Intelligent supply chain information system based on Internet of Things under asymmetric information

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Abstract: After China's entry into the WTO, the import and export trade has developed rapidly. Because of the advantages of water transportation, the port commodities have been greatly developed. With the development of IoT technology, logistics SCM has also been improved to some extent. In order to strengthen the overall effect of logistics management, it is necessary to innovate all aspects of management with the help of IoT technology. Through automatic management, the whole process of logistics can be effectively controlled and problems in management can be reduced. This paper studies the supply chain information system based on IoT technology under asymmetric information. This paper analyzes the influence of asymmetric information on emergency management and puts forward management measures to tackle this situation. It is found that asymmetric information leads to the reduction of supply chain system revenue and information value, and analyzes the information value law and factors of supply chain system under asymmetric information. After the optimization of business process, this paper analyzes the needs of the main bodies in the supply chain, and further analyzes the functions of the commodity information sharing platform. On this basis, according to the principle of information integration, this paper puts forward a technology-based information integration architecture, which is divided into system integration module and collaborative operation module. The system integration module is used to integrate the enterprise systems in the supply chain, and the collaborative operation module is used to complete the information exchange with ordinary customers. Besides the basic architecture, this paper also analyzes and designs some key modules in the platform. On the basis of considering that the sales cost information is asymmetric information and random market demand. Firstly, the decision-making situation of distributed system in normal state is analyzed, and the problem of asymmetric information is solved by redesigning variable parameters, thus realizing the perfect coordination between information sharing and supply chain.

1. Introduction

With the further development of economic globalization, commodity trade has developd rapidly in China, but the competition in the commodity market has become increasingly fierce, and consumers' requirements have become higher and higher[1]. Therefore, the requirements for commodity logistics have become higher and higher. In order to improve the response speed of commodity transportation supply chain to customer demand and reduce logistics costs, the demand for information integration of supply chain has become stronger and stronger[2]. The supply chain starts from the signing of orders, including raw material procurement, WIP production, warehouse management, distribution and transportation, and finally the process of delivering products to customers through the sales network[3]. Through the combination and control of logistics, information flow and capital flow, this process connects suppliers, manufacturers, logistics distribution, wholesalers, retailers and end users into a value-added chain. On this chain, materials increase their own value through reasonable processing, storage, packaging and transportation, and bring benefits to relevant enterprises. Using Internet of Things (IoT) technology, enterprises can optimize the management process and structure of supply chain management (SCM) system, improve the speed of information transmission and the accuracy of matching with things, and improve the operation mode of supply chain [4]. The SCM system developed based on the IoT technology can effectively help enterprises reduce operating costs, improve the ability to respond to the market and

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improve the level of enterprise management informatization, so as to improve the operation efficiency of the whole supply chain through the visual, automatic and intelligent management of all links of the supply chain.

As a strategic emerging industry, the IoT will become an important force to promote global economic development in the next decade or even longer, and the face of human life will open a new page[5]. SCM is a new concept in the field of management science rising with the development of information system technology in recent years. Through the information management system, all the links and business processes involved in the supply chain are integrated into realize information and automatic management[6]. An efficient and mature supply chain information management system requires on-demand traceability, process visualization and management automation. Therefore, the accurate collection and reception of information in each supply chain link, and the rapid implementation and efficient implementation of managers' decisions have become critical to the supply chain. How to build a new SCM model based on IoT technology, the specific application value of IoT technology in this model, how to accept or refuse to adopt IoT technology, and the factors that affect the Internet of things technology have also received more and more attention from the academic circles [7]. The rise of IoT technology in recent years has provided technical possibility for the supply chain system to realize the above requirements. Therefore, establishing the interactive information network and management service system of manufacturing resources and identification information is one of the important projects that remanufacturing enterprises need to be committed to in the closed-loop supply chain system. With the application of IoT technology, the enterprise's SCM will be more intelligent, from the traditional "one thing, one person, one thing" to "one thing" interconnection[8]. Due to the interconnection of things and direct information interaction, the system can effectively reduce the dependence on people, and realize the whole process automation and visualization of tracking, monitoring and management.

