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DESIGN OF INTELLIGENT BUILDING SCHEDULING SYSTEM FOR INTERNET OF THINGS AND CLOUD COMPUTING

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Abstract. The cloud computing (CC) and Internet of Things (IoT) are widely utilized and provided for intelligent perception and on-demand utilization like industries and public areas. The full sharing, free circulation and various manufacturing resources allocation are investigated in manufacturing. In order to ensure the real-time and effectiveness of resource storage scheduling in Internet of things information system, there are many kinds and quantities of building equipment. An improved ant colony algorithm is presented to remove the shortcomings of the existing ant colony algorithm with slow speed and fall into local optimum. The improved ant colony algorithm is transplanted into cloud computing environment. The advantages of fast computing and high speed storage of cloud computing can realize the real-time resource scheduling of building equipment. The experimental results present that the improved ant colony algorithm can obviously improve the efficiency of resource scheduling in cloud computing environment.All the experiments are performed on the MATLAB.

Key words: Intelligent Scheduling System; Resource Scheduling; Industries; Cloud Computing; Internet of Things; Ant Colony Algorithm; Path Optimization

AMS subject classifications. 68M14

1. Introduction. The IOT is a new concept put forward on the basis of the Internet, which can be understood as the extension and expansion of the Internet. It has been widely used in the integration of human society. Intelligent architecture and smart home applications are particularly significant. The public safety system of intelligent building is a technical prevention system or guarantee system constructed to maintain public safety and comprehensively use ”modern science and technology” to deal with all kinds of emergencies that endanger social safety. The contents include automatic fire alarm system, safety technology prevention system and emergency linkage system. Safety is the need of intelligent building so public safety system is an important part of intelligent building. With the maturity of Internet of things technology, it brings unprecedented development opportunity to intelligent building public safety system. This paper studies how to use Internet of things technology to improve the response speed and emergency linkage ability of intelligent building public safety system and improve the record of supervision and monitoring data from the city level platform. Currently, there are many kinds of electrical equipment in buildings, and the traditional Internet of things control theory and method have been difficult to complete the overall optimization of various equipment in buildings [1-3]. Cloud computing technology converts various computing and storage resources into virtual data form storage with efficient storage and computing power, and adds and expands resources according to actual needs and service modes. Cost saving, convenience and practicality, integration of resources and energy conservation and environmental protection, these advantages promote the introduction of cloud computing technology in the operation and development of the IOT is an inevitable choice. At present, there are many kinds of electrical equipment in buildings, and the traditional IOT control theory and method have been difficult to complete the overall optimization of various equipment in buildings. Cloud computing technology converts various computing and storage resources into virtual data form storage with efficient storage and computing power, and adds and expands resources according to actual needs and service modes. Cost saving, convenience and practicality, integration of resources and energy conservation and environmental protection, these advantages promote the introduction of cloud computing technology in the operation and development of the Internet of things is an inevitable choice [4, 5].

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Cloud computing has a large number of storage and computing nodes, achieves rapid computing on data, but the rapid computing lies in the scheduling of resources [6]. The optimal problem application for solving algorithm and scheduling algorithm has become the core of improving cloud service response time. At present, common algorithms include artificial neural network algorithm, genetic algorithm, simulated annealing algorithm and ant group algorithm, etc. Because each algorithm has some limitations, such as artificial neural network algorithm is difficult to achieve high accuracy in solving the optimal value problem, genetic algorithm has blindness in the search process, resulting in low efficiency of the algorithm. The simulated annealing algorithm solves the optimal value for too long [7, 8].

The efficiency and reliability of power supplies are improved by widened opportunities of IOT and traffic management is also optimized and reduces the traffic accidents. The dangerous wastes transmission is also supervised and medical information management is coordinated. Things-related application development is faced like variable geospatial deployment, or Cloud computing [9]. The running operating systems, networks, load balancing are taken care by application developer traditionally and allowing them to interact with the system. The account of scalability is also needed by the developer and utility model is applied by the cloud computing. The cloud services are accessed by the cloud users over the internet and only services which they need are paid by the users. The large numbers of services are supported by the cloud and the micro-lifecycle management is taken care-of. The variety of services is consisted by designing the cloud computing platform for maintaining applications on the Cloud [10].

