Optimization of Sports Goods Industry Development Mode Based on Internet of Things Technology

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Objectives: In order to effectively improve the information level of sports goods traceability, to achieve its safety and quality of the whole supervision and information sharing. In view of the current sports supplies supply chain management, there are many problems in operation efficiency, information level, management level. Methods: The application of Internet of Things (IOT) technology to supply chain management of sports goods is proposed, and the system model is constructed and designed. This paper analyzes the connotation of sporting goods traceability and the necessity and feasibility of implementing sporting goods traceability, and proposes the design of sporting goods traceability system based on Internet of Things technology. Results: Firstly, the tracing model of sporting goods based on RFID and EPC Internet of Things was constructed. Then the system was designed from the aspects of system requirements analysis, overall design and detailed design. Conclusion: This completes the real-time tracking and traceability of sporting goods, and promotes the informationization and visual management of the sporting goods supply chain.

Key words: internet of things; sporting goods; traceability system
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As a green industry, a sunrise industry and a civilian production industry, the sports industry is an important part of the modern industrial system. It has the characteristics of large market demand, wide correlation and strong integration [1]. Under the background of national fitness becoming a national strategy, the development of the sports industry has also climbed to a new height and has become a driving force for leading the rise of social and economic value [2]. The downside is that there are many circulation links and transaction levels in China's sporting goods. There are drawbacks in the legal system and management of the industry, and the degree of product standardization is low. Lack of international leading enterprises, low market concentration; poor independent research and development capabilities, insufficient investment in science and technology, and a single export channel [3-5]. At the same time, we must also recognize the problems and challenges faced by China's sporting goods supply chain: China's sporting goods circulation is complex, and there are many sources of products, so it is easy to have fake and shoddy products into the market [6]. Different sports products have different performance, storage and transportation requirements, and are prone to quality and safety problems [7]. However, we must always be aware of the problems facing the supply chain of sports goods, domestic sports goods circulation environment is more complex, the same products come from multiple channels, it is very easy to let counterfeit and inferior products into the market [8]. However, it must also be admitted that sports goods are involved in production, processing, circulation, sales and other complex links, and lack of information before each link of the correlation and sharing, when quality and safety

problems are found, can not effectively track and trace the source of the product, to find the key to the problem [9]. The information system of sports goods supply chain is seriously lagging behind, and the efficiency of supply chain management is low. Logistics service capacity is insufficient. Fake and shoddy products flow into the market, affecting people's physical and mental health [10]. In view of the existing problems in the supply chain of sports goods in China, it is necessary to cultivate the international competitiveness of sports enterprises, create international well-known brands, give full play to comparative advantages and participate in international competition in multi-mode [11].

The Internet of Things (IOT) is an important part of the new generation of information technology industry. It has broad prospects and space for development and has an important impact on the development of the national economy and the whole society. Therefore, the supply chain of sporting goods should grasp the important opportunity of developing information economy and promoting the application of wisdom, supported by the new generation of information technology such as Internet of Things. Accelerate the realization of information and visual supervision of various supply chain links, this paper combines the actual application needs, using radio frequency technology, RFID and Internet of Things and electronic product code system technology [12-14]. The traceability system architecture of the sporting goods supply chain was designed, and the main functional modules and implementation paths of the system were introduced in detail. In addition, it effectively solves the quality and safety problems and hidden dangers of sporting goods, and improves the efficiency and level of the entire supply chain management [15]. Cooperate with third-party logistics companies to provide transportation, distribution and custodial services to suppliers, provide transportation services to demanders, and vigorously improve logistics service capabilities. Strengthen the supervision of sports goods quality and the construction of information platform to ensure product quality and safety [16]. The second is the lack of integration, the supply capacity of sporting goods suppliers is uneven, and there are cases where production is not carried out according to standards. In view of these quality and safety issues and hidden dangers, it is very necessary to establish a sporting goods traceability system based on the Internet of Things technology to ensure the safe production and circulation of sporting goods and to protect the rights of sports manufacturers and consumers [17-19].

