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Order Degree and Cooperative Operation Mechanism of Subsystems in the Organization Mode of IoT

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As an extension of modern Internet technology, the Internet of Things (IoT) enables the interconnection between people and things, and things and things, and facilitates the iterative updating of various social production systems. Because an agricultural logistics system is an important part of modern agriculture, the issues of orderly scheduling and collaborative management have become significant problems for agricultural logistics. Based on the principles of ideal management in modern agricultural logistics, combined with the corresponding IoT technology to achieve the optimal allocation of resources and coordinated management of agricultural logistics subsystems, this paper designs an innovative architecture of agricultural logistics IoT at four levels of coordination: technology, information, service and management. To achieve the aims of this research, and integrating these four levels, a multi-agent collaborative mode of modern agricultural logistics network layer based on the clustering algorithm, is proposed. Through simulation and demonstration, it is found that the proposed solution can be applied to the physical network technology in agricultural logistics collaborative management and order degree, and has obvious practical value.

Keywords: Internet of Things (IoT) technology, modern agricultural logistics system, resource optimal allocation, IoT network layer multi-agent collaborative management mode, order degree problem.

1. INTRODUCTION

The ongoing development of Internet of Things (IoT) technology has enabled most entities in the world to be connected, while the physical network technology has been fully developed and applied in all walks of life [1–3]. Modern agricultural logistics has developed rapidly due to its particularity, and its rapid response, integrated functions and series of services have become the core of the rapid development of modern agricultural logistics [4–5]. However, due to the logistics strategy and the scheduling problems, there are still serious problems in the current agricultural logistics system. The problems are mainly associated with the lack of a common technology, low level of logistics informatization, the inability of traditional logistics methods to adapt to new service demand, and serious problems in the adjustment and order degree algorithm [6–9]. The collaborative management of logistics and the logistics order degree problem is more serious. The traditional agricultural logistics management and resources are widely dispersed, there is no management mechanism and market guidance, which reduces efficiency of the whole logistics industry, the management methods and management technology are not scientific, and there are serious problems with the scheduling of information [10–11]. IoT technology provides some opportunities for the development of modern agricultural logistics, but it has no effect due to the current algorithm problems and the applicability of the IoT network layer architecture in

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agricultural logistics level [12]. Therefore, given the current logistics situation, it is vital to make full use of the IoT technology to coordinate the order degree and management of agricultural logistics.

A large number of research institutions and scholars have carried out research and analyses on the application of IoT technology in agricultural logistics or modern logistics management, and have made certain phased achievements [13–14]. The engineers and R & D institutions that first studied the collaborative management ideas of the logistics and related industries were German. They defined collaborative management in terms of economic management, which restricted its application to upper management levels [15–19]; and they applied collaborative management to departments or related companies. The research into unified operations came from relevant scientists and enterprises in the United States. They divide the resources into two categories, namely, physical resources and intangible resources which are the resources involved in collaborative management [20–23]. At the information collaboration level, they are applied to the logistics industry and affect the collaborative research on supply chain information. In developed Western countries, the IoT technology was first applied to the logistics industry in order to address order degree and solve collaborative management problems, which sees the informatization, integration, automation and intelligence of the logistics industry as the future trend. Industrial developments are now taking advantage of the current IoT technology [24–25]. In the field of agricultural logistics, the literature on the application of IoT technology focuses mainly on how to improve the logistics system, operation mode and evaluation system in the regional logistics environment. Chinese scholars have proposed a "distributed logistics collaborative system" which comprises a multi-party structure and virtual network. The construction and implementation of an interconnected logistics distribution network can achieve regional normative logistics cooperation [26–27]; the corresponding European and American scholars tend to adopt the "top-down" structure in the application of IoT technology, which emphasizes the high top-level concentration of agricultural logistics system, from centralized to collaborative management, and its centralized control is very strict [28–30].