1.1. Contribution. In this paper, an improved ant colony algorithm is presented and applied to the allocation and scheduling of construction equipment in the IOT in cloud computing environment. Through simulation experiments, the ant colony algorithm can improve the resource scheduling efficiency in cloud computing environment.

The rest of the paper is organized as follows. Section 2 provides an overview of the exhaustive literature survey followed by a methodology adopted in section 3. A detailed discussion of obtained results is in section 4. Finally, Section 5 concludes the paper.

2. Literature Survey. The construction of ”Ping an City” puts forward higher requirements for the public safety system of intelligent building. The public safety system of intelligent building should meet the needs of supervision and emergency linkage of constructing ”Ping an City” in the new period, integrate the information of isolated public safety system, connect the public safety system of intelligent building to the city-level supervision and linkage platform, reduce the supervision cost of relevant government departments, improve the efficiency of supervision and emergency linkage, and meet the needs of ”Ping an City” and ”Smart City” construction. In order to solve the hardware design and the new system architecture exploration. Huang, Q et. al systematically design and achieve low-cost hybrid intelligent sensor platforms for the occupation of energy-saving buildings accurately. The presented hardware architecture is segmented into two parts: the main and door monitoring module. These sensor signals can fuse and analyze to enhance the accuracy of building occupation counts. The proposed system has been implemented on the bread plate and the PCB board. The experiment is measured to verify system functions and performance [11].

Wang, J et al. Proposed a multi-UAV wireless power supply communication (WPC) system for supporting 6G content. Specifically, each time slot is divided into an uplink and downlink sub-slot. In the downlink, multiple drones are considered as the air communication platform to transmit energy in multiple IoT users. In the uplink, the UVS and the user association is designed, and then the predetermined user is uploaded to a specific UAV by utilizing the harvested energy. Maximize the minimum average improving between all users by collaborating the UAV user association, user transmission power, and multi-UAV trajectory. In particular, the alternative iterative algorithm proposed in the text can effectively parse the non-convex optimization problem. Finally, numerical results indicate that this design can not only optimize the multi-UAV flight path, but also achieve higher objective values than the reference plan [12].

With the emergence of information age, the item Internet technology has been favored and has become another revolution in the information technology industry. In this era, in the case of building intelligent buildings, material technique can expand the intelligent systems practicality and enhance the management and service capacity of intelligent buildings, therefore improving people’s quality of life. On the basis of summarizing and analyzing research work, Kong, L. et al. Proposed the design and intelligent manufacturing architecture model of IOT technology. The result of model verification shows the construction industry's intelligent manufacturing model that can realize the human society and physical systems integration, realizing real-time management and control of people and infrastructure across networks [13].

An unprecedented opportunity is represented by the micro-grid technology for energy industry transfer to the new era of reliability, and efficiency for economical contribution. The power and transportation industry sectors both are yield by the Electric Vehicles (EVs) emergence but consume massive energy and affect the reliability [14]. The plug-in EVs problem is considered in this paper at public supply stations (EVPSS). For smart grid and cloud services, new communication architecture is detailed. The priority levels attributes and the waiting time optimization is done by the scheduling algorithms. The network architecture for smart grid based on cloud computing is presented in this paper for such issues investigation. The presented approach is evaluated by simulation and it is demonstrate the proposed approach effectiveness. The on-demand ordering and scalable storage helps the cloud computing and the processing services [15]. It is unacceptable the transferring data delay to cloud and back to the application. So much data is sent by the client to the cloud for processing and storage as network bandwidth is saturated and not be scalable. In many fields, Internet of Things (IoT) and cloud computing (CC) are utilized widely and a new is provided for intelligent perception and on-demand utilization [16]. The full sharing, free circulation and various manufacturing resources allocation are investigated in manufacturing. In this paper, CC- and IoT-based cloud manufacturing (CMfg) service system is presented and detailed and analyze the relationship among them. The system's merits, demerits and challenges are also discussed. The large datacenters powers the cloud computing by large datacenters which comprises the many virtualized server instances and supporting systems like power supply [17]. Classification of the equipment is done into hardware and software accessed by remote users. The cloud services are accessed by the users in the hardware through network equipment which connects the servers to the Internet. The cloud management system manages the user software which runs on top of servers. The reduction of energy for the given service defines the energy efficiency. The user with a novel means of communicating is presented by the IOT with Web world through ubiquitous object-enabled networks [18]. A convenient, on demand and scalable network access is enabled by the CC configurable resources computing. The integration of the IOT and CC is focused under Cloud things architecture. For integrating Cloud Computing, the various techniques are reviewed and an IoT-enabled smart home scenario is examined. The Cloud things architecture is also presented which accommodates cloud-things for accelerating IoT application.

