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Research Article

International Trade Transportation Cost Based on Internet of Things-Assisted Wireless Network Virtualization

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With the development of information technology and the advent of the Internet of Everything era, more and more fields have begun to use the convenience of the Internet of Things to solve problems. International trade is a form of trade that develops rapidly under the world trade situation, and the optimization of transportation costs has always been an important issue to be solved in international trade. Wireless network virtualization (WNV for short) is an abstraction of the concept of wireless network connectivity. It allows remote users to access an organization's internal network as if it was a physical connection. WNV has the characteristics of safety assurance, service quality assurance, scalability, flexibility, and manageability, and it has many advantages in the transportation industry. This paper is aimed at studying an IoT-assisted WNV technology to analyze the cost of international trade transportation. This paper proposes a resource optimization algorithm based on WNV and uses this algorithm to test the designed IoT-assisted WNV model. The test results show that using the WNV model can reduce the cost of transportation price by 3.13 yuan per ton per month on average, and the improved transportation efficiency is an average increase of 0.152 tons per kilometer per hour. The total transportation cost obtained by the WNV algorithm model in this paper is significantly reduced, and the transportation cost calculation effect using this model is better.

1. Introduction

With the opening of the world trade pattern, international trade has become an important way to promote the economic development of various countries. Among them, the cost of transportation has always been an important cost in trade. How to optimize the transportation route and reduce the transportation cost is the most important problem to be solved.

The Internet of Things (IOT for short) is a huge network formed by the combination of various information detection equipment and the Internet [1, 2]. The goal is to realize the interconnection of people, machines, and things anytime, anywhere. With the continuous advancement of artificial intelligence technology and communication technology, the development of the Internet of Things has entered a new stage [3]. Hundreds of millions of IoT terminals are installed. These IoT devices are deployed in production environments and generate massive amounts of data, collectively referred to as IoT big data. This data is sent to servers for real-time streaming and offline batch processing to aid in analysis and decision-making across industry data.

Simply put, WNV can be regarded as a network resource sharing technology. However, according to different scenarios, WNV can also include resource abstraction, resource partitioning, resource aggregation, centralized resource control, data, and control plane. To fully understand the virtualization of wireless networks, you need to consider its various aspects.

Transportation costs can be divided into fixed facility costs, mobile equipment ownership costs, and mobile equipment operating costs. Using the WNV technology assisted by the Internet of Things to analyze the cost of international trade transportation will make it more convenient and efficient to make decisions, thereby effectively reducing transportation costs.

The innovation of this paper is to propose an algorithm that optimizes resource allocation to reduce transportation costs. It designs an IoT-assisted WNV model and uses the algorithm to test the model. The test results are compared with the traditional transportation cost algorithm, and the advantages of the algorithm model are obtained.