It can be seen from the above that the application of IoT technology in agricultural logistics is not mature; moreover, it does not solve the problem of order degree and collaborative management. Hence, in this paper, an attempt is made to improve modern agricultural logistics management using IoT technology to achieve the optimal allocation of resources and coordinated management of the subsystems of agricultural logistics. In this paper, an innovative design is proposed for the architecture of agricultural logistics IoT, focusing on four collaborations: technology, information, service and management. The design comprises a multi-agent collaborative network layer based on a clustering algorithm. The experimental results from the simulation show that this approach can be applied successfully to the physical network technology for the collaborative management of agricultural logistics and order degree, and has demonstrable practical value.

The structure of this paper is as follows. The second section examines and analyzes the multi-agent cooperation mode of the current agricultural logistics network layer based on a clustering algorithm, starting from the network layer; the third section reports the simulation experiment for a small agricultural logistics scenario and analyzes the results of the proposed method; the concluding section summarizes the paper and outlines future research directions.

2. ANALYSIS AND RESEARCH ON MULTI-AGENT COOPERATION MODE OF MODERN AGRICULTURAL LOGISTICS NETWORK LAYER BASED ON CLUSTERING ALGORITHM

In the agricultural logistics IoT network layer, the multi-agent collaborative mode algorithm is applied to construct a logistics real-time road condition collaborative simulation problem model, through the simulation and corresponding numerical verification of, and solve the logistics system efficiency problem under the management. The architecture depicted in Figure 1 shows the application of the network technology of cultural relics and the implementation strategy used to solve the agricultural logistics order and collaborative management problem.

The four management layers of this IoT technology are the perception layer, network layer, application layer and technology management layer. Government departments and relevant logistics industry management departments are concentrated in the management layer. They can directly access the IoT technology from the front-end. The various functions of the system enable the real-time monitoring, tracking and management of goods, vehicles and road conditions.

2.1 Analysis on Collaborative Management and Order Degree of IoT in Modern Agricultural Logistics

At present, the collaborative management of agricultural logistics in the IoT environment is facing many multi-dimensional problems, as depicted in Figure 2. These problems pertain to service demand, the coexistence of collaborative management, collaborative management cooperation and information-sharing. The multi-dimensional problem is related to the technology collaboration in the perception layer of the IoT architecture, including key technology collaboration, standardized technology system and other aspects; the network layer is for information collaboration, which includes the realization of the sensor network, the wireless and wired communication network; the application layer includes services collaboration, which includes upstream and downstream content and the competition and cooperation of supply chain companies; the IoT perception management level includes the logistics companies involved in each subsystem and the elements of the collaboration, so as to achieve their optimal configuration and cooperation. In regard to co-existence problems, the IoT technology is applied to

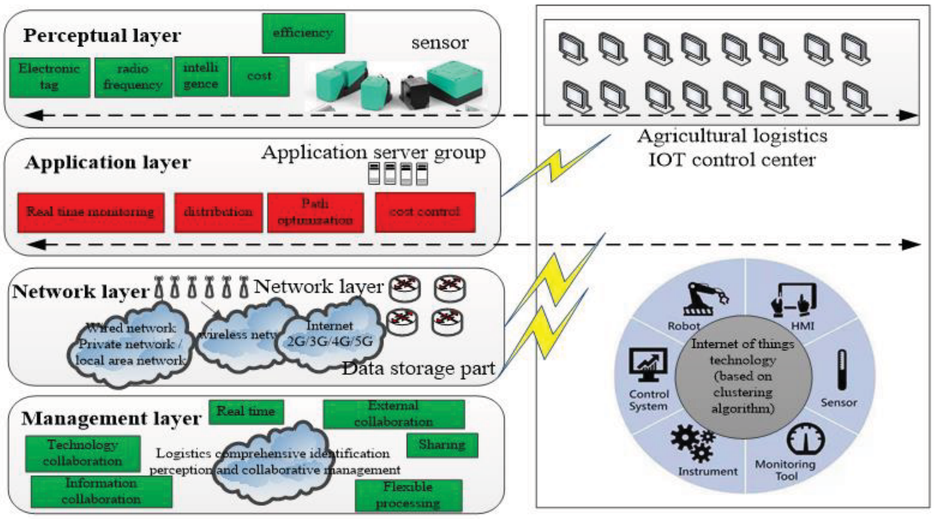

Figure 1 Multi-Agent Collaborative Architecture of Modern Agricultural Logistics IoT network Layer Based on Clustering Algorithm.

