Research Article

Optimization Strategy Analysis of Intelligent Product Service System Based on Computer Simulation Technology

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In order to solve the needs of a large number of users and the efficiency of user service requirements, an optimization strategy analysis method of intelligent product service system based on computer simulation technology is proposed. Aiming at the two challenges of massive requests and efficient service in the network intelligent service system, the characteristics of the network intelligent service system are analyzed, and the network intelligent service system is formally modeled as an agent system. The performance modeling, performance evaluation, and performance optimization methods of the network intelligent service system are proposed. In order to solve this massive demand, the performance modeling of the network intelligent service system is carried out based on queuing theory. This paper proposes a task assignment algorithm for the network intelligent service system. Through the application of these results, the processing efficiency of the entire medical insurance application system has been greatly improved, and the average completion time of all businesses has been shortened by 59%, providing new ideas for optimizing service methods and improving service quality.

1. Introduction

The use of computer simulation technology to complete the automation system planning, taking informatization as the support for the construction of the simulation model, promotes the improvement of the operational efficiency and operation ability of the logistics system and creates more profits for the enterprise [1]. In the actual analysis, it is necessary to use computer simulation technology to monitor and evaluate the operation status of the system equipment, logistics flow, etc., and find out the existing problems in order to propose optimization suggestions. Using dynamic simulation technology for modeling, the system operation can be modeled and drilled. In the system, by virtualizing the actions and behaviors of the workpieces in each link, the random variables that affect the operation of the logistics system can be obtained, which can be used to complete the model construction. Combined with the degree of influence of variables on the operating efficiency of the system, the simulation data can be modified, and finally, the best system optimization scheme can be obtained [2].

With the development and popularization of the Internet and mobile terminal technology, the application mode of the traditional management information system oriented to business handling and functional modules has undergone great changes. This system has changed from a closed-based internal modular circulation system to a system with networked, process-based, and intelligent functions [3]. The application system based on the network, process, and intelligent service mode is called the network intelligent service system. Networking means that anyone can conduct business transactions at any time and anywhere in an open network through network terminals, mobile phones, and other devices [4]. For example, in the early days, people could only go to the office hall to handle medical insurance reimbursement through various approval windows; now, you can not only handle the medical insurance reimbursement business as before but also apply for the medical insurance reimbursement business on the corresponding network terminal or mobile terminal; two methods are used to meet the needs of different Medicare reimbursement applicants. Process-based means that for the business organization that handles
it, after a task is completed, the process of transferring to the next task is automatically judged by the workflow drive. For example, after the medical insurance reimbursement business application is accepted, according to the workflow predetermined rules, the audit business is automatically transferred to the next audit node as in [5]. Intelligence means that the system becomes more and more intelligent, and the entire management information system serves the complex requests of users like an agent. For example, in order to complete the audit task, the system first makes necessary judgments, adopts reasonable scheduling, and allocates the most appropriate resources in the system [6].

As people’s business demands for network applications continue to increase and their expectations for system service efficiency are getting higher and higher, networked intelligent service systems need to face two major challenges in order to have networked, process-based, and intelligent service capabilities. One is the quantification of user requests; that is, since each service terminal of the system is open based on the Internet and oriented to the public, this will bring a large number of requests, and the system will also have complex load changes. Another challenge is service efficiency; that is, people’s expectations for service efficiency are significantly improved; it is required that the system can respond to requests on time, and the efficiency of request processing is also getting higher and higher, so the system needs to improve service efficiency to meet more requests in order to serve the public [7, 8].

In order to solve the above two challenges, improving the throughput capacity and service efficiency of the networked intelligent service system is the key problem to be solved by the networked intelligent service system.