The Internet of Things first appeared at the end of the 20th century. In the global financial crisis that erupted in 2008, the Internet of Things became the core technology for revitalizing a country or region, and it was highly valued and paid attention by the United States, Japan, South Korea and other countries [20]. On February 14, 2012, the Ministry of Industry and Information Industry issued the “Twelfth Five-Year Development Plan for the Internet of Things” [21]. In 2015, China will achieve significant results in the development and industrialization of core technologies of the Internet of Things, as well as the research and development of key standards, the establishment and improvement of industrial chains, and the demonstration and promotion of major applications in related fields [22]. It is also necessary to initially form an innovation-driven model, synergistic development and a safe and controllable IoT development pattern. Gaines (1998) and Fai & Tunzelmann (2001) respectively describe the industries in which industrial integration occurs, with a certain degree of industrial relevance or substitution of technology and products [23-25]. The concept of the Internet of Things first appeared in Bill Gates's 1995 Road to the Future, but it was limited to the development of wireless networks, hardware and equipment, and did not attract the attention of academic and industrial circles [26]. In 1999, the network radio frequency identification system proposed by the Automatic Identification Center of the Massachusetts Institute of Technology (MIT), "Auto ID Labs", is actually a network. The network connects all items to the Internet through information sensing devices (such as RFID). The purpose is to realize the intelligent identification and management of people and things. It is the prototype of the Internet of Things at the end of the last century [27].

METHODS

Radio Frequency Identification (RFID) is a non-contact automatic identification technology. The basic principle of RFID is to attach RFID tags to people or objects. By utilizing the transmission characteristics of radio frequency signal and spatial coupling (inductance or electromagnetic coupling), the category, time and location of storage items can be identified automatically in real time. It is the most widely used modern technology in manufacturing, product circulation and anti-counterfeiting traceability. In particular, RFID technology can give full play to the role of electronic tags, sports supplies raw materials procurement, production, circulation, sales and other supply chain links, the information is written into the system database. It is convenient for sports companies and regulatory authorities to track and monitor in real time, greatly reducing the error rate and helping to improve the transparency and management efficiency of the sporting goods supply chain. The traceability of sporting goods includes two aspects of product tracking and traceability. Tracking refers to the ability to follow a specific unit or batch of product operations from upstream to downstream of the sporting goods supply chain, which refers to the ability to track sporting goods from the production of sporting goods to specialty stores. The Internet of Things can break the traditional concept of separating physical facilities and IT facilities from each other, and integrate real-life things with virtual Internet of Things to achieve the goals of managing production operations and managing the economy. Sporting goods tracing is the trajectory of retrieving the minimum trajectory of each sporting goods and the attributes of the product. Sporting goods tracking records the location, time, direction and status of sporting goods in the circulation of the sporting goods supply chain.

The feature subset selection results of the three algorithms are shown in Table 1.

Table 1
Feature Subset Selection Result

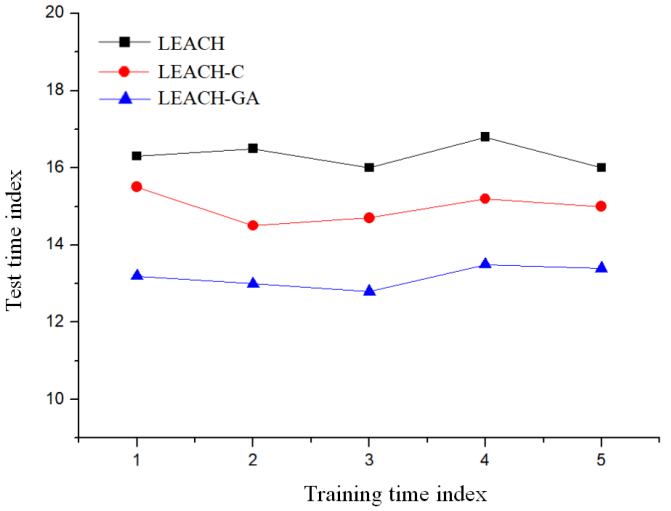
	Feature subset
LEACH	2, 7, 10
LEACH-C	1, 3, 5
LEACH-GA	1, 3, 7

The training and test time of the three algorithms. It can be seen from Table 2 and Figure 1 that LEACH-C has the best real-time performance, followed by LEACH-GA algorithm, and LEACH has the largest training time and test time.