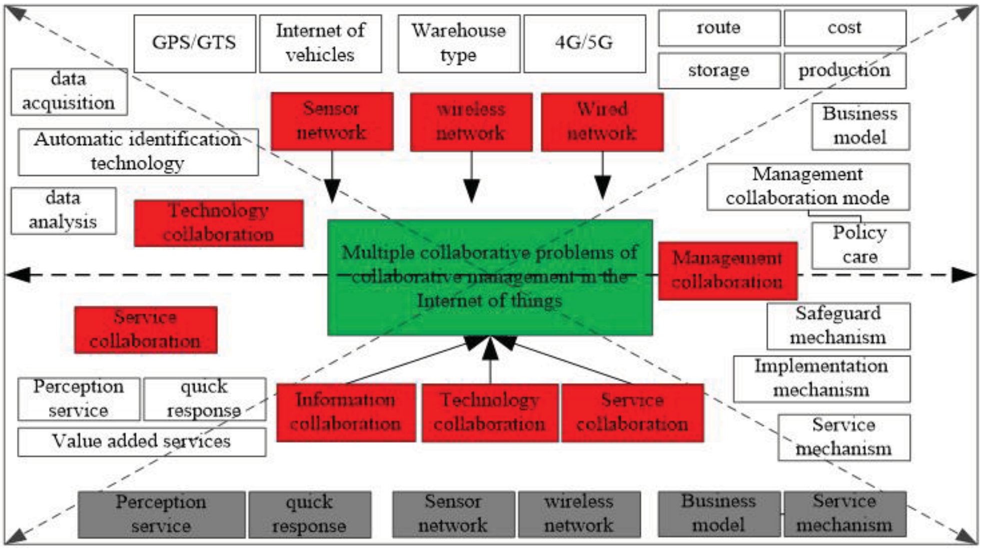

Figure 2 Framework Diagram of Multiple Collaborative Problems in Collaborative Management in an IoT Environment.

solve the common problems of dimensional coordination in modern agricultural logistics, and then realizes the mutual promotion and development of all levels of the logistics subsystem; for the cooperative problems, the IoT solves the multi-dimensional collaborative competition and cooperative relationship existing in the downstream supply chain of modern logistics; in terms of information sharing, it solves the problems of multi-dimensional collaborative competition and cooperation existing in the downstream supply chain. The sharing component solves the problems associated with information sharing, real-time information interaction and high-speed information communication between different subsystems.

Based on the above classification, four problems are evident: technology collaboration, information collaboration, service collaboration and management collaboration. The focus of this paper is on the problems associated with technical collaboration involving the relevant standard architecture, as depicted by the block diagram in Figure 3. This paper considers the network layer collaborative management and order related issues, including barcode technology, radio frequency identification technology, wireless transmission technology, positioning technology and electronic data exchange technology. The problem that needs to be solved in the network layer concentration is how to ensure that multiple agents in the system achieve good cooperation and a competitive, but productive, relationship, leading to efficient collaborative management.

2.2 Establishment of Mathematical Model

The mathematical model solves the information-sharing technology problems in the IoT network layer, and addresses the issue of information isolation. In an agricultural logistics system, the information collaboration needs to be applied in intelligent storage, goods storage, order information collaborative demand, transportation and distribution of real-time traffic information, distribution of vehicle information and goods status information at the collaborative demand level.

