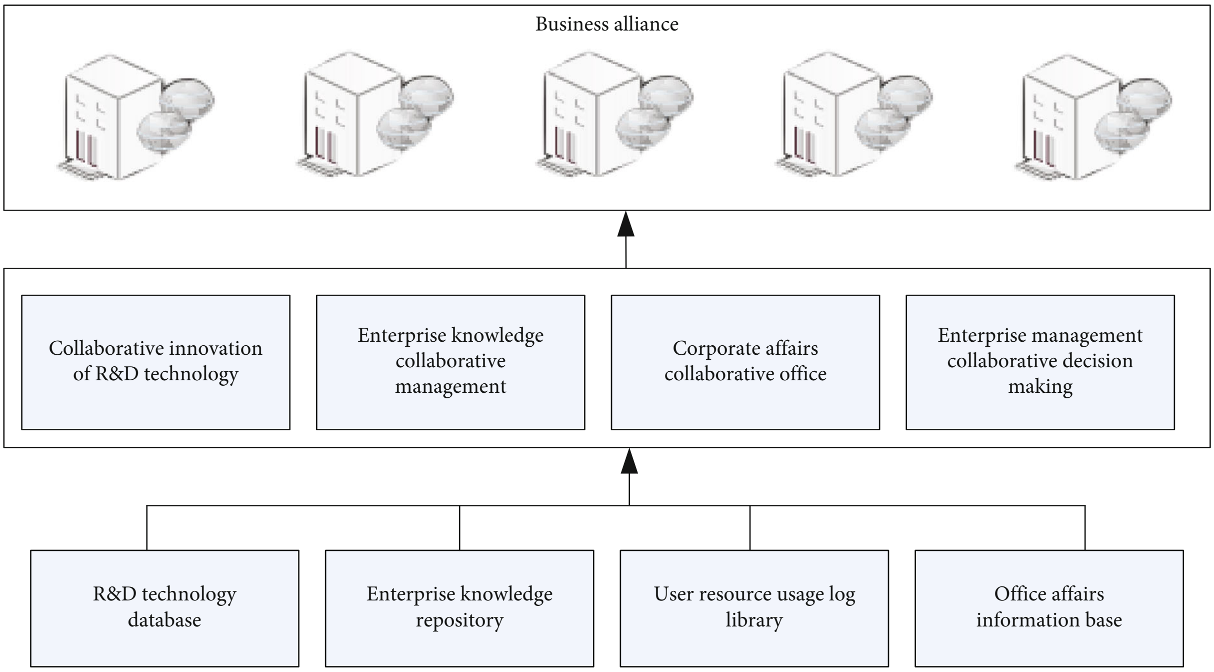


Figure 6: Conceptual model of enterprise collaborative innovation.