2. Intelligent supply chain of IoT under asymmetric information

2.1. Management mechanism of supply chain under asymmetric information

Asymmetric information was put forward by American economists joseph stiglitz, George Akerlof and Michael spence in 1970. The most important application field of asymmetric information theory is enterprise theory. Agents have private information about their actions or abilities. Since the principal can't accurately observe the agent's behavior, the agent will choose to maximize its own benefits, and the principal can only induce the agent to display his private information through a reasonable mechanism, so as to achieve the coordination of the interests of both parties. Under asymmetric information, the manufacturer can't observe the exact c_r. If the retailer's true marginal unit sales cost information is c_r, and the false cost information is c_r. Since the retailer's order quantity q is a function of its marginal unit sales cost c_r or $\hat{c}_r$, it is recorded as $q(c_r)$ or $q\left(\hat{c}_r\right)$ respectively, and the expected sales quantity is

$$S\left(q\left(\hat{c}_r\right)\right) = q\left(\hat{c}_r\right) - \int_0^{q\left(\hat{c}_r\right)} F(x)dx \tag{1}$$

The retailer's expected profit function is:

$$\prod_r\left(b,\hat{c_r}\right)=(p-v-b+t-h)S\left(q\left(\hat{c_r}\right)\right)$$
$$-\left(\hat{c_r}-v-b-h+w\right)q\left(\hat{c_r}\right)$$
$$-tu+(w_0-p_0-c_{r0})H(p_0) \tag{2}$$

The manufacturer's expected profit function is:

$$\prod_M\left(b,\hat{c_r}\right)=wq\left(\hat{c_r}\right)-b\int_0^{q\left(\hat{c_r}\right)}\left(q\left(\hat{c_r}\right)-x\right)f(x)dx$$
$$-c_m\left(q\left(\hat{c_r}\right)-D_0\right)-c_{m0}D_0-(w_0-v_0)H(p_0)$$
$$=wq\left(\hat{c_r}\right)-b\int_0^{q\left(\hat{c_r}\right)}F(x)dx-c_m\left(q\left(\hat{c_r}\right)-D_0\right)$$
$$-c_{m0}D_0-(w_0-v_0)H(P_0) \tag{3}$$

The expected profit function of the closed-loop supply chain is:

$$\prod=\prod_r+\prod_M=(p-v+t-h)S\left(q\left(\hat{c_r}\right)\right)$$
$$-\left(\hat{c_r}+c_m-v-h\right)q\left(\hat{c_r}\right)-tu+(v_0+p_0-c_{r0})$$
$$H(p_0)+(c_m-c_{m0})D_0 \tag{4}$$

In the case of asymmetric information, the production decision-making arrangement still has the following characteristics: when the market demand increases significantly, the optimal production will increase; when the market demand reduces significantly, the optimal production will reduce; When the decision-makers have less market demand information, the production arrangement will fluctuate greatly. In the case of asymmetric information, the decision-maker's production plan is closely related to the decision-maker's mastery of information[9]. Under the condition of asymmetric information, when the change of market demand is fixed, the manufacturer's optimal price shows an increasing trend with the increase of production cost. When the change of manufacturer's production cost is fixed, the manufacturer's optimal price shows a decreasing trend with the increase of market demand. However, within a certain range of market demand and production cost, the manufacturer's optimal price remains unchanged, indicating that the manufacturer's price has certain robustness.

2.2. Overview of IoT and intelligent logistics supply chain

The IoT came into being in 1999, also known as the expansion of Internet applications, in which innovation is the core of the development of the IoT. The supply chain takes the enterprise as the core and manages the capital flow and information flow. Strengthening the SCM can promote the sales and production development of enterprises. There are three main features of the IoT, namely, comprehensive perception, reliable transmission and intelligent processing. Comprehensive perception means that the IoT uses infrared sensors, sensors and other devices to sense objects and obtain information about them. Reliable transmission refers to the real-time interaction of information through the integration of telecommunication network and Internet; Intelligent processing refers to the intelligent control of objects by using various intelligent computing technologies such as cloud computing and fuzzy recognition. Figure 1 is the information function model diagram of the IoT.