2. Related Work

Regarding the transportation cost of WNV in international trade, many scholars have conducted in-depth research on it. The benefit-cost analysis of intelligent transportation system (ITS) has produced point estimates of the benefit-cost ratio of ITS deployment. Sheng discusses the need to perform a risk analysis to account for uncertainty in ITS benefit and cost parameters. Sheng suggests that the analysis is based on an overall assessment of a combination of point estimates, confidence limits, and probability distributions of benefits, costs, and ratios of benefits to costs. Sheng proposed two methods for risk analysis using Monte Carlo simulation. The first allows the parameters required for the risk analysis process to be calculated in the ITS deployment analysis system (IDAS) sketch planning tool. No method for this calculation has been proposed in the literature. The second approach is a generic risk analysis program that can be implemented in a sketch planning tool. This procedure was implemented in this study as part of an ITS screening assay. Sheng's results show that, for the case studies investigated, a risk analysis procedure based on changing the output variable (as in the case of IDAS) would result in a median (50th percentile) benefit-cost ratio close to that obtained by the procedure benefit-to-cost ratio. This is based on changing input variables. However, the resulting confidence limits may vary. The results also showed that the risk analysis yielded wide confidence intervals for the estimated benefit-cost ratios, reflecting the high degree of uncertainty in the values of ITS benefit and cost parameters reported in the National Benefit-Cost Study and database [4]. In Kayikci et al.'s research, the cost allocation model in multimodal transport is analyzed. In addition to this, three cost allocation models for the same freight volume are also analyzed and are the proportional distribution mechanism, the decomposition method, and the Shapley value, respectively. And the case of alliances consisting of two, three, and four maritime partners were compared [4]. Transportation cost estimates often rely on a fixed cost approach, treating costs as part of indirect costs, rather than a detailed estimate of the actual transportation operation. This is because operational-level data can be difficult to collect and analyze in practice. In this regard, the ubiquitous use of GPS devices in construction equipment could provide an automated means of monitoring the operation of transportation equipment. And a large amount of detailed spatiotemporal data can be generated daily from multiple devices in multiple construction projects, even in real-time. Ahn et al. propose a spatiotemporal data filtering and abstraction method for transportation cost estimation using fleet GPS data. The method extracts equipment activity from GPS data and thus predicts the required transportation needs for individual items. It uses geofencing and rule-based equipment operation analysis algorithms to extract key operational information from large-scale GPS data, such as the number of trailers and the required duration (i.e., transportation demand). The extracted transportation demand information, along with the associated item specifications, will then be used to train a support vector regression (SVR) model to predict the transportation demand in new projects and then use the associated demand to estimate the transportation unit cost of the equipment. To evaluate performance, it used a GPS dataset collected from 221 panelized residential projects over an 8-month period to train a predictive model and compared it to actual transportation costs estimated in practice. Ahn et al. found that estimation methods based on GPS data can provide more accurate transportation cost estimates for various panelized construction projects. And this method improves the understanding of large-scale spatiotemporal device data while improving the utilization of existing GPS data [5]. Underground freight transport (UFT) is a type of automated transport system in which vehicles transport goods through tunnels or pipelines beneath roads between intermodal terminals. UFT systems add to current cargo transportation capacity and alleviate problems associated with rapidly growing cargo transportation needs. While UFT has inherent benefits to reduce traffic congestion and improve the safety and security of freight, it also improves sustainability, but a detailed life cycle cost analysis is still needed to clearly demonstrate to planners and policymakers the economic viability of such a system. The main purpose of Zhang et al. is to conduct a comprehensive life-cycle benefit-cost analysis of a linear induction motor-based UFT system for five different scenarios. The approach consists of the following steps: (1) working with a stakeholder committee to develop UFT scenarios with different sizes (small, medium, and large) and routes (short and long); (2) determine life cycle cash flow; (3) calculate net present value, benefit-cost ratio, and internal rate of return; (4) conduct sensitivity analysis; and (5) conduct break-even analysis. The results of Zhang et al.'s study suggest that the biggest benefits of the UFT system are transportation revenue and air pollution reduction. The internal rate of return, benefit-to-cost ratio, and net present value of the UFT scheme show that the benefits offset the system costs. Sensitivity analysis results show that the economic viability of large- and medium-sized UFTs is more sensitive to tunnel construction costs and freight revenue. Zhang et al. also showed that the economic viability of UFT systems with short routes and small dimensions is more sensitive to higher discount rates and policies regarding freight prices. The results of the break-even analysis show that the payback period of large- and medium-sized UFT is shorter than that of the small-scale scheme. The results show that the transportation prices of all UFT schemes are highly competitive compared to the current trucking prices [6]. Rawat focuses on network-wide resource allocation for implementing WNV. Specifically, it starts with a review of motivations, supporting platforms, and the benefits of WNV. Then, Rawat discussed the resource allocation and technical challenges of WNV. Afterwards, Rawat proposes a resource allocation framework supporting software-defined networking (SDN) to facilitate WNV, including key processes and corresponding modeling methods. Furthermore, Rawat provides a case study as an example of resource allocation in WNV. Finally, Rawat discusses some topics that are critical to WNV [7]. Kist et al. offer a perspective on the fusion of three emerging technologies: SDN, EC, and blockchain technology for wireless network virtualization. SDN, with the help of controllers, can dynamically configure network resources for efficient management. EC not only helps to process user signals and queries on the corresponding base station with the shortest possible delay but also helps to avoid establishing a high-speed backhaul link between the base station and the centralized controller. Blockchain technology protects wireless infrastructure owners from double-spend attacks that allocate the same wireless resource (RF slice) to multiple virtual wireless networks. The proposed approach is aimed at reducing business friction and increasing trust and transparency in the wireless networking industry [8]. Zietlow et al. proposed fine-grained virtualization of baseband processing to enable more flexible distribution of processing workloads in a centralized architecture. Zietlow et al. also evaluates the benefits of the method in terms of bandwidth requirements for each fine-grained allocation option, including latency experienced by mobile users for each fine-grained allocation option, and usage of total CPU per fine-grained baseband processing function [9]. The research of the above scholars has achieved some results in WNV technology or in the analysis method of transportation cost. But its research does not actually apply WNV to the calculation of transportation cost, so the research content of this paper is of pioneering significance.