3. Used methodology. IOT refers to the connecting objects technology through the network. The Internet of things of building equipment discussed in this paper means that all kinds of building electric equipment in the building are unified and centralized to form an Internet network connected by things and things. Through the expansion and extension of wireless network sensing to various building electrical equipment in buildings, the Internet of things system uses its own three-tier architecture [19]. Through the wireless transmission network collection system, the parameters of intelligent equipment are transferred to the cloud computing service platform of application layer. Functionally, the overall structure of the iot system of building equipment is divided into "application layer, support layer, network layer, access layer and perception layer", as shown in figure 3.1.

Figure 3.1 directly interworking with the user is the application layer, which contains a variety of Web browser or client applications, users can use the application layer to provide remote monitoring and intelligent management of various electrical equipment in the building; the support layer consists of three parts: data service, communication service and application service, which are used for data storage, communication, processing and application in the Internet of things; The network layer is located in the middle layer of the Internet of things, which can be commonly used as Internet, LAN, heterogeneous network or virtual private network [20-22]. It is mainly used to complete the interconnection of the Internet of things network and ensure that the whole system can exchange visits.

3.1. Cloud computing service model architecture. The cloud computing platform virtualizes all configurable computing resources, and then integrates and configures them to form a resource pool to provide users with various required services, the specific service model of which is shown in figure 3.2.

Cloud computing platform can process massive data and achieve high resource integration rate. At the same time, based on distributed computing, the data that needs to be processed are also distributed in different nodes.

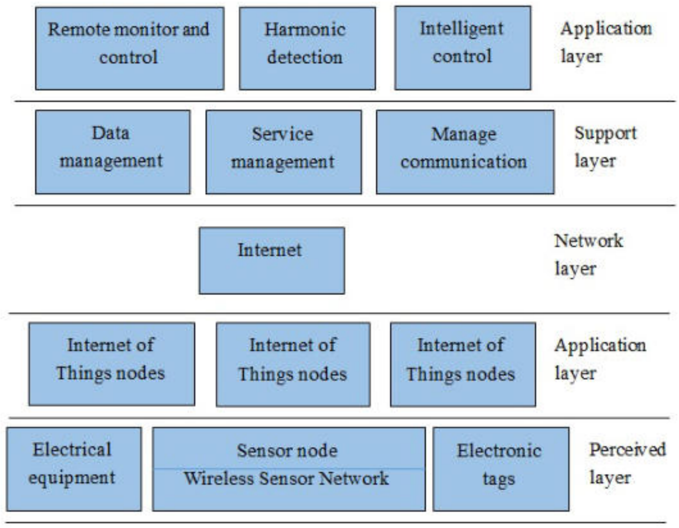

FIG. 3.1. *Overall Structure of the Internet of Things System for Building Equipment*