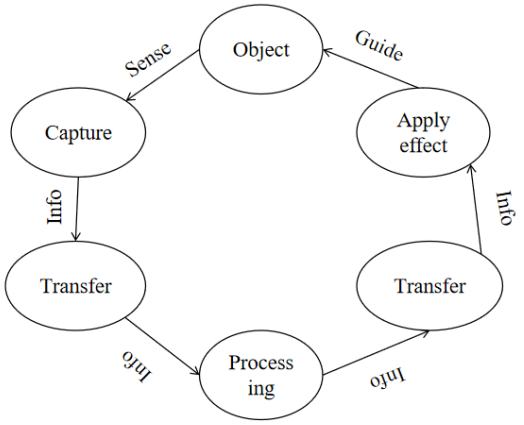

Figure 1 IoT information function model

At present, the problems in the supply chain are mainly visibility and cost control, and the logistics supply chain is difficult to keep pace with the cost fluctuation. The intelligent logistics supply chain system takes the flow of information as the main line, operates with the help of information technology and logistics technology, optimizes the resources of the whole logistics process, and forms an efficient logistics service system by using a unified management mode for the flow of funds, product manufacturing and logistics information. Intelligent logistics supply technology of IoT can make resources in various industries get centralized processing of logistics information, which brings convenient conditions for information integration. The intelligent logistics supply technology of IoT can make the logistics resources in different logistics industries get specialized information collection, which can make the information of logistics resources unified and integrated, and can also optimize the information stratification, which helps the vertical integration of logistics resources in the logistics industry. IoT intelligent logistics SCM has the characteristics of synchronous information sharing, and it can also optimize and visualize the supply chain. In the current intelligent logistics SCM of the IoT, it has many functions, which ensures the development of the logistics industry.

3. Design and application value of SCM system based on IoT technology

3.1. Design of SCM system based on IoT technology

The supply chain information system adopts B/S architecture, JavaJDK version 1.8 as the programming language, SSH (STMT S2+Spring+Hibernate) as the programming framework, and SQL Server 2019 as the database. By introducing the IoT technology into the SCM system, the seamless integration of the two is realized, thus improving the operation mode and efficiency of SCM. Figure 2 shows the functional diagram of SCM system.

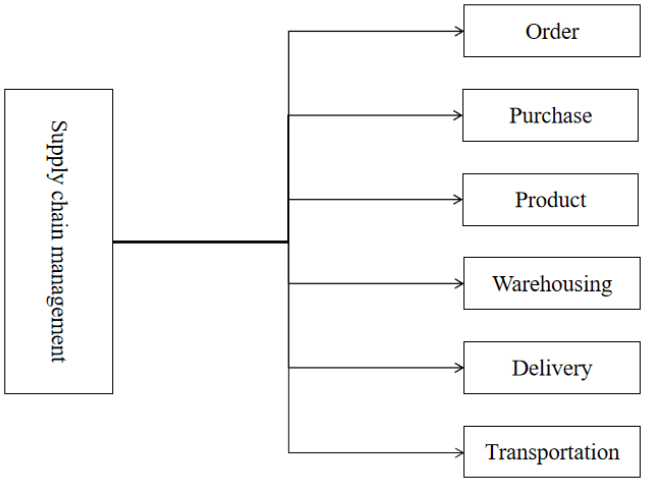

Figure 2 SCM system functions

After the order is signed, the system will automatically generate a unique order number. Through the order number, we can know the circulation of orders in all links of the enterprise supply chain in real time, master the whole process of order production, packaging and distribution, and realize the visualization of the whole process of orders by combining the IoT technology. Figure 3 shows the order-driven flow chart.