3. WNV's Transportation Cost Analysis Method

3.1. WNV Assisted by IoT

(1) IoT assistance

(1) The concept of the Internet of Things: Internet of Things (IOT), which is the "Internet of Everything." It is a huge network formed by the combination of various information detection equipment and the Internet. The goal is to realize the interconnection of people, machines, and things anytime, anywhere. With the continuous advancement of artificial intelligence technology and communication technology, the development of the Internet of Things has entered a new stage, and hundreds of millions of IoT terminals have been installed. These IoT devices are deployed in production environments and generate massive amounts of data, collectively referred to as IoT big data. These data are sent to the server for real-time stream processing and offline batch processing, which are used to assist and guide various industries for analysis and decision-making [10, 11]. Its specific concept can be shown in Figure 1

(2) During the origin and development of the Internet of Things, its development process can be shown in the timeline made in Figure 2. It has developed for more than 20 years from the initial conceptual significance in 1995 to the real Internet of Everything today. It greatly improves people's work efficiency and also greatly facilitates people's lives [12–14]

(3) In the application field of the Internet of Things, the current application fields of the Internet of Things are mainly concentrated in the following types: The first type is the application of data collection and dynamic monitoring of government customers. The application fields of this category include intelligent transportation, environmental protection, smart power, military management, city management, and public safety. The development of such fields is driven by government demand and relies on the government's strong financial support and policy guarantee. And this field is the first field that the Internet of Things penetrates, and its development level of the Internet of Things is in a leading position. And data collection and dynamic monitoring technology is relatively mature. Therefore, it will continue to develop rapidly in the future. However, due to the small scope of target customers in this field, competition will be fierce. Taking into account various factors, this field is the type of IoT segment that should be developed first in China. The second category is the data collection and monitoring of customers by companies and enterprises. Applications in this category include healthcare, precision, and agriculture. Users in this type of application field have certain financial strength and willingness to buy because high technology is the core competitiveness of enterprises. Its research on IoT solutions for resource enterprises has strongly promoted the development of high-end IoT applications. In addition, the target customers in this field have a wide range, and data acquisition and dynamic monitoring technologies have been widely used. So, it is easier to develop. The third category is location tracking. Application areas of this category include smart logistics and retail management. This type of field is the earliest field of IoT development, and a relatively complete business model and technical solutions have been formed. Its successful model is easy to replicate in many companies in the same field, and it can quickly obtain economic benefits. This type of field is also our focus area. The fourth category is the customer intelligence management of companies, and the application areas of this category include industrial supervision and intelligent buildings. This category covers a wide range of fields, such as industrial supervision, including intelligent energy oil, natural gas, coal, and other