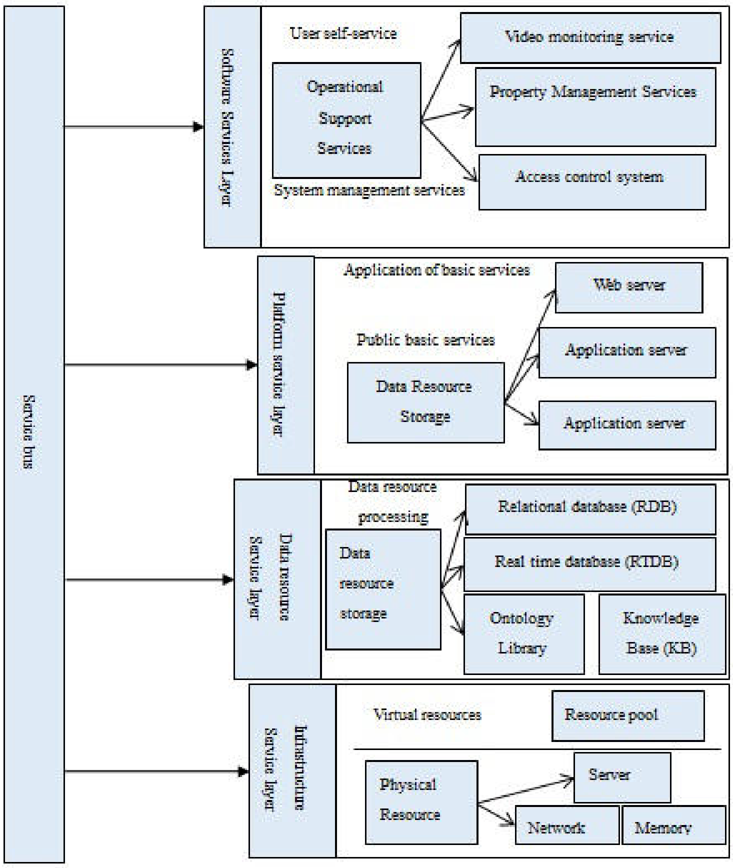

FIG. 3.2. *Schematic illustration of the service model for the cloud platform*

In order to improve the efficiency of cloud computing, it is very important to schedule and allocate computing nodes and resources reasonably [23-25]. The application of optimal problem solving algorithm and scheduling algorithm becomes the core to improve the response time of cloud service heart. Therefore, combined with an improved ant colony algorithm, the information resources in the resource pool are centralized and integrated, and finally presented to users and managers in a simple and efficient way, which can effectively support the information processing links of the Internet of things and improve the shortcomings of the traditional Internet of things system [26].

3.2. Improved Ant Colony Algorithm. Ant colony algorithm is a bionic algorithm, which is inspired by the foraging phenomenon of ant colony in nature. In the process of foraging in unknown areas, when individual ants find food, pheromones are released on the path they pass through, and their concentration indicates the length of the path. For other foraging ants, as long as the concentration of pheromone released is perceived in a certain range, it always moves in the direction of strong pheromone concentration, and always finds a shortest path to the destination in a certain time [27-29].

3.2.1. Classic Ant Colony Algorithm. The above phenomena are modeled mathematically. Let m ants be put into n random selection node. The ants k choose the direction of motion according to the concentration of pheromone and always move towards the high concentration path. At a certain time t, the transfer probability of ants moving from node i to node j is:

$$(P_{ij})^k = \begin{cases} \frac{\tau_{ij}^{\alpha}(t)\eta_{ij}^{\beta}(t)}{\sum \tau_{ij}^{\alpha}(t)\eta_{ij}^{\beta}(t)} & j \text{ belongs allowed}_k \\ 0 & \text{other} \end{cases} \tag{3.1}$$

In the equation 3.1, α represents the information heuristic factor, the larger the value represents the current path, the more important the ant is to choose the path, and the β is the expected heuristic factor. Represents the relative weight of the predictive value of computing power.

3.2.2. An Improved Ant Colony Algorithm Based on Chaos. The above equation 3.1 is the standard mathematical model of the traditional ant colony algorithm. It is obvious that when the number of ant colonies is m large or the number of nodes is n large, the calculation time of the algorithm will be slow or even stagnant. Accordingly, the mathematical model of the traditional ant colony algorithm is improved, and the Logistic mapping function is used to improve the dependence of the traditional ant colony algorithm on the randomness of the selection path. In the standard mathematical model of traditional ant colony algorithm, ants choose each path with equal probability. Using Logistic mapping function, chaotic variables with the same number of paths can be generated. The global search and optimal value are solved by the properties of chaotic motion. Logistic mapping functions can be expressed as:

$$x_{i+1} = \mu x_i(1-x_i), i = 0, 1, 2, 3, \ldots, n, 0 < \mu \leq 4 \tag{3.2}$$

The μ is a control parameter. When μ=4, the Logistic map is a typical chaotic state, which has the characteristics of randomness, regularity and ergodicity. After the initial path is chaotic, in order to avoid the phenomenon of slow response and local optimization, the pheromone concentration is also chaotic, that is:

$$\tau_{ij}(t+n) = \rho \cdot \tau_{ij}(t) + \Delta\tau_{ij} + q \cdot x_{ij} \tag{3.3}$$

x_{ij} is the chaotic quantity produced in equation 3.3 and q is the coefficient.The initial path of the traditional ant colony algorithm is chaotic (μ=4). Assuming $n = 3$, there are six possible paths. The final each path can be obtained by arrangement and combination as shown in Table 3.1.