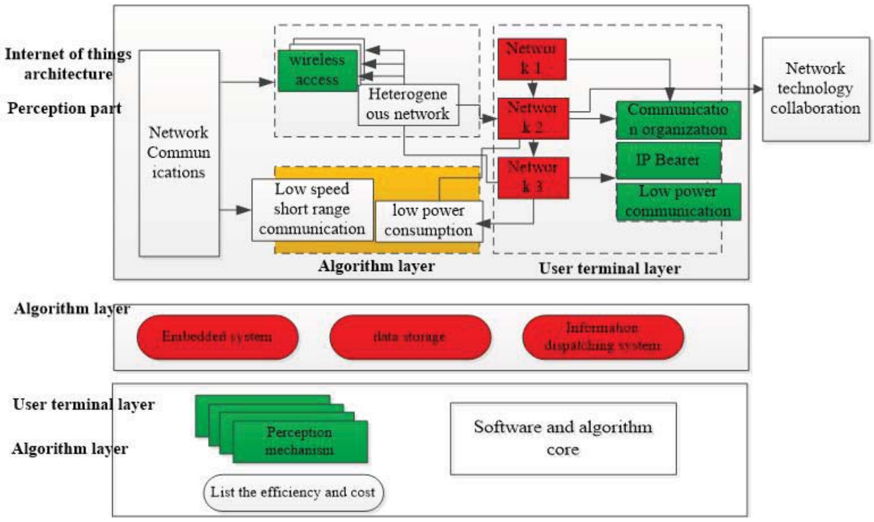

Figure 3 Architecture of Technical Collaboration Problems.

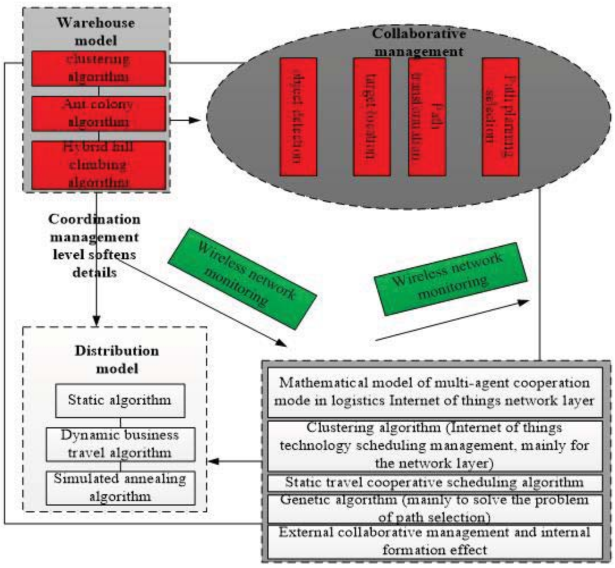

Figure 4 Block Diagram of Mathematical Model of Multi-Agent Cooperation Mode in Logistics IoT Network Layer.

At the same time, the marketing methods of collaborative management and the collaboration between order information and upstream and downstream supply chain information also need to be processed efficiently. The mathematical model is shown in Figure 4.

3. SOLUTION OF COLLABORATIVE MANAGEMENT AND ORDER DEGREE PROBLEM

In order to solve the problem of agricultural logistics collaborative management and the degree of order, the solution proposed in this paper is the IoT perception node algorithm based on the clustering algorithm, which divides the agricultural logistics nodes into clusters, and obtains the distribution and density of mobile logistics nodes in a specific region through the agglomerative subgroup division.

In the design of the IoT perception node algorithm, the definition and environment are firstly defined: the mobile logistics service request system and the mobile service responder in the agricultural logistics system are classified, and the nodes are classified according to the logistics distribution characteristics. Class A includes the service requesters of the logistics system; the class M includes the responders of mobile logistics services. The quantitative social relationship formula of the two is shown in Formula 1, where A and B represent any IoT node, the s represents the social attribute set of the mobile node, the corresponding V represents the quantitative value of social relations, the w represents the set of mobile nodes, and the w represents the society I represents the communication frequency set of any two kinds of nodes for a set time period.

$$M(A, B) = wL(A, B) + (1 - w)I(A, B) \qquad (1)$$

Based on this need, the probability table of agricultural logistics service nodes is constructed, the mobile network intermediate system is the bridge between subgroups, and then