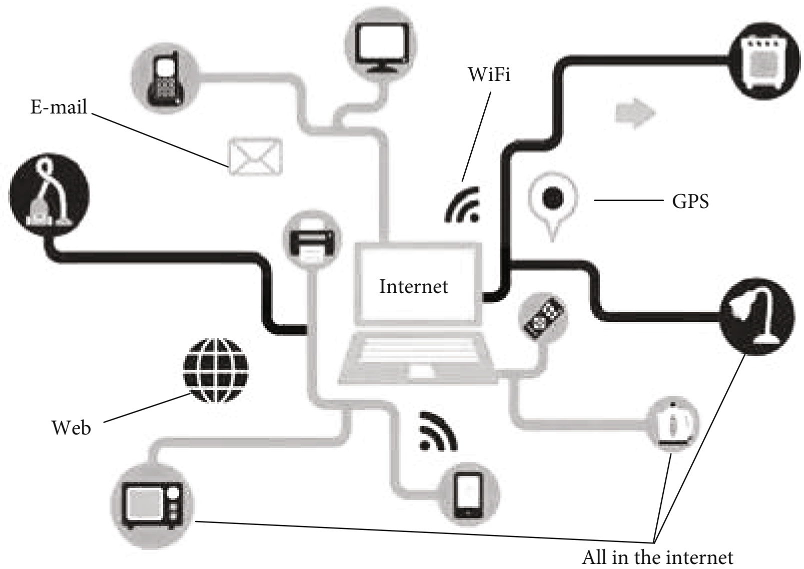


Figure 1: Schematic diagram of the Internet of Things

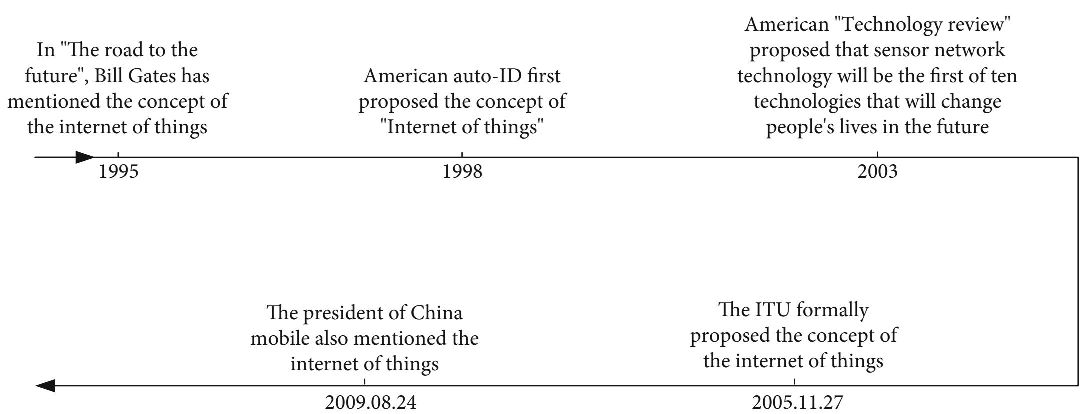
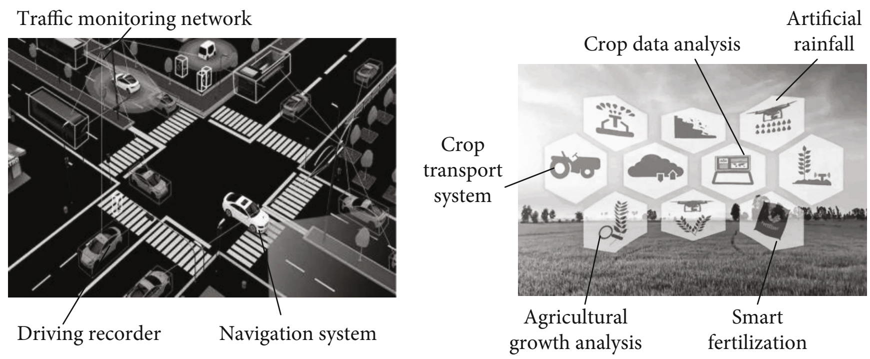