2. Literature Review

Because the content of the authors’ research is relatively new, the traditional research is not completely directly related to the authors’ research, in order to solve the two major challenges of request massization and service efficiency. The agent-based modeling method provides an idea for the author to formalize the networked intelligent service system. Service software and systems for traditional business processes can provide a reference for this study to solve the massive requests of the networked intelligent service system. System modeling and analysis methods based on business processes and related methods of system performance modeling and analysis provide references and ideas for solving the challenges of massive requests [9]. At present, Morales et al. believe that there are still some emerging websites that have built their platform into a crowdsourcing service platform. In crowdsourcing, resources are people. For the research on task allocation and scheduling in crowdsourcing, this research also focuses on how to improve the system’s performance. Service efficiency provides a method [10]. Workflow and business process based on agent systems were studied. By modeling and analyzing the agent system, we can better understand the composition of the system, find problems, and make improvements to the system [11]. Martin et al. believe that the modeling of business process-oriented service software and systems not only records the existing service system and determines the requirements of personnel, systems, and facilities but also lays the foundation for the planning and modification, performance evaluation, and optimization of the existing system. In recent years, researchers have been researching and exploring the life cycle of business processes, modeling methods and improvements, and performance evaluation [12]. In the modeling of business processes, Miraglia et al. proposed an efficient and formalized process design method; the rules of this process allow the generation of BPMN models integrated with rules from semantic knowledge engineering methods. Such a model can be viewed as a structured rule base; it provides an explicit inference flow dictated by process control flow. Studying the fundamentals of intelligent business process management, a framework business process management that distinguishes three levels needs to be introduced: multi-process management, process model management, and process instance management, and expanded the understanding of intelligent business process management [13]. In the performance evaluation of service systems such as business processes, Liu et al.’s research is mainly divided into two steps: the first step is to select performance indicators for performance evaluation, and the second step is to perform performance evaluation of business processes. When selecting performance indicators for business process performance evaluation, one of the most important indicators is time [14]. Jain and Jain believe that the time performance of business instances is an important basis for real-time management and scheduling of business processes and propose an equivalent model of time performance for activities in execution and waiting; the concept of instance attribution subatlases is proposed to track the dynamic change of the reachable subnetwork of the instance and solve the complex instance time performance problem, converted to a simpler performance-solving problem of attribution subgraphs; an example is used to demonstrate the performance evaluation process of business instances [15]. Yang et al. proposed new performance metrics for performance evaluation of business processes. There are researchers investing heavily information technology and the relevance of business process reengineering to improve enterprise productivity and performance by integrating individual tasks into complete cross-functional processes [16]. Moradi et al. use fixed effects and first differences to analyze firm-level panel data covering the period 1987-2008 and found that in the project launch year, return on assets has dropped significantly. According to the fixed effects results, performance and productivity measures improved after the project started; it shows that BPR does have a positive effect on corporate performance on average. Besides, enterprise-wide business process reengineering projects during project initiation compared to functionally focused projects have more negative returns [17].

To sum up, the modeling and performance evaluation of business processes are the basis and premise of business process optimization, and these modeling, performance evaluation, and optimization methods are used for reference in the study of networked intelligent service systems. However, there are few researches on the modeling of business
3. Research Methods

3.1. Formal Modeling of Networked Intelligent Service System. In view of the two major challenges of request massification and service efficiency of the networked intelligent service system, by analyzing the similarity between the networked intelligent service system and the agent system’s service capabilities, the authors formalize the modeling of the networked intelligent service system into an agent system; the agent system has the functions of processing massive user requests and improving service efficiency. The entire system acts like an agent in the face of complex requests from users. By quickly accepting requests from system users and completing tasks in real time, it solves the challenge of massive requests and at the same time assigns tasks to the most suitable people or positions to complete, solving the challenge of service efficiency. The four elements of the agent system are environment, state, action, and reward. The environment faced mainly refers to the user’s request. The agent system makes decisions on the allocation of tasks and resources by perceiving the environment, improving service efficiency, and optimizing the environment feedback of the agent system as incentives and rewards [18].

The authors formalize the modeling of the networked intelligent service system based on the agent system, the networked intelligent service system is similar to the agent system, but it is different from the agent system. The four elements of the agent system in artificial intelligence are environment, state, action, and reward; these four elements are mapped into different categories under the networked intelligent service system [19].

The networked intelligent service system model can be represented by a four-tuple \(<N_E, N_S, N_A, N_R>\), where \(N_E\) is the environment of the networked intelligent service system, \(N_S\) is the state of the networked intelligent service system, \(N_A\) is the action of the networked intelligent service system, and \(N_R\) is the reward of the networked intelligent service system.