Table 2
Real-Time Comparison

	Time performance	
	Training time (s)	Test time (s)
LEACH	54	75
LEACH-C	35	43
LEACH-GA	47	56

Figure 1
Real-Time Comparison



In the RFID technology application, an electronic tag is installed on the target item, and the radio frequency signal transmitted by the reader recognizes the target object of the e-mail electronic tag. The electronic tag acquires and activates the RF signal, and transmits the stored data information to the reader through the antenna in the tag. At present, China is building a well-off society in an all-round way and promoting national fitness activities. The government has increased its investment in sports. The system has low investment in research and development and application, short investment recovery period and high return rate. It is a profitable project. The construction of this system is economically feasible. Traceability refers to the ability to identify a particular unit or batch of product sources from downstream to upstream of the sporting goods supply chain. It is the ability to trace back the origin, purpose and location of an entity by means of a record identification method, that is, the ability to trace the sporting goods from a specialty store to a sporting goods raw material. The Internet of Things (IOT) refers to a network of real-time exchange of information, positioning, tracking and management of products by means of radio frequency identification systems, global positioning systems, laser scanning and other equipment and by means of related protocols to connect all items with the Internet. The reader receives the RF signal reflected from the activated tag, demodulates and decodes it, and feeds the encoded information in the tag back to the control computer, thus completes the automatic identification of the items. Because sports is related to people's health, the quality and safety of

sports goods is of great importance, improving the quality and speed of the supply chain of sports goods is conducive to improving consumers'confidence and enthusiasm in the quality of sports products.

From the graph, we can see the comparison of the three algorithms in dynamic collaboration and stability, and the results are shown in figures 2 and 3.

Figure 2
Comparison of Three Algorithms for Dynamic Collaboration Stability

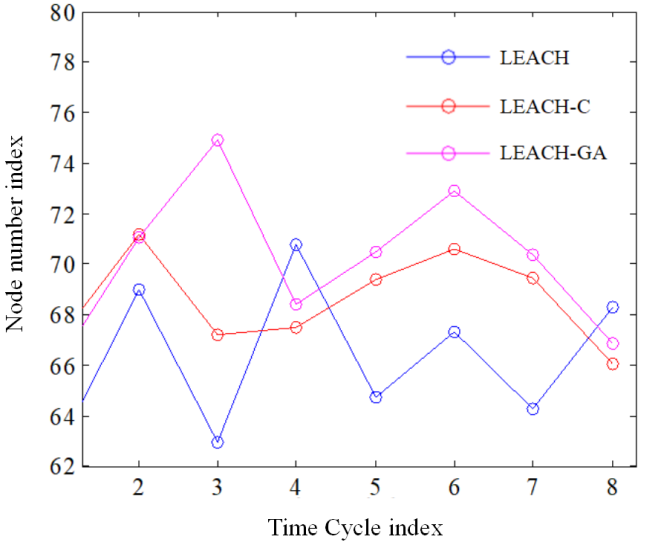
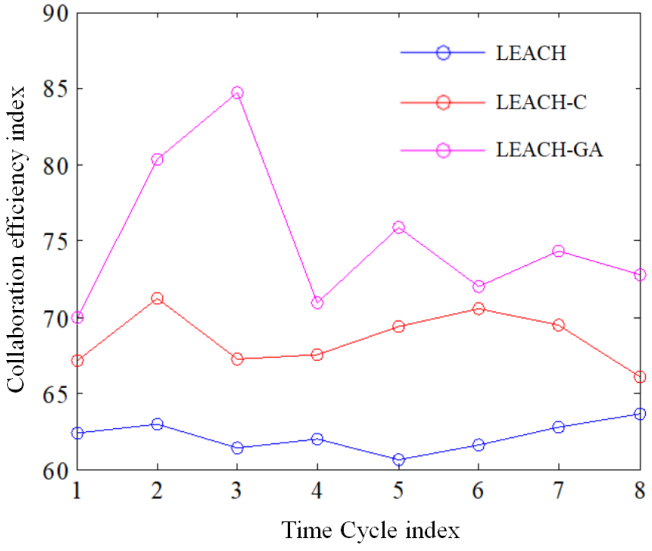