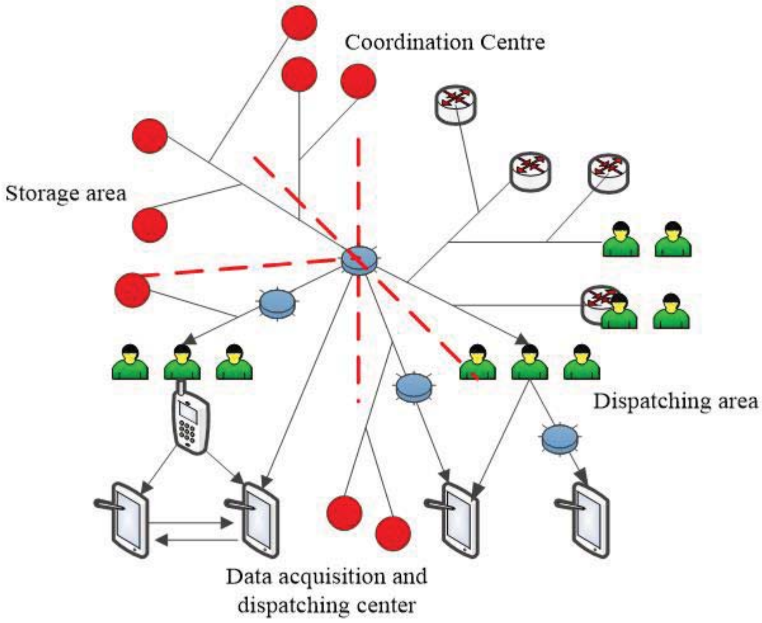

Figure 5 Optimal Path Tree of Social Relations in Logistics IoT Network Layer.

Table 1 Generation Probability Table of Mobile Node Generated by Social Relation Tree.

Time	L1	L2	L3	L4	L5	L6	L7
1:00	1.132	_	_	1.143	_	1.183	_
2:00	_	1.234	_	1.234	_	1.234	_
3:00	_	_	1.355	_	_	_	_
4:00	_	_	_	1.354	_	_	_
5:00	_	_	_	_	1.367	_	_
6:00	_	_	_	_	_	1.772	_
7:00	_	_	_	_	_	_	1.342
8:00	1.234	_	1.321	_	1.421	_	_
9:00	1.723	_	1.672	_	1.781	_	_
10:00	_	1.671	1.665	_	_	1.621	_
11:00	_	_	_	_	_	_	_

the optimal path tree of social relations between different node pairs is calculated, and the optimal path tree of social relations is constructed. The optimal path tree is shown in Figure 5, which indicates the social relationship networks of mobile nodes in different regions.

The generation of the probability table of mobile nodes based on this social relation tree is shown below in Table 1.

The corresponding core code functions are as follows:

```
A = zeros (500500): % generates 500 random nodes;
For a=1:500;
    For b=1:500;
        p=rand(1);
If p < = 0.04%, one service node connects 4 other nodes on average;
    A(a,b)=1;
    clsc
    A(a,b)=0;
      end
    end
end
    xy=500*rand(2,500);
    xy=xy';
    gplot(A,xy);
```

The application of the clustering algorithm in the perception level of the IoT, enables the network layer to conduct collaborative management. The network layer collaborative management solves two problems: the dynamic distribution service level and the system target level. In the agricultural logistics distribution process, it is used to solve the overall efficiency and cost problems, which involve complex path planning, path operation cost, vehicle operation cost, etc. In the dynamic path distribution problem, the main transportation target can be regarded as the shortest path to all distribution locations. The agricultural logistics companies need to coordinate the information within the whole system. They need to consider the real-time traffic information, the road construction in the path, the path changes caused by vehicle congestion and the transportation time. At the system target level, logistics companies need to take into account the distribution costs associated with vehicle delivery time, the punctuality, rapidity and the compression of logistics companies.

