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A Study on Edge Computing and Efficiency Optimization for Agricultural Supply Chain Architecture: A Review Approach

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Abstract: *The current paper is related to the application of edge computing and efficiency optimization for agricultural supply chain architecture. It is a review-based paper. Based on the existing supply chain structure, this paper classifies the structure of the agricultural supply chain according to different standards and analyzes the advantages of each type. We classify the supply chain structure from four different aspects: the complexity of the supply chain, the concentration degree of enterprises on supply chain nodes, the reliability of the supply chain, and the optimization objective.*

Keywords: Edge Computing, Efficiency Optimization, Agricultural Supply Chain, etc.

I. Introduction

With the development of the economy and society, the economic competition between enterprises or regions has been transformed into the competition of their respective supply chains. As a largely agricultural country, the development of China's agriculture is increasingly dependent on the merits and demerits of its own supply chain, so choosing a suitable supply chain structure for its own development has become the key to the success of regional agricultural economic development. Although China's supply chain theory has made great progress, there are few research results on supply chain structure, especially on agricultural supply chain structure.

Based on the existing supply chain structure, this paper classifies the structure of the agricultural supply chain according to different standards and analyzes the advantages of each type. We classify the supply chain structure from four different aspects: the complexity of the supply chain, the concentration degree of enterprises on supply chain nodes, the reliability of the supply chain, and the optimization objective.

II. Types of Supply chain Architecture

1. Classified by the Complexity of the Supply Chain

1.1 Chained Structure

This is a single structure, each node participates in the chain through the upstream and downstream nodes, and has no other contact with each other except the adjacent nodes. This structure is not common in reality but is a simple neighboring relationship to simplify the study of the advanced complex supply chain. The basic structure is shown in Figure 1.

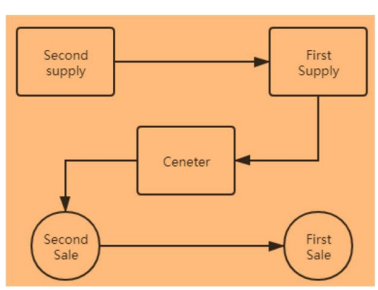

Figure 1: Structure of Simple Supply Chain

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1.2 Network Structure

This structure is more common and has a certain complexity. Each supplier can serve multiple manufacturers, and each manufacturer can obtain raw materials from different suppliers. The products produced are distributed by different distributors according to different product types or differences in product quality or price, etc. The structure is shown in Figure 2.

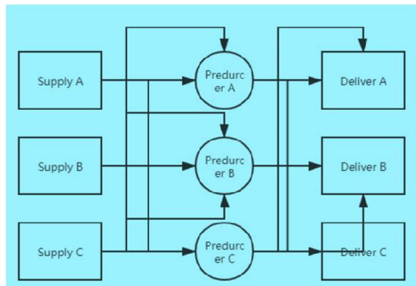

Figure 2: Structure of Net Supply Chain

2. Agricultural Supply Chain Node Enterprise Concentration Degree Classification

According to the agricultural supply chain node enterprise concentration degree classification, the practice has proved that in the process of building a supply chain, in order to achieve the ``competition-cooperation-coordination" process and finally, to achieve the goal of win-win, there is always one enterprise (manufacturer, supplier, retailer) as the initiator and becomes the core of the supply chain. Therefore, the agricultural supply chain should also be built around the core enterprises or legal persons, which is conducive to reaching consensus among the nodes of the agricultural supply chain, reducing transaction costs, and improving the operational efficiency of the supply chain. The common structure includes a two-level supply chain, three-level supply chain, and multi-level supply chain. The multi-level supply chain centered on distributors and retailers of agricultural products, as shown in Figure 3, is the supply chain structure of the largest supermarkets.

Most of these large supermarkets have a strong retail network and serve multiple customer groups. It is based on a powerful trading company, which is conducive to the flow of agricultural products logistics, but it is easy to increase the inventory of the whole chain, so this type of structure should mainly solve the inventory problem of the supply chain. Perhaps this type of structure can reduce the inventory and increase the flow speed of logistics, but it cannot guarantee the overall optimal.