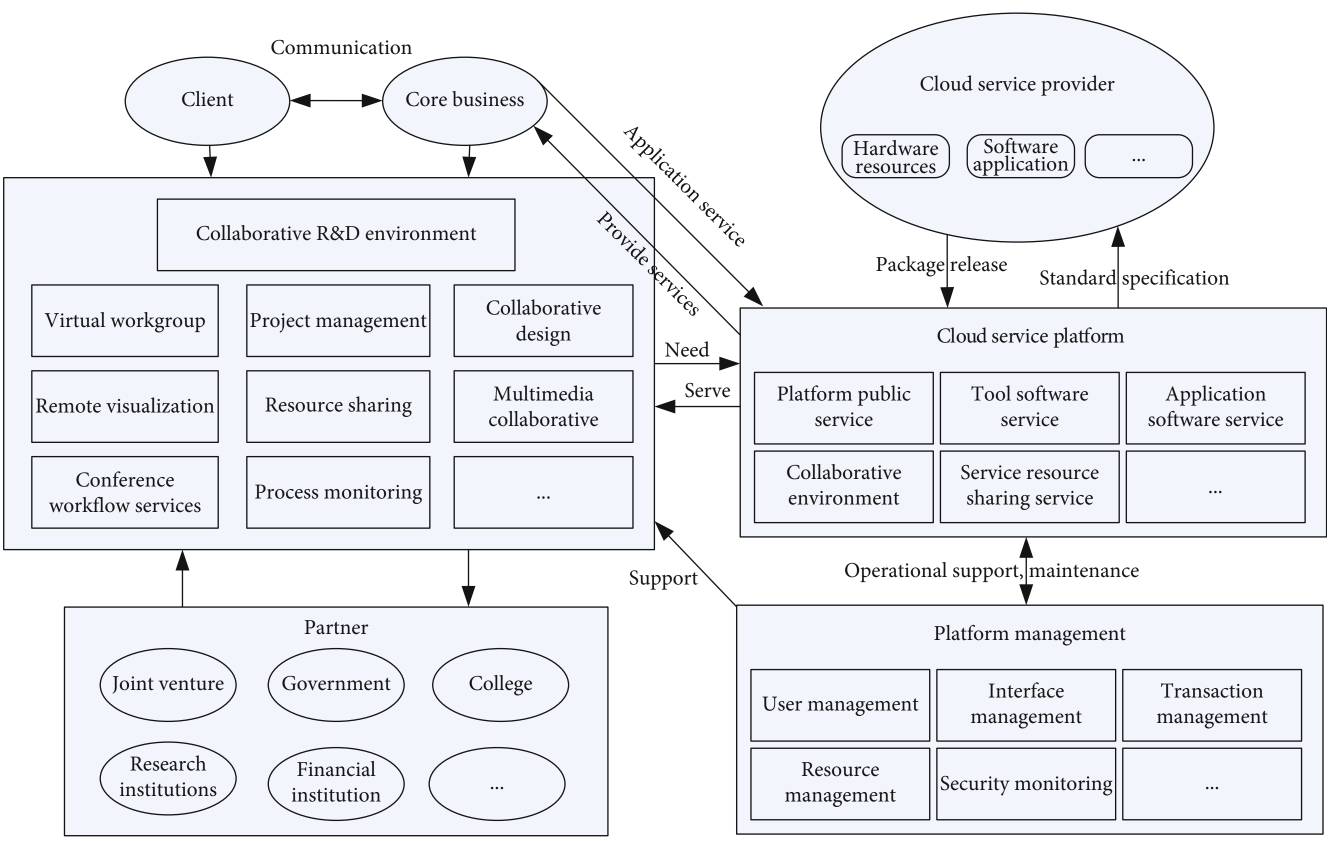


Figure 7: Innovative R&D collaboration environment.

Table 1: Development environment.

Tool	Illustrate
MyElipse 10	Integrated distribution environment
JDK 8	Java development kit
Dubbo	Web service governance framework
SSM	Open source J2EE development framework
MySQl, Hbase, Redis	Database

Table 2: Operating environment.

Tool	Illustrate
Tomcat 8	Web server
OpenStack	Cloud infrastructure management
VMware 12	Virtualization tool
CentOs 7	The operating system of the virtual machine

Suppose the system synergy efficiency is S, the service synergy factor is, and S is a function of δ, so formula (18) becomes

$$S(\sigma) = \begin{cases} S_0\,(x = 0), \\ \ln\,(\sigma + 1) + S_0\,(0 < \sigma < \sigma_0), \\ S_i\,(x_i < x). \end{cases} \tag{18}$$

7. Management Collaboration

The system starts from a low-efficiency synergy point, and after a short period of synergy operation, it will produce a period of high-speed synergy operation. When a balanced efficiency synergy point is reached, the logistics system will continue to operate at the balance point. Let the system synergy efficiency be y, the management synergy factor be x, x is a function of time t, the system initial state synergy efficiency y_0, the balance synergy efficiency y_i, the transition state x_d synergy efficiency y_d is

$$y = \begin{cases} y_0\,(x = 0), \\ \arctan\,(x - x_d) + y_d\,(0 < x < x_i), \\ y_i\,(x_i < x). \end{cases} \tag{19}$$

Suppose the system synergy efficiency is S, the management department synergy factor is ε, and S is a function of ε, so formula (19) becomes

$$S(\varepsilon) = \begin{cases} S_0\,(\varepsilon = 0), \\ \arctan\,(\varepsilon - \varepsilon_d) + S_d\,(0 < \varepsilon < \varepsilon_i)\,, \\ S_i\,(\varepsilon_i < \varepsilon). \end{cases} \tag{20}$$