Figure 3
Comparison of Three Algorithms for Dynamic Collaboration Efficiency



The Internet of Things (IOT) refers to the combination of various information sensing devices and devices with the Internet, through the object of electronic tags, sensors, two-dimensional code and other wireless networks connected to realize the dialogue between people. Things can also be

connected, all items connected to the network to facilitate identification, management and control. EPC system consists of EPC coding system, radio frequency system (EPC tag, reader), information network system (middleware, object name resolution service, entity markup language) and so on. In EPC applications, the identified objects can transfer and interact information without human intervention. Sports supplies supply chain management system is a collection of raw materials procurement, production, warehousing and distribution, transportation, circulation, sales, tracking as one of the network system. The development of the system realizes the organic combination of sports goods from raw material suppliers, manufacturers, wholesalers to retailers and consumers. Establishing the identification, collection, transmission and association management of information in all aspects of the supply chain, and realizing the integration and sharing of information, in order to achieve traceability in the entire sporting goods supply chain. The combination of the Internet of Things and modern logistics technology has made the management and operation of sporting goods more efficient. Sporting goods have a wide variety of characteristics, value sports training, the importance of events, sporting goods put forward higher requirements for the safety and efficiency of logistics. The basic principle is global unified product coding technology, RFID technology, sensing equipment and wireless communication technology. Instantly and automatically identify and track the flow and status of items in the global supply chain, enabling information sharing and improving supply chain efficiency and transparency.

This system is aimed at the problems existing in the process of sports goods supply chain management, combined with the actual needs of sporting goods enterprises, systematic development can help sports enterprises to achieve optimal scheduling and dynamic control of the whole process of logistics. Efficiently integrate the logistics business of the enterprise to provide efficient and practical logistics management systems and operational means for the purpose of comprehensively improving economic efficiency and efficiency. Based on the curren t domestic and international practical experience, the implementation of the sporting goods traceability system mainly involves information identification, information collection, information exchange and logistics tracking. It can be seen that the application of Internet of Things technology in the management of sporting goods enhances the logistics efficiency of sporting goods. Ensuring the quality and safety of sporting goods plays an important role. Realize the information management of the whole process of the logistics chain from the procurement, production, storage, circulation and transportation of raw materials, facilitate the dynamic query and tracking service of product information, and realize the function of report generation and printing. Logistics tracking technology uses geographic information system GIS and positioning navigation system GPS, GIS / GPS technology can be traceable system, the logistics process of sports goods for the whole tracking record, providing the implementation of traceability information base. The system uses RIFD radio frequency identification technology to acquire the unique electronic identification mark attached to a single sporting goods. With the sporting goods moving between the nodes of the supply chain. Increase the flow information and historical records of sports goods supply chain, and realize the information sharing between the upstream and downstream enterprises. It provides a more detailed visual supply chain and realizes the basic goal of tracking, tracing and managing sports goods.

RESULTS

Sporting goods supply chain is a network structure including production, processing, storage, transportation and sales. To ensure the quality and safety of sports products, it is necessary to record and supervise the quality and safety information of each link in the chain, so as to realize the supervision of the whole process of the supply chain of sports goods. Sports supplies supply chain management system through a single sporting goods on the tag, and then in the drug warehousing, circulation, sales and other aspects of the data collection. It is uploaded to the network shared database to realize information

sharing and real-time monitoring of the entire supply chain. A unified EPC coding management scheme is adopted to identify products in the traceability network. Through the Web network or mobile terminal equipment, consumers access the sports product traceability system, inquiry product details. Using RFID technology for anti-counterfeiting is the most effective solution at present. Product quality inspection is to prevent non-compliant products or damaged products from entering the market, preventing athletes or ordinary consumers from causing safety accidents due to quality problems of sporting goods. Sports product manufacturers must establish a targeted quality inspection department to be responsible for the entire supervision and sampling inspection process of product production, to test whether the product quality meets the normative standards. This paper designs a traceability system based on RFID and EPC Internet of Things, and uses EPD's unified coding system to identify the anti-counterfeit code of sports products. According to the existing business scope and technology category of the sporting goods supply chain, combined with the actual situation of the system and the application status of sporting goods.

To judge the performance of the LEACH-GA algorithm, we must first simulate the network life cycle. The simulation results are shown in Figure 4 and Table 3.