Figure 2: The origin and development of the Internet of Things

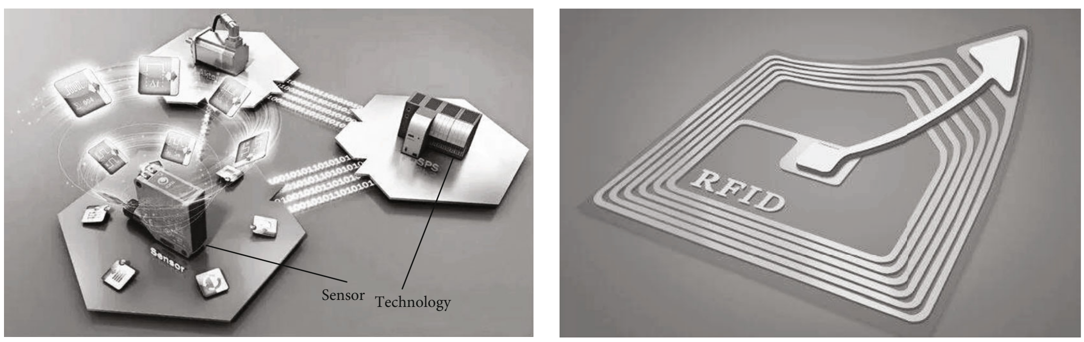
development, manufacturing production line control. The industry characteristics of these application areas are too obvious. IoT applications are not easy to directly replicate on a large scale and are highly specialized and difficult to develop. For example, oil and coal will use different development technologies, and the IoT technology solutions used should also be developed separately. Therefore, in the next period of time, there will be many difficulties in the development of the Internet of Things in this field. The fifth category is the intelligent control of personal life and other aspects. Applications in this category include the smart home. Applications in this field are closely related to people's lives and can directly bring convenience to our lives. Facing the needs of more than one billion people in China, its market potential is huge and it is a blue ocean. However, at present, the technical difficulty and high cost of intelligent control are limited, and people's willingness to pay and ability are limited. Therefore, how to reduce costs on the premise of meeting people's needs is the key problem to be solved in this field. Figure 3 shows the widely used IoT industry [15, 16].

(4) The core technologies of the Internet of Things mainly include sensing technology, radiofrequency identification technology, two-dimensional code technology, and GPS technology, as shown in Figure 4 [17]. Sensing technology is called the three pillars of information technology together with computer technology and communication. From the perspective of the Internet of Things, sensing technology is an important indicator to measure the degree of informatization of a country. As the 2nd Hangzhou Internet of Things and Sensing Technology Application Summit Forum, it will promote the rapid development of domestic sensor industrialization. Sensing

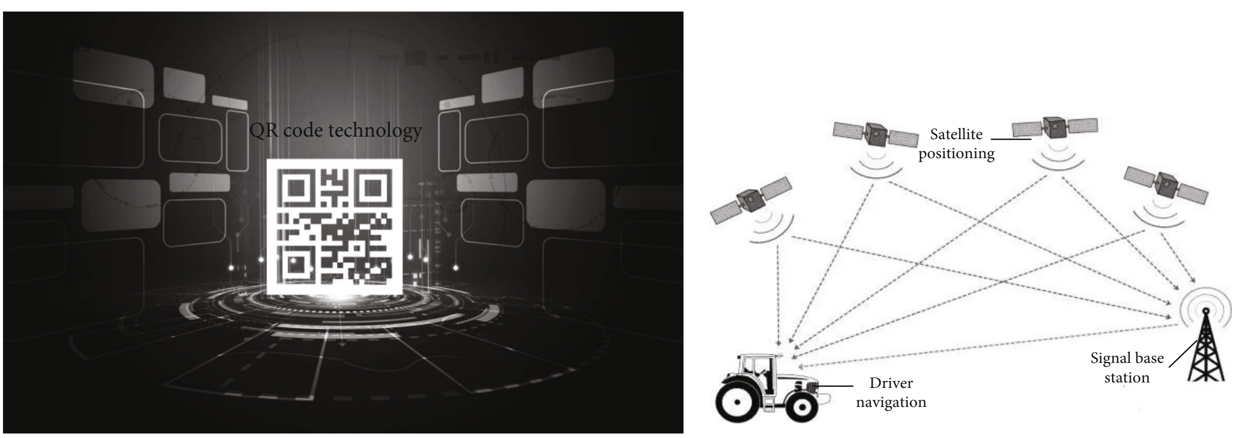


(a) Traffic IoT diagram (b) Agricultural IoT

Figure 3: IoT application areas.



(a) Sensing technology diagram (b) Radiofrequency identification technology



(c) Two-dimensional code technical diagram (d) GPS technology

Figure 4: IoT core technologies.

technology is a multidisciplinary modern science and engineering technology about obtaining information from natural sources, processing (transforming), and identifying them. It involves the planning and design, development, manufacture/construction, testing, application and evaluation improvement of sensors (also known as transducers), information processing, and identification. Radiofrequency identification (RFID) is a type of automatic identification technology. It conducts noncontact two-way data communication through radiofrequency and uses radiofrequency to read and write recording media

Table 1: Internet of Things literature publication status.