8. Nonhuman Interference Factors

Nonhuman factor interference refers to the impact of natural factors such as meteorological disasters, geological disasters, and seasonal emergencies on the degree of coordination of the logistics system. Therefore, the study of nonhuman factors has become an indispensable link in the analysis and establishment of order parameter formulas. Let the system synergy efficiency be y, the nonhuman factors be x, x is a function of time t, the system initial state synergy efficiency y_0, when the lowest synergy efficiency state x_d, synergy efficiency is y_d, balance synergy efficiency y, there is [23]

$$y = \frac{\sin\,(x - x_i)}{x} + y_i, x > 0. \tag{21}$$

Let the system synergy efficiency be S, and the nonhuman factors be, S is a function, so formula (21) becomes

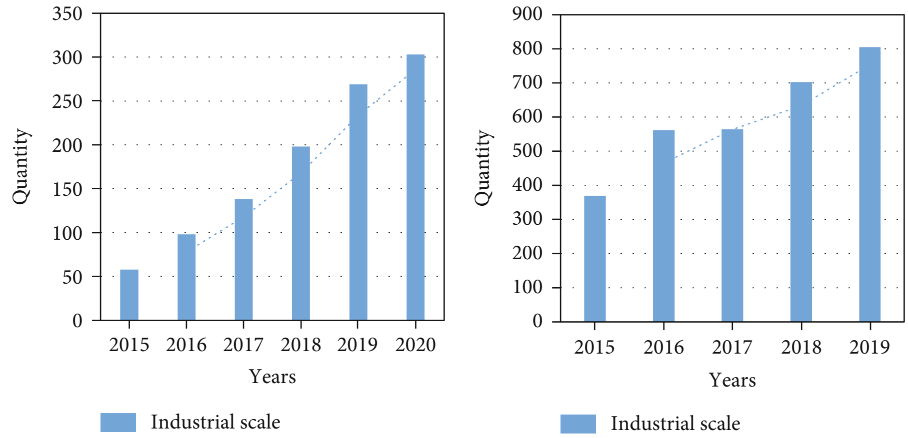
$$S(\gamma) = \frac{\sin\,(\gamma - \gamma_i)}{\gamma} + S_i, \gamma > 0. \tag{22}$$

For a complex cooperative system, the macroscopic changes in the system do not depend on the forced action of a given external force, but on the "synergy" effect between subsystems. Whether it is technical collaboration, service collaboration, or management collaboration, they all depend on the premise of information collaboration and, at the same time, affect the efficiency of information collaboration.

9. Enterprise Collaborative Innovation Cloud Service Theory and Architecture

9.1. Smart Enterprise Collaborative Innovation Digital Ecological Environment. Collaborative innovation means that enterprises, governments, universities, scientific research institutions, and cloud service developers and other innovative entities fully release each other's "talents, needs, technology, information, capital," and other innovative vitality elements and form a business model with enterprises, universities and colleges. It is a multisubject interactive innovation model with scientific research institutions as the main body and the government and third-party institutions as the auxiliary, so as to achieve the goals of common development, benefit sharing, and complementary advantages. In the cloud computing-based environment, combined with the theory of collaborative innovation, this paper proposes an open collaborative sharing, scalable, and sustainable evolution digital ecological model for collaborative innovation of smart enterprises. The smart enterprise collaborative innovation digital ecological environment model (SECIDE-model) is shown in Figure 3.

As shown in Figure 3, this model provides IT infrastructure resources as IaaS services to enterprises and various innovative entities through virtualization technology [24]. On this basis, cloud service developers use the PaaS platform to develop various enterprise cloud service applications and publish the services to the cloud service center. Users can use the cloud platform to pay for the required cloud services,



(a) IoT industry growth (b) IoT industry market size and growth

Figure 8: Development of the Internet of Things.