The formal modeling of the networked intelligent service system as an agent system mainly solves two problems: one is to respond to and resolve massive requests, and the other is to raise people's expectations for service efficiency. According to the above analysis of the similarity of the service capabilities of the networked intelligent service system and the agent system, the analysis of the four elements of the agent, and the corresponding relationship of the four elements in the networked intelligent service system, a formal model of the agent-based networked intelligent service system is obtained, as shown in Figure 1 [20].

3.2. Performance Evaluation and Optimization of Networked Intelligent Service System. Aiming at the massive request challenge of the networked intelligent service system, in order to deal with the massive requests in real time, it is necessary to evaluate the performance of the networked intelligent service system. First, the idea of queuing theory is adopted to model the performance of the networked intelligent service system based on the formal modeling of the agent system; after that, the performance indicators used for performance evaluation were selected, and the formulas of these performance indicators were interpreted under the queuing theory model \(M/M/c\); a method for performance evaluation of networked intelligent service systems is presented [21].

In the networked intelligent service system, assuming that the arrival of a task is random and independent and has no long-term correlation, the arrival process can be described as a Poisson process. For a task, the length of service time to complete it is also random and independent of the arrival of the task, so the service time can be characterized by a negative exponential distribution. In this way, the queuing network can be used to describe the networked intelligent service system. From a single point of view, such a task service relationship between task arrival and service window can be represented by the block diagram shown in Figure 2 [22].

When applying the \(M/M/c\) model of queuing theory to analyze the networked intelligent service system, all the performance indicators of queues in queuing theory, such as performance indicators such as average queue length, average job residence time, and queue throughput, can all be used to describe the modeled networked intelligent service system. There are many kinds of performance evaluation indicators for the networked intelligent service system. Here, the following four indicators are mainly selected and used.
The input $L_q$ because it is different from that of industrial processes, the nodes cannot complete the work on time, and these jobs will accumulate more and more at the nodes. Contrary to the above situation is "underwork," which describes the situation that the node can complete the work quickly, and the work does not accumulate at the node. According to the characteristics of the $M/M/c$ model, the definition of work reaching intensity is

$$\rho = \frac{\lambda}{\mu}, \quad (1)$$

where $\rho$ is the average rate of customer arrivals, that is, the average number of customers arriving per minute. $\mu$ is the average service rate of the system, which is the number of customers the service desk can serve per minute. Then, the average queue length $L_q$ is obtained, which is expressed as

$$L_q = \sum_{i=0}^{\infty} (i - C)P_i = \frac{\rho^{C+1}P_0}{(C-1)!(C-\rho)}, \quad (2)$$

where $P_i$ is the queue length distribution calculated from the number of customers in the queue system and the number of service desks and $P_0$ is the initial value of $P_i$. $C$ is the number of service desks.

3.2.2. Average Work Stay Time. The evaluation of service processes is different from that of industrial processes, because it is difficult to have a clear input or output of a visual standard; it is difficult to measure and compare. Many studies have shown that only the time parameter is the most important for evaluation and comparison. Let $W_S$ denote the average residence time of the job; in its formula, $W_q$ is the average waiting time, such as

$$W_S = W_q + 1 = \frac{\mu(\lambda/\mu)^{C}P_0}{(C-1)!(C\mu - \lambda)} + 1, \quad (3)$$

$$W_q = \frac{L_q}{\lambda} = \frac{\mu(\lambda/\mu)^{C}}{(C-1)!(C\mu - \lambda)}P_0, \quad (4)$$

$$L_S = \lambda W_S, \quad (5)$$

where $L_S$ is the average number of people in the system.

3.2.3. Working Intensity. The job arrival strength $\rho$ represents the current service strength of the node when a job arrives at the node. It is used to describe the free and idle states of a node. If the intensity is high, the node has been busy. Conversely, if it is low-intensity, the node is in an "underworked" state.

3.2.4. Throughput. Throughput is the maximum efficiency of a node’s work or the maximum rate of a transaction process, represented by $H$. If a networked intelligent service system has a large throughput, it means that the networked intelligent service system has good service capability and high utilization rate. Throughput can also be characterized by throughput rate, which is the number of tasks completed by a node per unit of time.

Extending this analysis method from the first node to other nodes, the $M/M/c$ or $M/M/1$ queue model can be used to solve this problem for all nodes in the system. Likewise, each node has to consider external incoming traffic and fallback phenomena.