Article	Number	About transportation
Master's and doctoral dissertation	5430	56
Periodicals	77507	378
Foreign literature	41746	445
Domestic literature	50065	220
Full text	667112	51224

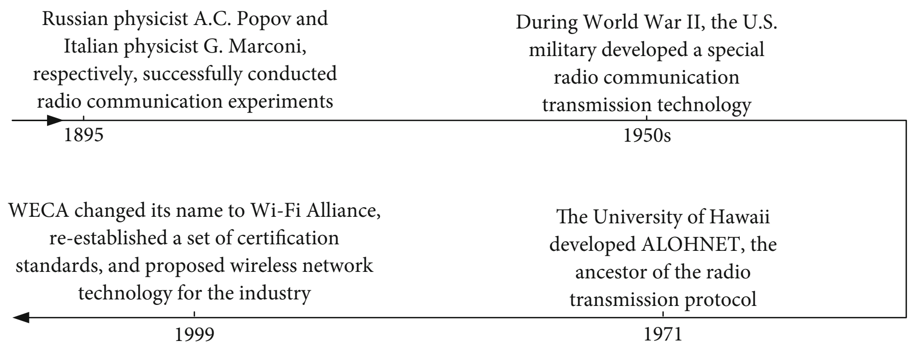


Figure 5: The origin and development of wireless networks

(electronic tags or radio frequency cards), so as to achieve the purpose of identifying targets and data exchange. It is considered to be one of the most promising information technologies in the 21st century. A two-dimensional barcode/two-dimensional code is a black and white graphic that records data symbol information and is distributed on a plane (two-dimensional direction) with a certain geometric figure according to a certain rule. The concept of "0" and "1" bit stream that constitutes the internal logic foundation of the computer is cleverly used in coding. It uses a number of geometric shapes corresponding to binary to represent text and numerical information and is automatically read by image input equipment or photoelectric scanning equipment to realize automatic information processing. The GPS system is a high-precision, all-weather, and global radio navigation, positioning and timing multi-functional system. GPS technology has developed into a multifield, multimode, multipurpose, and multimodel international high-tech industry. The GPS system consists of three parts: the space part, the ground measurement and control part, and the user equipment

(5) At present, for the development of the Internet of Things, this paper makes statistics on its related literature, as shown in Table 1

As can be seen in Table 1, 667,000 papers have been published on the Internet of Things, of which 51,000 are about transportation. Among them, there are more than 50,000 domestic papers. There are 77,000 journals and 5,430 master and doctoral theses. This fully shows that many scholars have carried out in-depth exploration on the Internet of Things, and the development trend of the Internet of Things is good [18, 19].

(2) Wireless network virtualization

(1) Simply put, network virtualization can be considered a network resource sharing technology. However, according to different scenarios, network virtualization may also include resource abstraction, resource division, resource aggregation, centralized control of resources, data plane, and control plane. To fully appreciate network virtualization, all aspects of it must be considered. Wireless network virtualization is network virtualization in the wireless network environment [20, 21]. Wireless network virtualization is considered a technology that enables sharing of physical wireless infrastructure and RF slices to improve not only the capacity and coverage of wireless networks but also wireless security [15]

(2) The source and development of wireless network can be shown in Figure 5. From the initial radio-communication to WiFi communication technology, over a hundred years have passed, and the development of this technology has greatly facilitated people's lives [22–24]

(3) At present, the applications of WNV mainly include VLAN and VPN, as shown in Figure 6

(4) Its architecture mainly includes wireless spectrum resources, wireless network infrastructure, wireless virtual resources ,and wireless virtual controllers, as shown in Table 2

(5) Its main requirements are as follows: First, isolation, isolation ensures any changes in a virtual network. For example, changes in the number of end users, mobility of end users, and channel conditions will not affect the resource allocation of other virtual networks. The second is customization. The MNO should be able to implement different customized scheduling policies in the virtual network. The goal of MNOs is to maximize their revenue while satisfying user needs. In addition, different MNOs may have different services, QoS requirements, and pricing models. Radio resources are allocated to users based on scheduling policies, and each MNO should be able to flexibly implement its customized scheduling policies to achieve its own goals. The third is the effective utilization of resources. In the case of limited resources, the high utilization rate of resources is improved, the system capacity is increased, and the income of the MNO