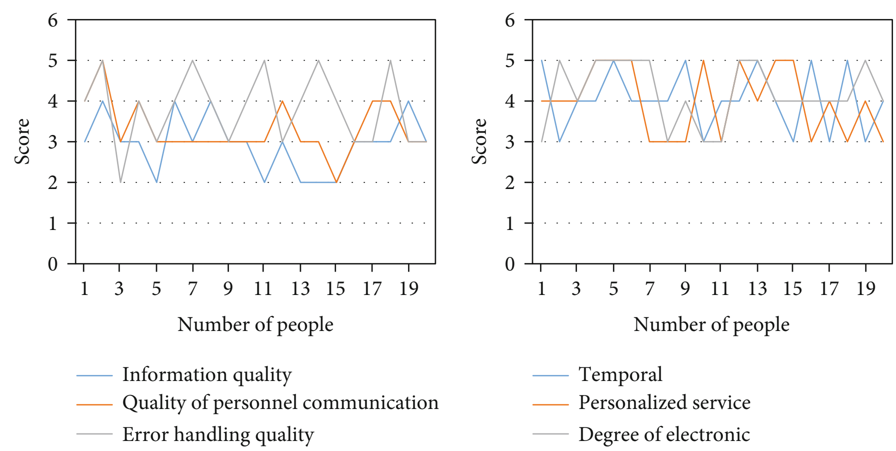


Figure 9: Results of service quality scoring based on SERVQUAL scale.

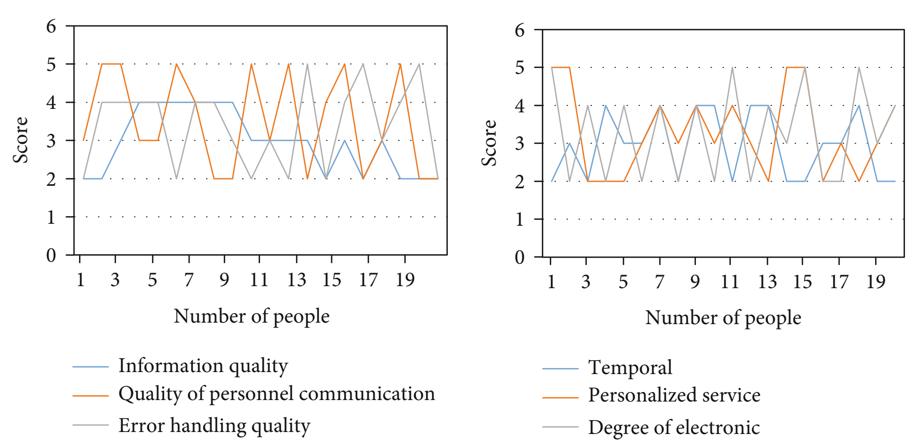


Figure 10: Satisfaction score based on SERVQUAL scale.

that is, SaaS services. Using the characteristics of collaborative sharing of resources in the cloud computing environment, a large amount of business data information of enterprises and institutions can be gathered. It can realize that enterprises are the main body of innovation, and the government provides various policy support and supervision. Colleges' and universities' scientific research institutions provide talent training and scientific and technological achievements. Financial institutions provide financial support. Cloud service developers provide software services for smart enterprises to collaboratively innovate a digital ecological environment.

(1) Smart enterprise collaborative innovation cloud service architecture model

On the basis of SECIDE-Model, a cloud service architecture model for collaborative innovation of intelligent enterprises, which is oriented to multiorganization, multitenancy, and open, collaborative and shared, is proposed as shown in Figure 4.

As shown in Figure 4, the intelligent enterprise collaborative innovation cloud service architecture adopts the idea of layered design. Each layer is independent and related to each other. The realization of the lower layer is the foundation of the upper layer, and the realization of the upper layer depends on the lower layer. The IaaS layer virtualizes hardware resources such as high-performance computing devices, high-speed communication networks, and large-scale storage devices at the physical layer, forming various virtual service resource pools to provide external services, and is also the basis for upper-layer services; the PaaS layer provides users with a development environment platform and basic business model services; the SaaS layer provides users with tenant space in a multitenant environment, and tenants can customize various Web services according to their needs, such as product collaborative research and development services, enterprise supply demand search services, virtual organization management services, industry information dynamic push services, and other personalized services.