In Table 3.1, D represents the ordinal number of different paths; V represents the direction of motion; C represents the trajectory between three nodes. The logical transformation relationship between the three can be expressed as follows:

$$D_i = D_{i-1} - (v_i - 1)(n-i)!, i = 0, 1, 2, \ldots, n-1;\ D_0 = D, v_i = \frac{D_{ij}}{n-i}! \tag{3.4}$$

To sum up, the process of solving the optimal value based on the proposed improved ant colony algorithm is summarized, as shown in figure 3.3.

TABLE 3.1
All possible motion paths

D	V	C
1	11	123
2	12	132
3	21	213
4	22	231
5	31	312
6	32	321

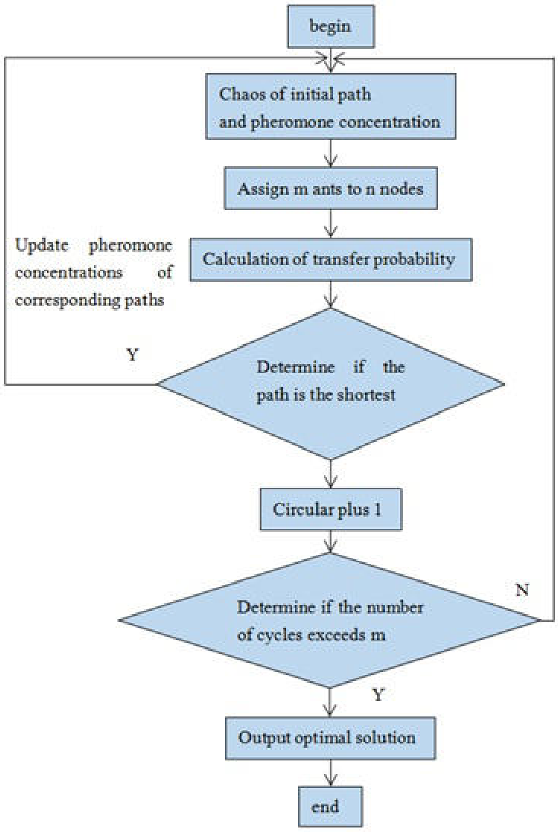

FIG. 3.3. *Flow chart of optimal solution*

3.3. Intelligent scheduling of devices based on improved ant colony algorithm. Ant colony algorithm can find the optimal path, which can be defined as the best scheduling mode in the intelligent scheduling system of Internet of things. Many devices in the Internet of things environment are modeled as nodes in cloud computing environment. The node morphology is divided into storage nodes and computing nodes. The storage nodes are mapped to data storage devices in the Internet of things, and the computing nodes are mapped to data computing and data processing devices in the Internet of things [30]. All nodes in the Internet of things system correspond to the current data processing capacity and their maximum processing capacity at a certain time point. The purpose of ant colony algorithm is to dynamically plan and distribute the traffic according to the load of the current Internet of things system and the load of each node to maximize the performance of the whole system.