According to the above calculation results, it can be obtained that under the current situation, there are relevant performance indicators of the entire networked intelligent service system.

The average service intensity $\bar{\rho}$ of the networked intelligent service system is

$$\bar{\rho} = \frac{\rho_1 + \rho_2 + \cdots + \rho_n}{n}, \quad (6)$$

The average waiting leader $L_q$ of the queue is

$$L_q = \frac{L_{q_1} + L_{q_2} + \cdots + L_{q_n}}{n}. \quad (7)$$

For applicants, the total time $W_{sum}$ required to complete the entire process is

$$W_{sum} = W_{s_1} + W_{s_2} + \cdots + W_{s_n}. \quad (8)$$

The average stay time $\bar{W}$ for a node is

$$\bar{W} = W_{s_1} + W_{s_2} + \cdots + W_{s_n}. \quad (9)$$

Using formulas (5) to (9), the quantitative data is calculated, and the performance evaluation of each node is obtained based on these data, and then, the judgment of the node whose service efficiency needs to be improved is obtained.
In the networked intelligent service system, when a node is full of business, and the node cannot process the business, the work of the node cannot be transmitted to the next node normally, and such a node is called a bottleneck node. The bottleneck node affects the efficiency of the entire system, so only by improving the service efficiency of the bottleneck node can the efficiency of the entire system be improved. Whether a node is a bottleneck node is also affected by the workload. It is a bottleneck node when the workload is saturated, but it may not be a bottleneck node when the workload is insufficient. The case of insufficient workload is not considered here, and only the general case is discussed.

In a system, there may be multiple nodes that affect the efficiency. Using the calculation formulas (5) to (9), the performance index values of each node are calculated. By analyzing and comparing these index values, the most efficient efficiency can be obtained, poor bottleneck node.

1. The Bottleneck Node with the Worst Queue Length Index Value. Calculate the maximum queue length of each node

\[ L_{qk} = \max \{L_{q1}, L_{q2}, \ldots, L_{qn}\}. \]  

Then, the node \( S_k \) is the bottleneck node with the worst queue length index value.

2. The Bottleneck Node with the Worst Average Job Stay Time Indicator Value. Calculate the maximum value of the average job stay time of each node

\[ W_{Sj} = \max \{W_{S1} + W_{S2} + \cdots + W_{Sn}\}. \]  

Then, node \( S_j \) is the bottleneck node with the worst average job residence time.

3. The Bottleneck Node with the Largest Job Arrival Intensity Index Value. Calculate the maximum value of the job arrival intensity of each node

\[ \rho_l = \max (\rho_1, \rho_2, \ldots, \rho_n). \]  

Then, the node \( S_l \) is the bottleneck node with the largest job arrival intensity.

4. The Bottleneck Node with the Smallest Throughput. Calculate the minimum throughput of each node

\[ H_{S_l} = \min \{H_{S1}, H_{S2}, \ldots, H_{Sn}\}. \]  

Then, the node \( S_l \) is the bottleneck node with the smallest throughput.

3.3. Task Allocation Algorithm of Networked Intelligent Service System. In view of the challenge of service efficiency of the networked intelligent service system, in order to assign tasks to the most suitable people and positions, the authors propose a task assignment algorithm for the networked intelligent service system. In the case of massive data, because the tasks accepted by the system are different, the resources allocated by the agent system are also different. At the same time, many tasks are no longer performed only by the fixed staff in the system; these tasks can be outsourced by using crowdsourcing platforms to improve service efficiency and save work costs. In order to make task allocation and resource allocation more efficient and orderly, the task assignment algorithm of the networked intelligent service system proposed by the authors optimizes the service efficiency of the networked intelligent service system, reduces the operating cost of the system, and satisfies people’s expectations for system service efficiency.

Aiming at the second challenge faced by the networked intelligent service system, namely, service efficiency, the authors propose a task allocation algorithm; the algorithm is based on a crowdsourced task assignment method that assigns tasks to the most appropriate resources to complete. The task allocation algorithm is divided into two parts: the first part is the generation of a personalized task list, and the second part is the allocation of resources [23].