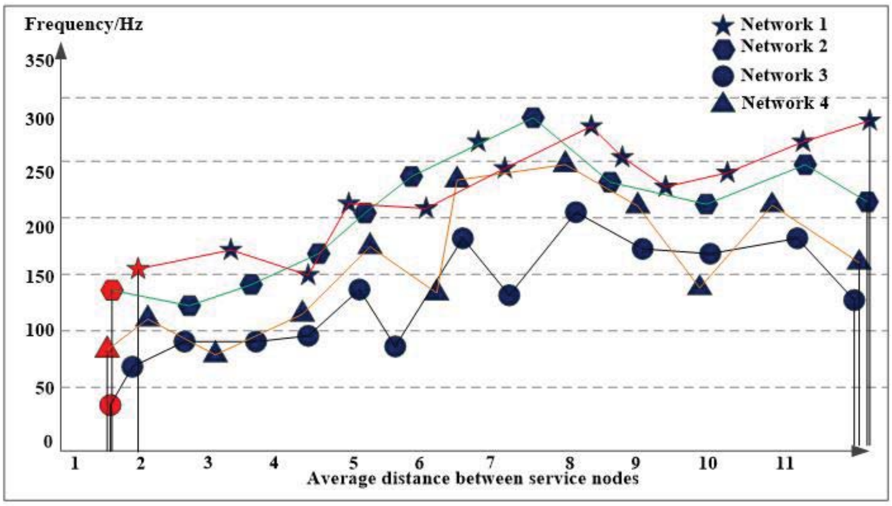

Figure 6 Simulation Line Chart of the Shortest Distance of Mobile Service Nodes Under Mobile Service Node Aggregation Subgroup.

When agricultural logistics companies implement collaborative management based on IoT technology, they need to take into consideration the management problems in terms of flexibility, which refers to making full use of the response capacity when the external environment changes to solve the problem of resource allocation and service demand. When using flexible collaborative management, we need to realize the whole network real-time monitoring strategy of logistics network. The monitoring angle is discussed from four aspects: 1. We need to carry out flexible collaborative management of the whole logistics industry upstream and downstream supply chain, connect the inventory information of upstream and downstream enterprises through the IoT technology, and manage the raw material reserves and the sales of warehoused goods. Hence, the real-time selection of the supply time, and the reasonable planning of production can ensure that the market demand will be met in time. 2. IoT technology is used to monitor the production process in real time, and a flexible management process is included. Through IoT technology, the allocation of raw materials, human resources and goods on the logistics supply chain is monitored, and the strategies are updated in time to increase the flexibility of the entire agricultural logistics subsystem. 3. The relevant information is collected in time, the flexibility of the whole logistics system is increased, information related to the IoT is collected, the demand for transport capacity is integrated, vehicles and manpower are allocated appropriately, and the traffic conditions are mastered. 4. The flexible processing of information in the agricultural logistics system, and the timely updating of relevant information via the IoT, will help to ensure the timeliness of the information and increase the performance of the information management system.

At the same time, when the whole agricultural logistics collaborative management is carried out, it needs to be stimulated by external collaborative management, thus forming a beneficial collaborative management cycle, and then establishing an ideal coordination mechanism for modern agricultural logistics management based on physical network technology, so as to ensure the order of the system from the system and specification.

4. COLLABORATIVE MANAGEMENT EXPERIMENT AND EFFECT ANALYSIS OF A SMALL AGRICULTURAL LOGISTICS SCENE SUBSYSTEM BASED ON IOT TECHNOLOGY

Based on the above theoretical analysis and research, a small agricultural logistics scenario is simulated using MATLAB. The number of mobile service nodes selected for this logistics scenario is set at 500. At the same time, the relevant data sets for 100 days in the region are collected and the agglomerated subgroup of mobile service nodes is constructed. The broken line graph in Figure 6 shows the shortest distance simulation of the mobile service node aggregation subgroup. It can be seen from Figure 6 that the appropriate distance set for a network service node can significantly improve the request and efficiency the agricultural logistics service. The efficiency of each node in the network and between each service node is clear, improving the perception and timeliness of the logistics discovery.