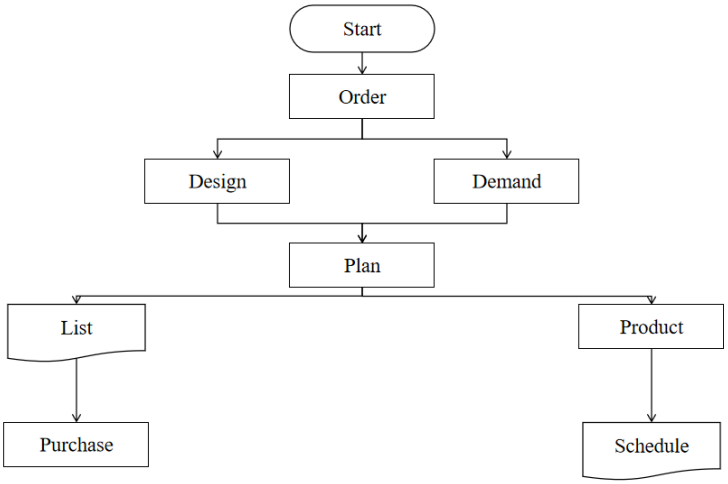

Figure 3 Order-driven process

In the process of material procurement, the system needs to be interconnected and integrated with services, and the services registered and published in the service registration center are material procurement information services. This service is provided by the procurement module of the system, which is the service provider; Electronic data exchange is conducted between the system and supplier enterprises to serve consumers. In the process of production control, the system needs to be interconnected and integrated with the electronic kanban system and the production line system respectively. In the material warehousing management, the identification system needs to be interconnected and integrated with the warehousing module of the system and the warehousing module of the system, and the warehousing material information service is provided by the system. In the design of transportation business process, the geographical position of the system is updated immediately when the vehicle arrives, so as to accurately predict the position and arrival time of the cargo vehicle and realize the real-time monitoring of transportation business process. The intelligent dispatching system of SCM system mainly solves the problem of customer product distribution, aiming at the minimum number of vehicles, the shortest mileage, the fastest time and the lowest cost, etc., scientifically and intelligently allocates available vehicles, generates the dispatching work list, and completes the transportation and distribution tasks. Intelligent scheduling system consists of interaction layer, decision-making layer and resource layer. Intelligent scheduling subsystem is an important part of SCM system, which directly determines the cost and efficiency of cargo transportation and distribution. Figure 4 shows the design of intelligent dispatching system.