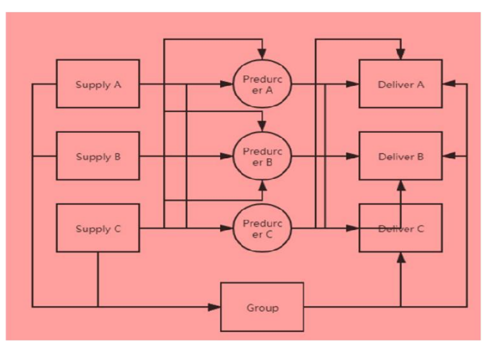

Figure 3. Structure of Concentration Supply Chain

3. Classified by Supply Chain Reliability

According to the current agricultural market environment, what agricultural producers are facing is the survival of the market, and the personalized needs of consumers are enhanced. How to effectively and reliably guarantee the interests of producers and the needs of users is an essential consideration for the establishment of the agricultural supply chain. These

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categories are all structural types centered on agricultural producers, which can be divided into three categories according to the different reliability of supply chains: OR-type supply chain as shown in Figure 4, AND supply chain as shown in Figure 5, And hybrid supply chain structure. The relationship between suppliers of hybrid structure is a combination of AND and OR, which is common in reality and is also the most stable and reasonable type [6]. There are many kinds of raw materials needed by producers, there are many suppliers in each raw material industry, and there is fair competition among suppliers in each industry. However, such a structure must also ensure that the downstream node relations have a certain OR structure.

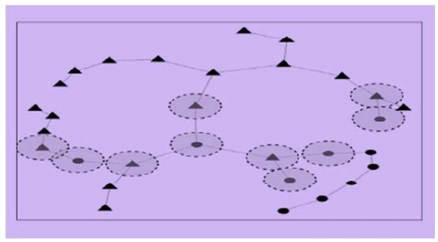

Figure 4: Structure of Producer Distribution.

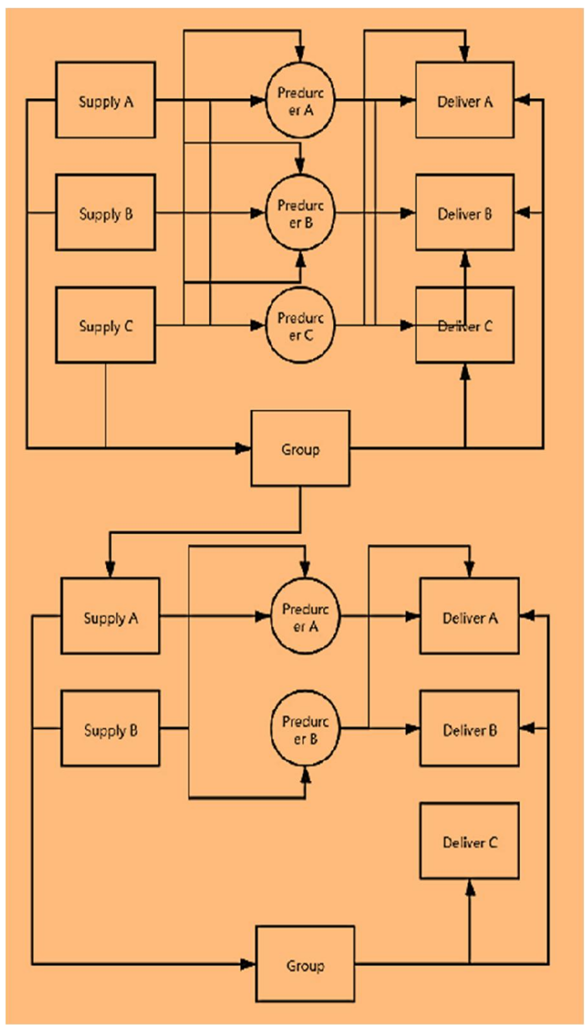

Figure 5: Structure of AND Supply Chain

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4. According to the Optimization Objectives of the Supply Chain

Because the supply chain has two kinds of obvious functions, namely logistics function and business flow function. The logistics function is to convert raw materials into final products and move them from one node of the supply chain to the next; The function of business flow is to ensure that all kinds of products have a certain market, and can meet the needs of customers, and can realize value-added. The implementation of each function requires a certain cost. The sum of business flow cost and logistics cost constitutes the total cost of the supply chain [7], [8]. Therefore, according to the different objectives of supply chain optimization (reducing logistics cost and commercial flow cost), agricultural supply chain structure can be divided into the following two types: cost structure and high flexibility structure. Because functional agricultural products have the characteristics of relatively stable demand, the establishment of the supply chain should focus on reducing logistics costs, which is suitable for the establishment of a low-cost supply chain structure. As the market of innovative agricultural products has great uncertainty, we should consider establishing a supply chain with high flexibility structure to reduce the cost of commercial flow.