Figure 4
Network Lifetime of Three Different Algorithms

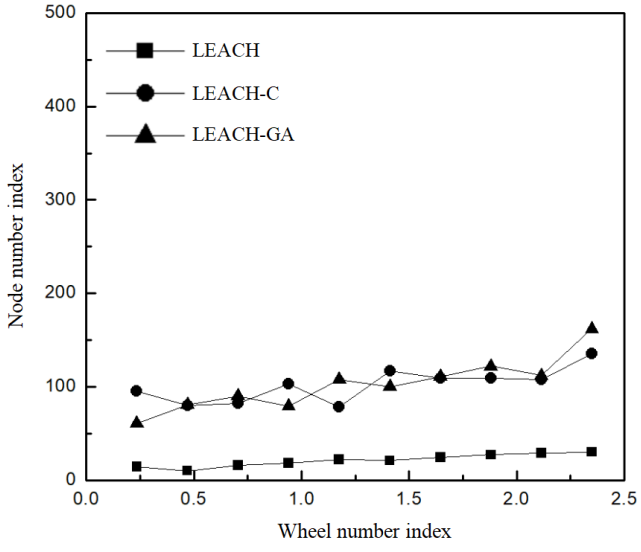


Table 3
Network Lifetime of Three Different Algorithms

	Wheel number	Number of nodes
LEACH	15	56
LEACH-C	18	55
LEACH-GA	23	53

As shown in Fig. 5 and Table 4, the remaining energy of the network after each round is three different algorithms of LEACH algorithm, LEACH-C algorithm and LEACH-GA algorithm.

Figure 5
Network Residual Energy Map of Three Different Algorithms

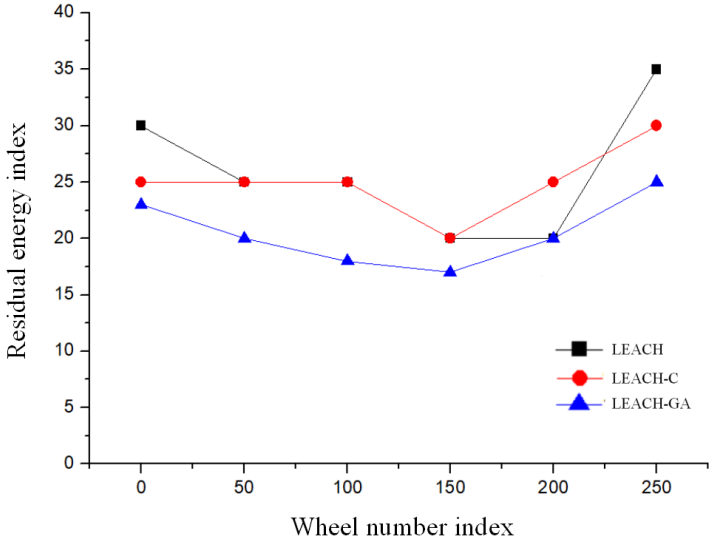
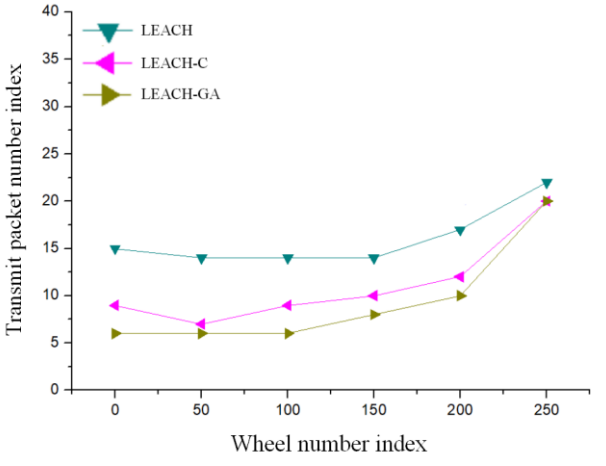


Table 4
Network Residual Energy Map of Three Different Algorithms

	Wheel number	Number of nodes
LEACH	58	75
LEACH-C	62	68
LEACH-GA	35	34

Figure 6 The comparison of the number of packets sent by the cluster head node to the sink node under different algorithms represented.