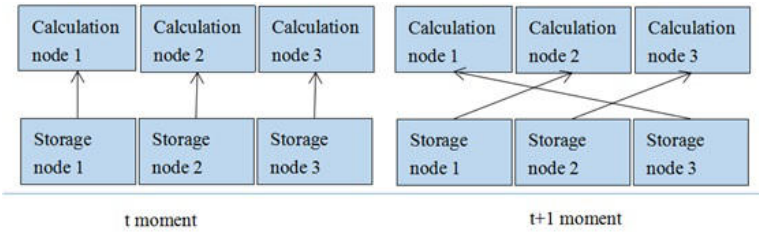

Fig. 3.4. *Scheduling of Ant Colony Algorithm in Cloud Environment*

Table 4.1
Record of Experimental Results of Traditional Ant Colony Algorithm

Task	Time/ s	Task	Time/ s	Task	Time/ s
15	2.0	45	8.6	75	16.6
20	2.3	50	9.6	80	20.1
25	2.7	55	10.6	85	21.8
30	3.4	60	11.9	90	26.3
35	4.5	65	13.5	95	28.4
40	6.6	70	14.4	100	29.7

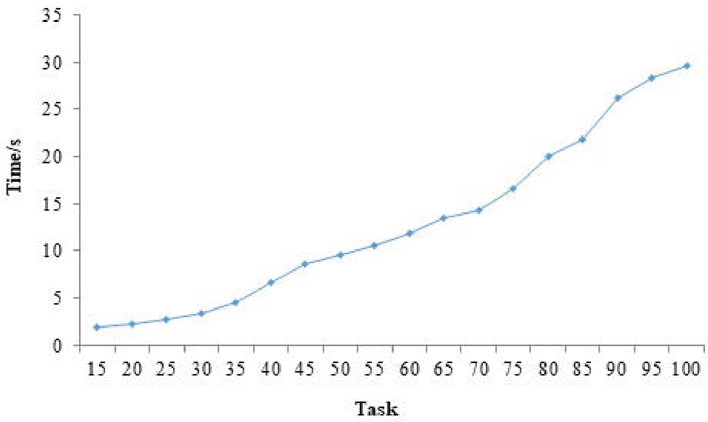

Fig. 4.1. *Record of Experimental Results of Traditional Ant Colony Algorithm*

Every t time, the computing node and the storage node in the Internet of things system synchronize the data. Data synchronization includes the current processing data and storage data of each node. The purpose of synchronization is to distribute traffic according to the optimal scheduling scheme of ant colony algorithm, as shown in figure 3.4.

4. Simulation Experiment. In cloud computing environment, the efficiency difference between traditional ant colony algorithm and improved ant colony algorithm in resource scheduling is compared. The relevant parameters in the algorithm are set as follows: heuristic factor $\alpha = 1$, expectation heuristic factor $\beta = 0.998$, control parameter $\mu = 4$ at the same time, set the number of execution tasks to 20$\sim$100, the number of nodes is 20. The simulation experiment is carried out under the same experimental parameters. Each algorithm runs 10 times to take the average value. The statistical records of the two ant colony algorithms are shown in tables 4.1 and 4.2 and shown graphically in figure 4.1 and figure 4.2 for better visualization.

As the number of execution tasks increases from 15 100 in turn, in each state, the two algorithms execute 10 times, and the average value of the 10 calculation times as the record value, which is recorded in tables 4.1

Table 4.2
Record of Experimental Results of Improved Ant Colony Algorithm

Task	Time/ s	Task	Time/ s	Task	Time/ s
15	2.0	45	7.5	75	15.4
20	2.2	50	8.2	80	17.2
25	2.8	55	9.7	85	18.5
30	3.3	60	11.4	90	20.2
35	4.0	65	12.3	95	21.4
40	5.2	70	13.3	100	22.9