In the collaborative management of the agricultural logistics system, the discovery efficiency broken line graph of logistics perception node is shown in Figure 7. It can be seen from the figure that when the agricultural logistics subsystem becomes larger and more complex, the efficiency of the service node fast discovery and arrangement on the collaborative management level is also increased, and the logistics path success rate is also higher and constantly improving.

In the corresponding agricultural logistics warehouse collaborative management scheme rapid development and success efficiency, the experimental environment for this study is as follows: software is used to generate experimental data randomly, at the same time, the corresponding logistics system in a number of production and service points in a certain matrix, the corresponding agricultural logistics center is designed in the center of the matrix, the corresponding production point inventory unit. The average time storage cost is set at 0.3, the production cost for a single-day production

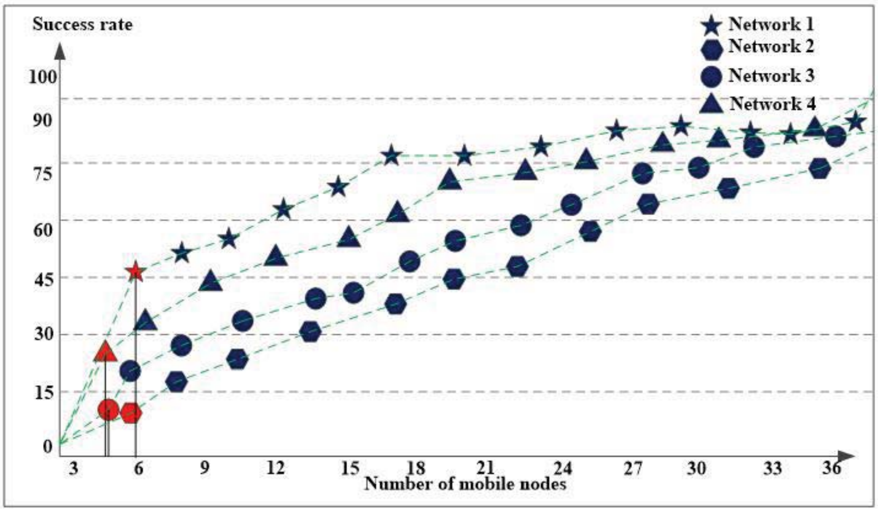

Figure 7 Simulation Line Chart of Logistics Perception Node Discovery Efficiency.

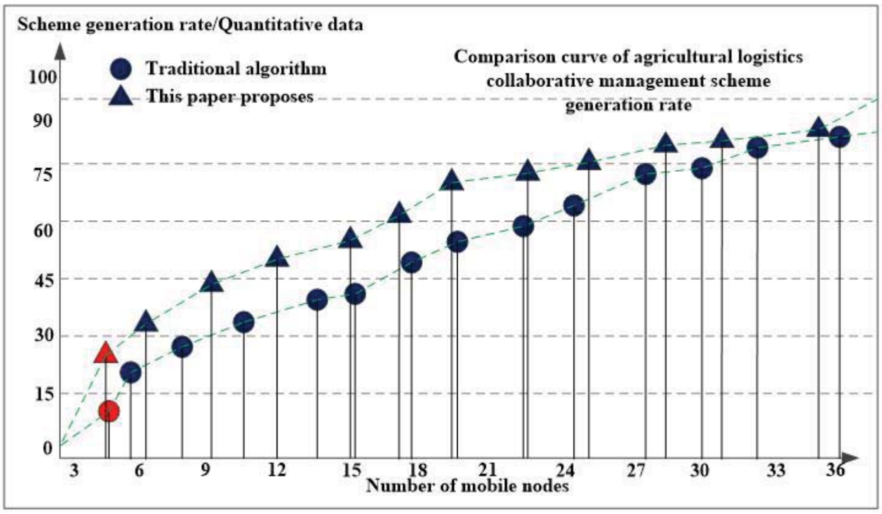

Figure 8 Comparison Curve of Generation Rate of Agricultural Logistics Collaborative Management Scheme.

service point has a variance distribution of 0.3, the vehicle variable cost is 8, and the storage capacity is 160 units. The simulation experiment is conducted to investigate the influence of the number of production points, the length of the production cycle, and the number of vehicles on the logistics subsystem and whether the proposed scheme has the best performance. The number of production points in the logistics center matrix is set as 10, the production cycle is 10 days, and the number of single vehicle experiments is 1. Compared with the traditional agricultural logistics collaborative management, the scheme generation speed and collaborative management cost curve are shown in Figure 8 and Figure 9. Figure 8 and Figure 9 show that the algorithm proposed in this paper has obvious scheme generation speed and efficiency advantages that can address the cost and efficiency problems of collaborative management in agricultural logistics subsystems.