Figure 6
Packet Sending Amount of Three Algorithms



The traceability model based on RFID and EPC Internet of Things is based on the database cluster, integrating the monitoring database of each enterprise in the sporting goods supply chain. The raw material suppliers, manufacturers, processing/logistics distribution centers, wholesalers, specialty stores/retailers and other nodes in the sporting goods supply chain use RFID technology, using product identification systems and information acquisition systems. When the sporting goods are out of the warehouse, it is necessary to carry out packaging for the sports products that are delivered out of the warehouse, and produce the quality traceability code of the products, and establish the relationship between the sports goods manufacturing enterprises and the export quality and safety traceability codes. Ensure that the manufacturer and the information in the product distribution market are connected and the data is sent to the network server. The RFID technology award product identification code is written into the RFID chip, and is encrypted to form a unique identification of the electronic tag to identify authenticity. When quality and safety problems arise, the root cause can be traced quickly and accurately. Product information data collection, production information management, inventory information management, transportation information management, sales information management, problem product traceability management, product consumer query function. Sports goods quality and safety supervision departments and consumers input product coding information on the traceability system platform, and obtain product details through the platform's root ONS server. To achieve real-time and comprehensive management of sports products, can quickly and accurately locate the node of the product problems. Adopting EPC unique label as the product labeling system and technology can realize the traceability of sports products in the world, which is conducive to the promotion of China's sports goods export capability.

The following is the evolution equation of particle swarm optimization (PSO). Formulas (1) and (2) represent the particle velocity update formula and position update formula respectively.

$$F_{ik} = \sum_{j=1}^{m} q_j x_{ij} \tag{1}$$

$$f(t) = \sum_{j=1}^{N} \sum_{k \in Z} d_k^j \varphi_{jk}(t) + \sum_{k \in Z} c_k^N \varphi_{Nk}(t) \tag{2}$$

Particle swarm optimization with inertia weight factor E is shown in formula (3) and formula (4).

$$E_{mi} = \sum_{i=1}^{k} (i\Delta t) \cdot |S_{mi}|^2 \tag{3}$$

$$\vec{E} = \frac{E_{mi}}{\sqrt{\sum_{i=1}^{k} E_{mi}}} \tag{4}$$

Although the inertia weight factor W in monotone decreasing inertia weight strategy is also decreasing, it is different from the traditional linear decreasing inertia weight (LDIW) and nonlinear decreasing inertia weight (NDIW). It multiplied by a correction factor H in the original linear decreasing inertia weight. The expression of H is shown in formula 5.

$$H = [h_1, h_2, ..., h_k] = A^{1/2} E \tag{5}$$

The modified inertia weight factor U is shown in the formula (6).

$$U_{ij} = \frac{H_{ij}}{\sqrt{\sum_{t=1}^{k} H_{it}^2}}, i = 1, ..., n, j = 1, ..., k \tag{6}$$

According to the relationship between the bandwidth of cluster head nodes and the number of nodes in the cluster, this paper defines the bandwidth factor of cluster head as the minimum of the average bandwidth allocation of cluster head in dx clusters, as shown in formula (7).

$$\frac{dx_1^{(1)}}{dt} + ax_1^{(1)} = \sum_{i=1}^{N} b_i x_i^{(1)} \tag{7}$$

The cluster head energy factor is defined as the minimum value of the average distribution of the cluster head energy in a cluster, as shown in equation (8), where B is the energy of the cluster head T and Y is the number of nodes in the cluster.

$$\hat{a} = (B^T B)^{-1} B^T Y_N \tag{8}$$

The rate of packet generation is adjusted to the situation in the table. The recall and precision of the three algorithms are shown in Table 5, Table

6, Figure 7, and Figure 8. The average latency of the service request and the average response time. The extensions are shown in Table 7, Table 8, Figure 9, and Figure 10, respectively.

Table 5
Comparison of Average Recall Ratios Under Different Packet Generation Rates

Average recall (%)	Packet generation interval (s)
35	562
24	472
45	562

Table 6
Comparison of Average Precision Ratios Under Different Packet Generation Rates

Average precision (%)	Packet generation interval (s)
51	321
24	624
36	521

Table 7
Comparison of Service Request Delays In Different Packet Generation Rates

Service request average latency (s)	Packet generation interval (s)
259	517
568	657
759	387

Table 8
Comparison of Service Response Delays in Different Packet Generation Rates

Service response average delay (s)	Packet generation interval (s)
512	452
351	354
624	325

Figure 7
Comparison of Average Recall Ratios Under Different Packet Generation Rates