(2) Architecture of cloud service platform for collaborative innovation of smart enterprises

Based on the abovementioned smart enterprise collaborative innovation digital ecological model and smart enterprise collaborative innovation cloud service architecture model, combined with service-oriented architecture standards, this paper proposes an architecture—the smart enterprise collaborative innovation cloud service platform architecture. The smart enterprise collaborative innovation cloud service architecture combines cloud computing technology and SOA architecture ideas. The entire architecture can be summarized into two parts—cloud server and platform information portal, as shown in Figure 5.

As shown in Figure 5, it is based on the virtualized massive infrastructure service resource pool, supported by public basic business process services and platform development and operation environment, through a cloud service center, various general cloud services or customized of personalized cloud services are aggregated, assembled, and published. In this way, users can use various smart terminal devices to obtain various industry information and enterprise cloud applications at anytime and anywhere.

9.2. Theory of Enterprise Collaborative Innovation

10. Conceptual Model of Enterprise Collaborative Innovation

The enterprise collaborative innovation service platform is a functional service platform, which provides collaborative development and management innovation of enterprise R&D technical knowledge, collaborative work innovation of enterprise office platform, and enterprise management collaborative decision-making innovation that can be used remotely, shared, and provide services on demand.

The collaborative development and innovation of enterprise R&D technology is through the sharing of technical information resources within the enterprise, the purchase of technical patents on the collaborative innovation enterprise platform, and the public R&D with alliance enterprises on the collaborative innovation platform. The product research and development technology of the enterprise have greatly improved the level of technological research and development, quickly overcome technical difficulties, and increased the market competitiveness of the enterprise. The collaborative management innovation service of enterprise R&D technical knowledge provided by the cloud computing enterprise collaborative innovation platform based on the network resource sharing model, in order to achieve a high degree of sharing of R&D technical knowledge, the transformation of technical knowledge resources from departmentalization to enterprisization and platformization, the effective transformation of invisible technical knowledge, and the effective reuse of high-tech technical knowledge resources. The collaborative work innovation of the enterprise office platform is to solve the complex and tedious office affairs within the enterprise by providing various office function services that can be called remotely, eliminate the information island, and allow the staff of various departments of the enterprise to work collaboratively on a unified platform. The conceptual model of the enterprise collaborative innovation service platform is shown in Figure 6.

As shown in Figure 6, the collaborative decision-making innovation of enterprise management can firstly process the huge data information such as the shared enterprise knowledge resource base, shared R&D technical data, and shared enterprise dynamic information on the platform to recommend new ideas for the enterprise management opportunity information for decision-making. Secondly, it provides different decision-making services required by enterprises, such as actual income, service, expected risk service, enterprise production model analysis service, product marketing model analysis service (product sales channel service, product price comparison service, enterprise supply demand search service), product profit model analysis service (profit channel service, profit change query service, price adjustment service), and product risk control model analysis service, and provides intelligent decision-making functions for enterprise management.

11. Innovative R&D Collaboration Mechanism

In a R&D collaboration environment for a specific product, it includes four types of collaboration: R&D personnel, R&D information, work process, and application tools. The essence of R&D collaboration lies in the collaboration between staff, who collaboratively participate in data fusion of all parties, process connection, aggregation of service applications, and collaboration of R&D personnel, so as to meet the requirements of R&D collaboration. The innovative R&D collaboration environment is shown in Figure 7.

As shown in Figure 7, there are three main work modes for operators in innovative R&D collaboration: collaborative R&D, shared data, and independent work. In the collaborative R&D mode, the members of the R&D project team participate in all activities in the project collaboration, and through the services provided by the collaborative development system environment, relevant information is disclosed to all or part of the authorized members in the group, and relevant requirements are put forward to the R&D supervisor, or report progress to the entire R&D team. In this case, through an efficient real-time communication mechanism, members of the R&D team share a desktop display environment, and members can fully perceive each other's operations when discussing and improving problems; in the case of shared data, the collaborative member of the R&D team does not participate in the current R&D operation, but the member's device is in the state of data sharing, so that other R&D members in the group can access the shared data in the local data storage of the device to achieve the goal of interactive collaboration. In this operation mode, the system information exchange is not frequent, and asynchronous communication is generally used to solve the problem; while in the independent operation mode, the members of the R&D team independently design according to their own R&D tasks. At this time, the system has no real-time data communication, but other members of the R&D team can perceive its progress.