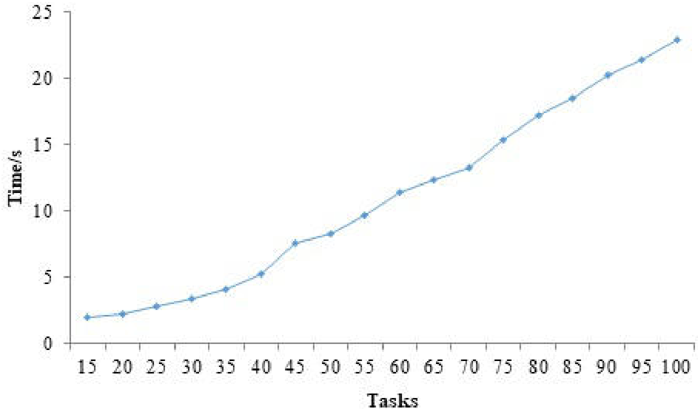

Fig. 4.2. *Record of Experimental Results of Improved Ant Colony Algorithm*

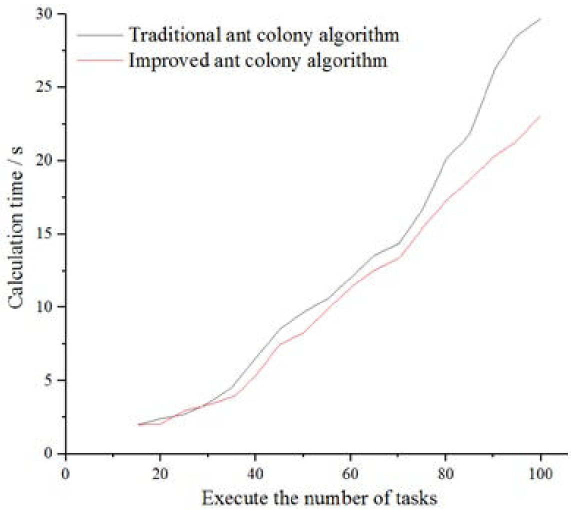

Fig. 4.3. *The optimal value of the two algorithms solves the time variation curve*

and 4.2, respectively. For recording results, the curves of execution time required by the two algorithms with the increase of the number of execution tasks are investigated, as shown in figure 4.3.

Figure 4.3 shows that when the number of tasks is less than 40, The time gap between the two algorithms in cloud computing is very small; But when the number of tasks is increased (greater than 70), The difference between them becomes more and more obvious; And when the number of tasks is 100, An improved ant colony

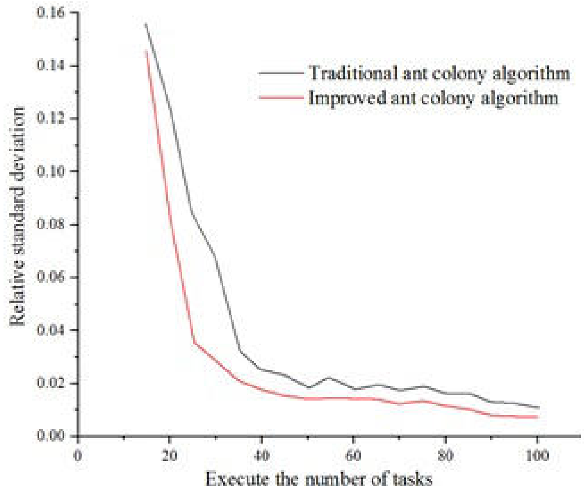

FIG. 4.4. *Optimal value of two algorithms to solve relative standard deviation variation curve*

algorithm takes less than 25 s, to solve the optimal value However, the traditional ant colony algorithm takes nearly 30 s. to solve the problem In order to further investigate the optimal value solving effect of the two algorithms, Statistical analysis of the relative standard deviation of the data recorded in tables 2 and 3 above, The results are shown in figure 4.4.

The figure 4.4 shows that when the number of tasks increases, the deviation of the improved ant colony algorithm becomes smaller and linear, which is better than the existing ant colony algorithm. In the actual cloud computing environment, it is necessary to deal with massive data, and the length of computing time directly determines the resource scheduling efficiency of the whole Internet of things information system. Through the above comparative analysis, the improved ant colony algorithm can modify the scheduling efficiency more than the traditional ant colony algorithm in cloud computing environment.

5. Conclusion. Based on Logistic mapping, an improved ant colony algorithm is presented for building equipment in CC environment. It greatly improves the dependence of traditional ant colony algorithm on the randomness of choice path, overcomes the shortcomings of slow convergence and local optimization of traditional ant colony algorithm, and integrates the improved ant colony algorithm with the advantages of CC fast resource scheduling. The simulation experiment compares and analyzes the change curve of the time required for the optimal solution when the number of tasks is increased by the ant colony algorithm. The results show that the improved ant colony algorithm is more suitable for CC environment. As the number of execution tasks increases from 15∼100 in turn, in each state, the two algorithms execute 10 times, and the average value of the 10 calculation times as the record value. For recording results, the curves of execution time required by the two algorithms with the increase of execution tasks are investigated.

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