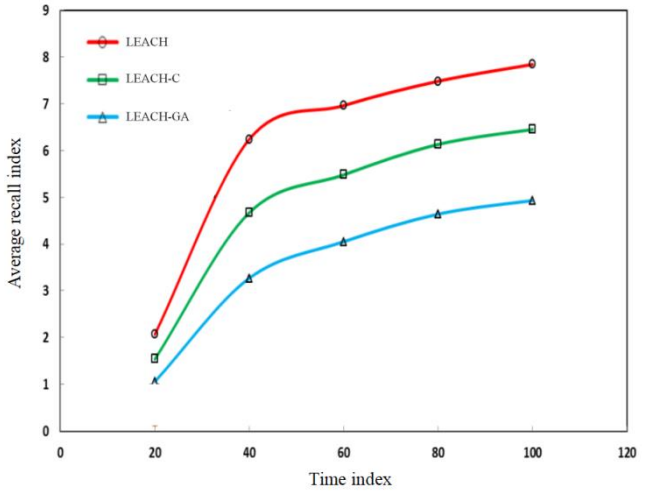


Figure 8
Comparison of Average Precision Ratios Under Different Packet Generation Rates

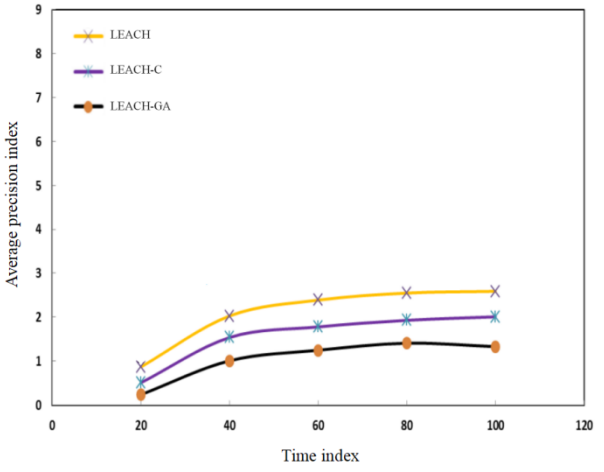


Figure 9
Comparison of Service Request Delays in Different Packet Generation Rates

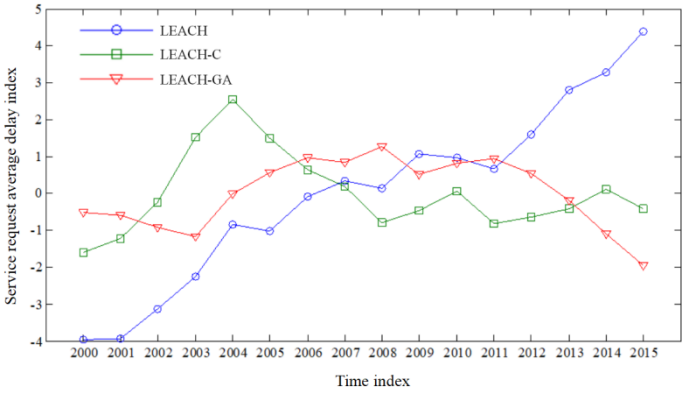
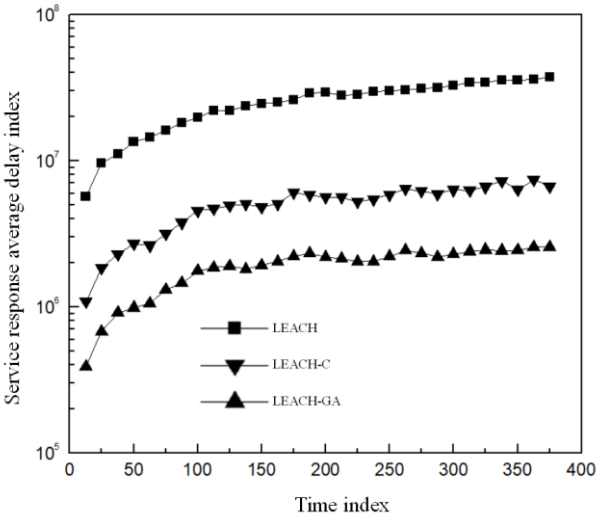


Figure 10
Comparison of Service Response Delays in Different Packet Generation Rates



As shown in the formula (9), where x is the distance from the ordinary node k to the cluster head N of the cluster in which it is located, and b is the number of ordinary nodes in the cluster.

$$x_1^{(0)}(k)+az_1^{(1)}(k)=\sum_{i=2}^{N}b_i x_i^{(1)}(k\in K,K=1,2,\Lambda\ ,n,\Lambda\ ) \quad (9)$$