The following conclusions are drawn from the experimental results presented above in Figure 9.

1. The simulation results of three different experiments verify that the IoT technology based on the clustering algorithm can achieve efficient operation at different levels of management collaboration, such as information collaboration and perceptual collaboration between the subsystems of agricultural logistics, which has obvious advantages in terms of efficiency compared with the traditional logistics algorithm.
2. The simulation environment for each of the three different experiments is well-aligned with the current real-life scheduling environment.
3. The experimental results show that the algorithm makes full use of the dividend brought by the changing information, solves the cost problem of management collaboration, and also solves the efficiency problem of management collaboration; in particular, the performance of information collaboration in management collaboration is given the best play.

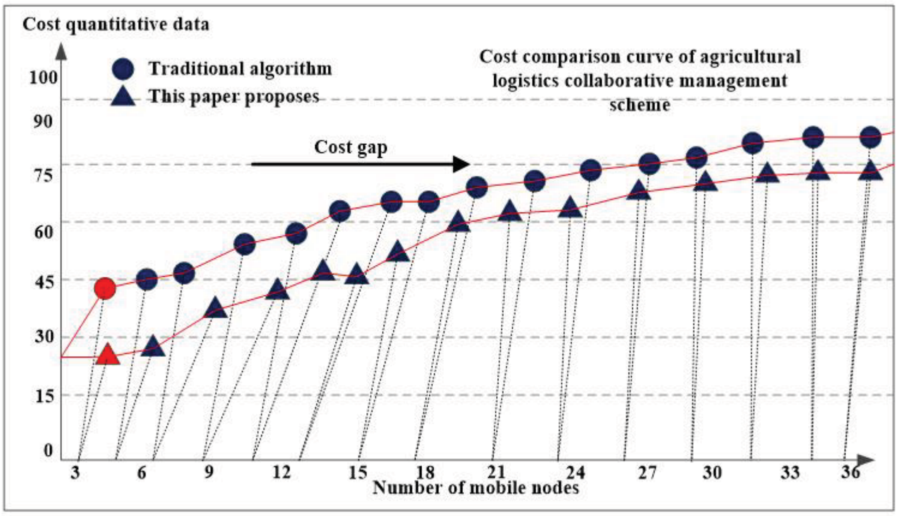

Figure 9 Cost Comparison Chart of Agricultural Logistics Collaborative Management Scheme.

Based on the above experimental analysis, we can verify that the multi-layer agent collaborative mode of the modern logistics IoT network layer based on the clustering algorithm, and the starting point of collaborative management and order degree analyzed in this paper, have obvious industrial advantages and practical research significance for the collaborative development of agricultural logistics subsystems and cost control.

5. CONCLUSION

In this paper, the evolution of IoT technology is examined and analyzed, as is the current situation of agricultural logistics and its problems together with the technical and other issues faced by the current physical network technology in the field of agricultural logistics. In an attempt to address these issues, an architecture for agricultural logistics IoT is designed and evaluated in terms of four collaborations: technology, information, service and management. Based on these, a proposal is developed that involves the multi-agent cooperation mode of a modern agricultural logistics IoT network layer based on game theory. The simulation and experiments indicate that the method proposed in this paper can be applied to the physical network technology in agricultural logistics collaborative management and order degree, and has demonstrable practical value. In future work, we will focus on optimizing the current experimental IoT architecture in terms of operational efficiency and energy consumption. At the same time, we will include the artificial intelligence algorithm for further optimization of the operation and management strategy.

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