The agricultural supply chain structure can be divided into different types, from different angles for each category has its adaptation range, and in real-life, the supply chain structure of these different perspectives is often cross each other, so to establish the reasonable structure of agricultural supply chain, must first to the classification of the master supply chain is clear, according to the different situation with different types of structure, Each region should establish its supply chain structure system according to its characteristics and the actual situation. With the diversified development of mobile Internet services and applications, people's requirements for data rate and service quality is getting higher and higher. As a key technology in the future communication technology, mobile edge computing can greatly reduce the delay of MEC server to user's computing task request and response and the possibility of network congestion between transmission network and core network by narrowing the geographical distance between MEC server with rich computing resources and users. For users, since the computing resources and power of mobile devices are limited, unloading tasks to the MEC server can improve the energy efficiency of mobile terminals. However, as users are self-interested, more resources will be wasted in the process of preempting computing resources.

In addition, since the user is not stationary and the coverage of the MEC server is limited, the user will repeatedly send the unload request if the calculation result is not received in time after updating the location, resulting in the waste of computing resources. The above two problems are more serious in resource-constrained scenarios, so how to optimize the energy efficiency of mobile terminals in mobile edge computing and reasonably manage server computing resources is worth further study. In this paper, an agricultural supply chain architecture based on edge computing and efficiency optimization is proposed. Firstly, from the perspective of how to improve the energy efficiency of mobile terminals, methods to improve the energy efficiency of mobile terminals are studied in multi-user systems where mobile terminals compete for MEC servers with limited computing resources. Then, this paper focuses on the waste of computing resources caused by user movement under the scenario of limited server coverage in MEC system and studies the problem from the perspective of effective management of computing resources [9].

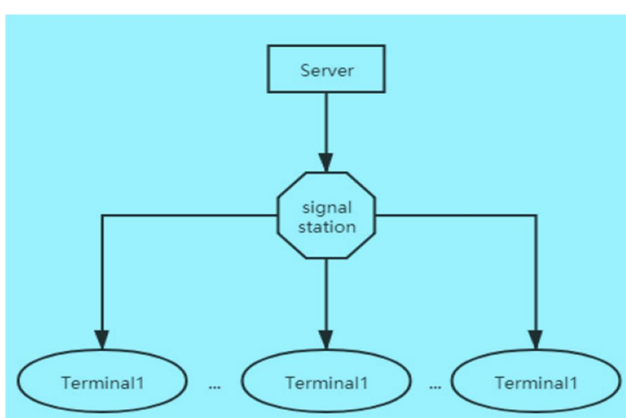

Figure 6: Structure of MEC

III. Edge Computing

3.1 Definition and Development of Edge Computing

With the rapid development of the IoT, billions of smart devices are installed each year. It is estimated that more than 70 billion smart devices will be installed by 2020. The access of a large number of devices has led to an increase in the amount of data to be processed. We face the challenge of processing and analyzing those data, especially if it needs to be processed in real-time. Simply using a cloud server is not able to provide real-time response while handling such a large data set. Edge computing is proposed for solving the problem of data explosion and network delay.

The research fields of Edge computing include Fog computing [6], Cloudlet [7, 8], and Mobile Edge Computing (MEC) [9, 10]. Although Edge computing has been proposed for a long time, there is no uniform and strict definition. Satyanarayanan [11] defines it as, ''Edge computing is a new computing model that deploys computing and storage resources (such as Cloudlets, fog nodes) to networks closer to mobile devices or sensors.'' Its system architecture is shown in Figure 7., which is divided into three layers: terminal device, edge node, and cloud center. As we all know, 5G is becoming more and more popular, and edge computing is one of the core technologies in the 5G era, but its architecture is open and can also be deployed and applied to 4G LTE networks. Operators will smoothly evolve on the existing network structure, and finally, achieve full coverage of the computing power of low-level network nodes, and continue to improve edge computing capabilities.

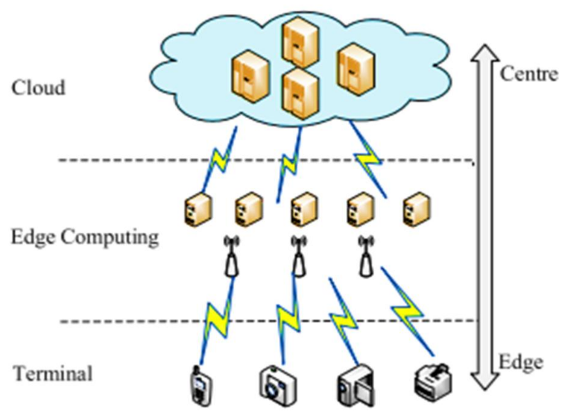

Figure 7: The System Architecture.