12. System Implementation

12.1. Development Environment and Platform. We use Java as the main development language, development environment, and tools for platform development, including JDK, MyEclpse, and related open source development frameworks. On the client side, front-end technologies such as html, JS, and Ajax are used to complete the development. The development environment is shown in Table 1.

As shown in Table 1, the basic cloud computing environment of the platform is built with OpenStack, and Vmware is used to provide virtualization technology. The developed cloud service applications are deployed in Tomcat containers. The operating environment is shown in Table 2.

As shown in Table 2, the infrastructure layer uses Vmware to virtualize three servers, install the CentOS7 operating system, build a basic development and test environment, and use OpenStack for unified scheduling management. The data layer uses MySQL as the main storage database, HBase as the extended database, Redis as the cache database, and MyBatis as the storage middleware to realize data persistence. The service layer is responsible for handling specific service logic, and this layer implements SOA service governance through the integration of Alibaba's Dubbo framework and Spring. As an excellent high-performance web service governance framework, Dubb supports webservice-related technical standards and can be seamlessly integrated with open source frameworks such as Spring and SpringMVC. The web layer responds to user requests and uses SprngMVC as the development framework of the web layer. The front page is developed with CSS+html+JavaScript, and AJAX is used to enhance the interactive experience.

12.2. System Applications. The smart enterprise collaborative innovation cloud service platform uses Internet cloud computing technology, combined with collaborative innovation theory, to create a digital ecological environment shared by multiple users in enterprises, governments, universities, and scientific research institutions. Figure 8 shows the market size and market segments of China's IoT industry.

As shown in Figure 8, the collaborative innovation cloud service platform, as a public service innovation platform, provides a new innovation model and breaks the geographical restrictions and organizational barriers of innovation cooperation. Enterprises can publish innovation demands, receive innovation information, and use innovation services anytime and anywhere through the innovation information portal. At the same time, universities and scientific research institutions can publish their own scientific research results, form a quick connection with enterprises, and collaborate to complete innovative research and development. Cloud service developers can build innovative services under the platform specification.

According to the scoring system summarized above, 20 pieces of valid scoring data were selected to score enterprise Z's delivery service, delivery service, and online shopping satisfaction. The results of the service quality score based on the SERVQUAL scale are shown in Figure 9:

As shown in Figure 9, in the selection of evaluation indicators, not only from a theoretical perspective but also from an empirical perspective to select indicators suitable for service quality evaluation, the unity of subjective and objective and the combination of theory and practice, have great practicality. The selected indicators have been applied and verified in many logistics enterprises in Hunan Province, which preliminarily proved the scientific significance of this research. The results of the satisfaction score based on the SERVQUAL scale are shown in Figure 10.

As shown in Figure 10, with the continuous increase of user visits and the continuous accumulation of cloud service developers, the platform presents a trend of continuous evolution, which can accumulate a large number of high-quality innovative service resources and form a rich innovative knowledge resource base. It greatly improves the innovation ability of enterprises.

13. Conclusions

At present, China's small- and medium-sized enterprises are developing vigorously, but there are still various problems, such as insufficient innovation ability and difficulty in obtaining resources. There are also shortcomings in the construction of enterprise informatization, such as the existence of a large number of repeated construction of informatization infrastructure, the existence of a large number of heterogeneous information systems in the enterprise, and the existence of "information islands", which affect the development of enterprise informatization. Aiming at these deficiencies, the smart enterprise collaborative innovation cloud service platform is committed to building a brand new enterprise service environment, focusing on cloud computing to realize enterprise informatization, and through innovative enterprise service models to improve enterprise production efficiency and enhance enterprise innovation capabilities. This paper proposes an emerging service computing model, which is based on cloud computing and has the characteristics of public facilities, multiorganization and multitenancy, and high availability. Individual users, enterprise tenants, governments, universities, scientific research institutions, and enterprise cloud application service developers form a collaborative, shared, open, and sustainable digital ecological environment. The smart enterprise cloud service platform realizes the cloud aggregation of enterprise cloud services, but there are still some areas to be improved, for example, how to get out of the experimental environment, how to schedule large-scale cloud services in the production environment, and related fault tolerance issues.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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