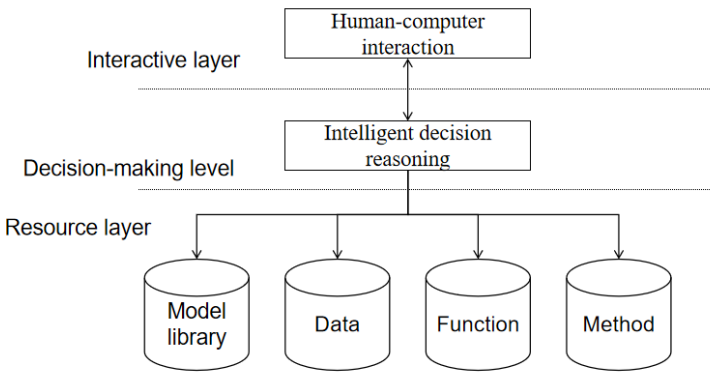

Figure 4 Design of intelligent dispatching system

3.2. Application value of SCM system based on IoT technology

The influence of visibility information on the performance of manufacturers in supply chain can be determined by three different ways. Completely invisible: the manufacturer has no knowledge of the information in reverse supply chain, and does not know the statistical characteristics of the number of products recovered in each link, so it can only make production and inventory strategies according to its forecast of external demand. Understand the statistical information: the manufacturer has mastered the statistical information such as the statistical distribution, expectation, variance, etc. of the quantity of recycled products in all stages and links through statistical methods. Completely visible: by adopting RFID technology, manufacturers can realize the real-time monitoring of each recycled product in reverse supply chain, but it doesn't mean that manufacturers have all the information. The SCM system based on the IoT technology aims at the main problems and development needed at present[10]. It combines the latest IoT technology with remanufacturing information service system, and builds a remanufacturing closed-loop supply chain information service system based on the IoT technology. It realizes the information, automation, intelligence and service management of the closed-loop supply chain through real-time demand docking, optimal allocation of resources, reasonable scheduling of equipment and rapid integration of services. Finally, through the feasibility and scientificity of the information service system, the resource utilization efficiency is improved, and the personalized service needed by different consumers are met, so as to realize the information, automation, intelligence and service management of the supply chain. The emergence of SCM system based on IoT technology provides an important theory and method for improving the overall operation management level and collaboration efficiency of remanufacturing industry. The two-way connection between each link in the supply chain and consumer market information is realized, and the intelligent manufacturing with the perception of manufacturing resources and things is realized.

4. Conclusions

With the development of economic globalization and the rapid development of commercial vehicle trade in China, commercial vehicle logistics has gradually prospered. However, with the fierce market competition and strict customer requirements, the commercial vehicle transportation supply chain is also facing the problems of slow response and high overall cost. At present, in the logistics industry, the development of technology and the improvement of demand make the market competition more intense. Adopting the traditional logistics management mode cannot meet the current demand, nor is it conducive to the development of enterprises. It is necessary to develop intelligent logistics SCM system with the help of IoT technology, so that the development level of logistics industry can be rapidly improved. Seizing the commanding height of the development of the IoT industry, promoting its application research and business model research in the industry, accurately evaluating its application value, excavating the key factors affecting its popularization and application are always the basic starting point of this paper. In doing this, we can promote the rapid development of the IoT industry in China, and supplement and enrich the existing literature and theories. The rapid development of IoT technology has brought more conditions to the logistics industry. With the help of IoT technology, we can improve the traditional logistics SCM and make the management more automatic. Using IoT technology can improve the operation mode of supply chain, optimize business process design and application system integration design and implementation. According to the different business process links of the supply chain, it is composed of the following six parts. That is, business systems such as order, purchase warehousing, production warehousing, distribution and transportation, as well as vehicle intelligent dispatching system in transportation management, can realize comprehensive information and visual management, which is an important force to promote global economic development, and the face of human life will start a new page.

References

[1] Qin Ming. Discussion on the application of blockchain technology in supply chain logistics. No.2019-12, pp.64-69, 2021.

[2] Hong Fanghua, Zhu Sida, Jiang Yue, et al. Research on intelligent monitoring and early warning of supply chain in the context of ubiquitous power IoT. China Management Information, vol.22, no.24, pp.2, 2019.

[3] Mao Huanyu, Zhang Guo. Design of supply chain sharing platform for smart factory based on IoT. Electronic Design Engineering, vol.28, no.9, pp.5, 2020.

[4] Cai Yaxuan. Analysis of Intelligent Logistics SCM under the IoT. Times Auto, no.17, pp.2, 2020.

[5] Han Xuan, Zhang Ying, Shang Yali, et al. Intelligent management scheme of material supply chain under the ubiquitous power IoT situation. Management and Technology of Small and Medium Enterprises, no.12, pp.2, 2019.

[6] Zhang Juan. Discussion on the construction of IoT and smart supply chain training room for logistics management specialty. Information Weekly, no.24, pp.1, 2018.

[7] Chen Sijie, Yang Yudong. The application of IoT in SCM and the new challenges it brings. Modern Management Science, no.11, pp.3, 2018.

[8] Li Yuquan, Jing Shudian, Fu Erquan, et al. A smart metering information service platform based on the IoT. Industrial Metrology, vol.27, no.4, pp.4, 2017.

[9] Jiang Ji. Discussion and Analysis on my country's IoT Information Service System. Computer Fan, vol.000, no.021, pp.272, 2017.

[10] Hu Peiling. Research on Intelligent Logistics SCM Based on IoT. Modern Marketing: Xueyuan Edition, no.3, pp.2, 2021.