3.2 Hierarchy of Edge Computing

The Edge Computing Consortium (ECC) defines four areas for Edge computing: equipment domain (Perception and control layer), network domain (Connection and network layer), data domain (Storage and service layer), application domain (Business and intelligence layer). As shown in Figure 8: these four layers are the computing objects of Edge computing. Equipment domain: in the equipment domain, Edge computing can directly process the perceived information. For example, intelligent identification can be directly deployed in video collection and audio collection. Network domain: in the network domain, the automatic conversion of each network protocol is realized, and the data format is standardized. At the same time, the Edge computing in the network domain can conduct intelligent management of the ''converged network'', reduce the redundancy of the network, ensure the security of the network, and further participate in the optimization of the network.

Data domain: Edge computing in the data domain makes data management smarter and more flexible. First, Edge computing can analyze the integrity and consistency of the data, and conduct data collation to delete redundant and wrong data in the system. Secondly, Edge computing can maintain efficient coordination with cloud computing and share cloud computing tasks. Application domain: Edge computing in the application domain provides localized business logic and application intelligence. It enables applications to be flexible and fast- responding. Edge computing can provide localized application services independently when it loses contact with the cloud.

Edge computing is deployed in the above four domains, where it is closer to the user and application scenarios. It enables the device to have intelligent sensing capabilities and it can be equipped with adaptive connection strategies and more optimized deployment strategies. It can solve data heterogeneity and related network synchronization problems in the system, and provide local business logic and application intelligence. Edge computing is an open and distributed platform that provides network, computing, and storage services at the edge of the network, close to the data end. It meets the demands of intelligent, real-time business, data optimization, and security aspects of agricultural digital transformation. In addition, there are two kinds of edge servers mentioned in this paper: remote edge computing servers located on the edge of wireless networks; local edge computing devices.

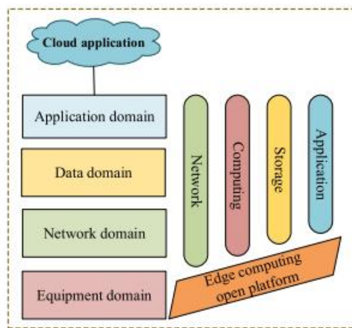

Figure 8: The Hierarchical Deployment Structure for Edge Computing

IV. Results and Discussion

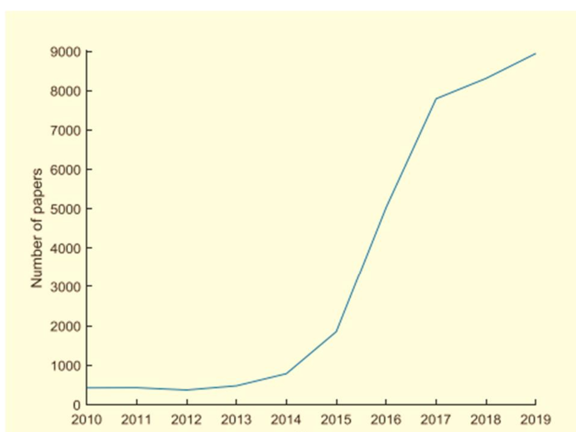

Figure 9: The Number of Papers Retrieved by ''Edge Computing'' on Google Scholar

From the development trend since 2010, the attention to Edge computing continues to rise, as shown in Figure 9 (Some data quoted from [12]). Especially since 2016, the attention to Edge computing has increased rapidly. Shi et al. derived five typical scenarios for the application of Edge computing: cloud offload, video analytics, collaborative edge, smart home, and smart city [13]. Sun et al. proposed a real-time fault detection algorithm based on Edge computing and cloud computing for the video monitoring system, which effectively improved the average repair time [14]. In [15], in order to meet the demand for smart homes, a system based on Edge computing was designed to predict the demand for household electricity.

The system can provide a better quality of service and enhance the scalability of the system. In [16], Higashino et al. proposed a large-scale Spatio-temporal information collection mechanism based on Edge computing and IoT to mitigate disasters and build a safe and intelligent city.

V. Conclusion

Based on the existing supply chain structure, this paper classifies the structure of the agricultural supply chain according to different standards and analyzes the advantages of each type. We classify the supply chain structure from four different aspects: the complexity of the supply chain, the concentration degree of enterprises on supply chain nodes, the reliability of the supply chain, and the optimization objective.

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