The definition of the distribution factor between clusters is as shown in equation (10).

$$E_{Rx}(l)=E_{Rx-elec}(l)=lE_{elec} \quad (10)$$

The cluster selection algorithm for gateway selection optimization proposed in this paper takes the above four optimal cluster head influence factors as the independent variables of the objective function. The definition of the objective function is as shown in formula (11).

$$W=\alpha(\beta(\frac{E^2_{i-current}}{E^2_{i-init}})+(1-\beta)\frac{d_i}{d_{\max}})) \quad (11)$$

The load of the cluster head d in the IoT perception layer at max time is expressed by the following formula:

$$d_{\max}=\max\{d_i\},i=1..n \quad (12)$$

Where i is the average coefficient, n is the measurement time; di is the largest data queue length in the cluster head i in the Internet of Things sensing layer.

The sporting goods traceability system designed in this paper is based on the safe production and sales of sporting goods, and is based on Internet of Things technologies such as sensing technology, intelligent processing technology and network communication technology. Establish a reasonable sporting goods traceability system through the production and distribution of sporting goods. This layer is located at the bottom of the system and is the basis of the system operation. It consists of RFID tags, antennas, readers, sensor devices, etc. It is mainly responsible for collecting information related to sports goods, so as to provide the original data source for the system. At the same time, it can also write data information in every link of the supply chain to the RFID tag. Sports product data collection. The premise of information management is to use widely accepted standards for information identification, while taking into account the global flow of sporting goods information, we must adopt a univer sal global standard system for management. Product manufacturing is the upstream link of sports supplies supply chain, responsible for the collection of raw materials, processing, packaging and other work. Through wireless sensor to achieve the collection of sports product data indicators, attribute information, analysis of product production and processing process according to standards. The sporting goods manufacturer transports the products to the warehouse, and lets the warehouse manager register, edit and inquire the information such as the production area, the certificate number, the quantity in warehouse and the testing date. It is mainly used for registration, processing and management of product information on the same day.

The content of data service layer is EPC middleware, EPC IS and ONS server. EPC middleware is mainly responsible for data exchange between hardware layer and data layer. The product code read by the RFID system is filtered to simplify the system burden, and then the processed data is stored in the database and transmitted to the OND server. RFID tags are used to collect data of sports products, and radio frequency signals are used to identify sports products to be scanned, and then the data and information stored on the target object are automatically read. RFID tags do not need manual direct operation, and the data reading distance is large, can operate in a variety of high temperature and high pressure environment, as well as waterproof, anti-magnetic and other functions, generally longer service life. In order to prevent non-compliant products or damaged products from entering the market, athletes and ordinary consumers are prevented from causing safety accidents due to equipment quality problems. In order to ensure the quality of its products, sports enterprises must set up corresponding quality inspection departments, responsible for the whole process of product quality supervision and product sampling

inspection, mainly to check whether the product quality is up to standard. The users of the system include system administrators, enterprise producers, retailers, operators, consumers, etc., after the above users log in to the network management platform. Click the mouse to count the traceability of the product in the sporting goods traceability module. Enter the barcode number of the relevant product under the trace code input box. Click on the query operation, the system automatically displays the relevant information about the production and circulation of the product based on the traceable barcode.

DISCUSSION

Sports products are an important supporting force to promote the rapid and healthy development of the sports industry. The frequent occurrence of quality and safety issues has exposed serious problems in the supply chain traceability mechanism. The application of Internet of Things technology in the field of sports goods supply chain will have a huge impact and positive impact on the development of the sports industry. In short, according to the Internet of Things technology design sporting goods traceability system, all kinds of sports goods production, circulation, sales enterprises of various information can be timely inquired and recorded. At the same time, the relevant government departments can also use the goods traceability system to trace and recall the responsibility of problematic products, which has a positive impact on the development and growth of the sports industry. In this paper, RFID tag as the information carrier, and the use of EPC coding system to effectively identify sports products, to achieve the Internet of Things framework of sports goods traceability system. It provides an effective path for tracing the root of the quality and safety problems of sports products, improves the accuracy and rapidity of tracing, and provides a certain reference for future related research. In addition, product data synchronization service, system interface, logistics model and other application support content, need to be improved in the later design.

Human Subjects Approval Statement

This paper did not include human subjects.

Conflict of Interest Disclosure Statement

None declared.

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