The generation of the personalized task list is to generate different task lists for different requests. There are many different types of tasks in the entire task set of the entire networked intelligent service system; for an applicant, he may need to start from the first step of the system process; then, the system needs to extract the task subset that completes the task from the entire task set to complete his application. If the applicant has already done the first step of the system process, then his application only needs to start from the second step of the system process, and there is no need to perform the first step. The generation process is shown in Figure 3.

The allocation of resources is to assign tasks to the right people to handle. When the networked intelligent service system faces a request, the agent system first generates a personalized task list, then, in all resource sets, select the resources that match the requested personalized task list, make decisions, and allocate appropriate resources to the corresponding tasks. The resource allocation process is shown in Figure 4.

4. Analysis of Results

4.1. Intelligent Artificial Resource Allocation Algorithm. After completing the generation of the personalized task list mentioned above, the design agent system will allocate appropriate resources for the tasks to be completed; this is the second part of the task allocation algorithm—the intelligent artificial resource allocation algorithm.

The resources to complete this task have a total of \( m \) workers, and each worker has a work queue; the reason why the task queue is used is to realize the principle of first-come, first-served. The work queue of the \( i \)th worker is \( W_{Qi} \), and \( W_{i-1} (i) \) is the number of tasks in the work queue at time \( t \). All task queues can be assigned to tasks, and
Finally, the algorithm results will allocate tasks to appropriate resources [24].

4.2. Practical Application Verification. The author’s research results are applied in the medical insurance reimbursement business process for application verification and experimental analysis. By collecting practical application data, the performance modeling of the medical insurance reimbursement business process based on queuing theory is carried out, the performance index values related to the current process are calculated through the data, and then, the performance of the process is evaluated. The whole process is optimized, and finally, the task allocation algorithm is applied to the process to optimize.

Then, the task allocation optimization algorithm is applied to social insurance, and the completion time of the top ten most frequently requested services in social insurance is calculated. Figure 5 shows the 10 most commonly used services in social insurance and a comparison of the average completion time before applying the task assignment optimization algorithm and after applying the task assignment optimization algorithm. The results show that after applying the task allocation optimization algorithm, the average completion time of the top 10 most frequently requested services is greatly reduced, and the average completion time is shortened by $1/14.29/34.76 = 58.9\% \approx 59\%$.

In the government department’s social insurance reimbursement business process, after using the task allocation algorithm, the ratio of the average completion time required by ordinary software systems to the top ten most frequently requested social insurance reimbursement business services is shown in Figure 6. These ten services are arranged in order of decreasing average completion time under common software systems. It can be seen that after using the task allocation optimization algorithm, the task completion time of the entire process is greatly reduced, and the service efficiency of the process is improved [25].
5. Conclusion

With the wide application of the networked intelligent service system, its related research has attracted more and more attention, and its modeling, performance evaluation, and performance optimization have become one of the important research topics. The authors study the modeling, resource allocation, and key technologies of the networked intelligent service system and prove the correctness of the research results through experiments. The work done in the full text is summarized as follows:

(1) The authors propose a formal modeling method for networked intelligent service systems. Aiming at the two major challenges of massive request and efficient service of networked intelligent service systems, the characteristics of networked intelligent service systems are analyzed, and it is found that it has many similar service capabilities to the agent. Therefore, the networked intelligent service system is formally modeled as an agent system.

(2) The authors propose methods for performance modeling, performance evaluation, and performance optimization of networked intelligent service systems. In order to solve the massive request, the performance modeling of the networked intelligent service system is carried out based on queuing theory.

(3) The authors propose a task assignment algorithm for the networked intelligent service system. Aiming at the challenge of efficient service of networked intelligent service systems, the system needs to be able to assign different tasks to appropriate people to improve service efficiency. In order to this end, the author applies the idea of the crowdsourcing task assignment method to generate different task lists for different users; appropriate tasks are then assigned to appropriate people, so that task assignment can be carried out in a more efficient and orderly manner, which improves the service efficiency of the networked intelligent service system and reduces the operating cost of the system.

(4) Using data from medical insurance reimbursement business processes, the main content of the study is experimentally validated. Based on queuing theory, the performance modeling and performance evaluation of the process are carried out, and the process is optimized through the task allocation algorithm. Experiments have proved that, through the application of the results, the processing efficiency of the entire medical insurance application system has been greatly improved, and the average completion time of all businesses has been shortened by 59%.

Data Availability

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

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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