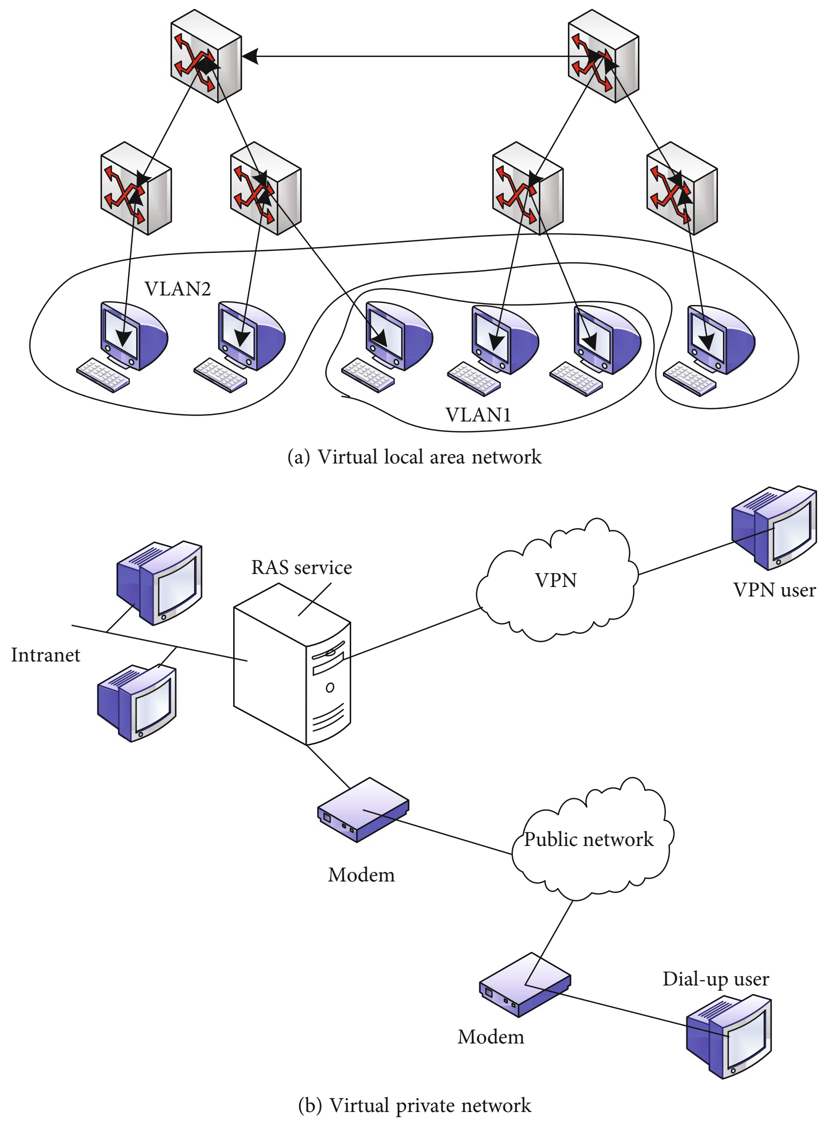


Figure 6: Network virtualization.

Table 2: Architecture of wireless network virtualization.

Main part	Function
Wireless virtual controller	Customization, manageability, and programmability for virtual slices
Wireless virtual resource	Virtual resources obtained by slicing wireless network infrastructure and spectrum into multiple virtual slices
Wireless network infrastructure	Wireless network infrastructure refers to the entire wireless physical underlying network, which is the basis for establishing a wireless network
Wireless spectrum resources	Wireless spectrum resource is one of the most important resources in wireless communication.

is increased, but at the same time, the complexity of the system may be increased [25, 26]

3.2. International Trade and Transportation. Generally speaking, the development of international trade theory has roughly gone through four stages: classical trade theory, neoclassical trade field theory, new trade theory, and new classical trade theory. International trade can be further divided into import and export trade and overseas trade, and their meanings and differences are shown in Figure 7.

At present, the means of transportation for different goods will also be different. The main means of transportation can be divided into sea, land, and air. As shown in Figure 8, shipping refers to the transportation of transport ships, and there are certain differences in the types of

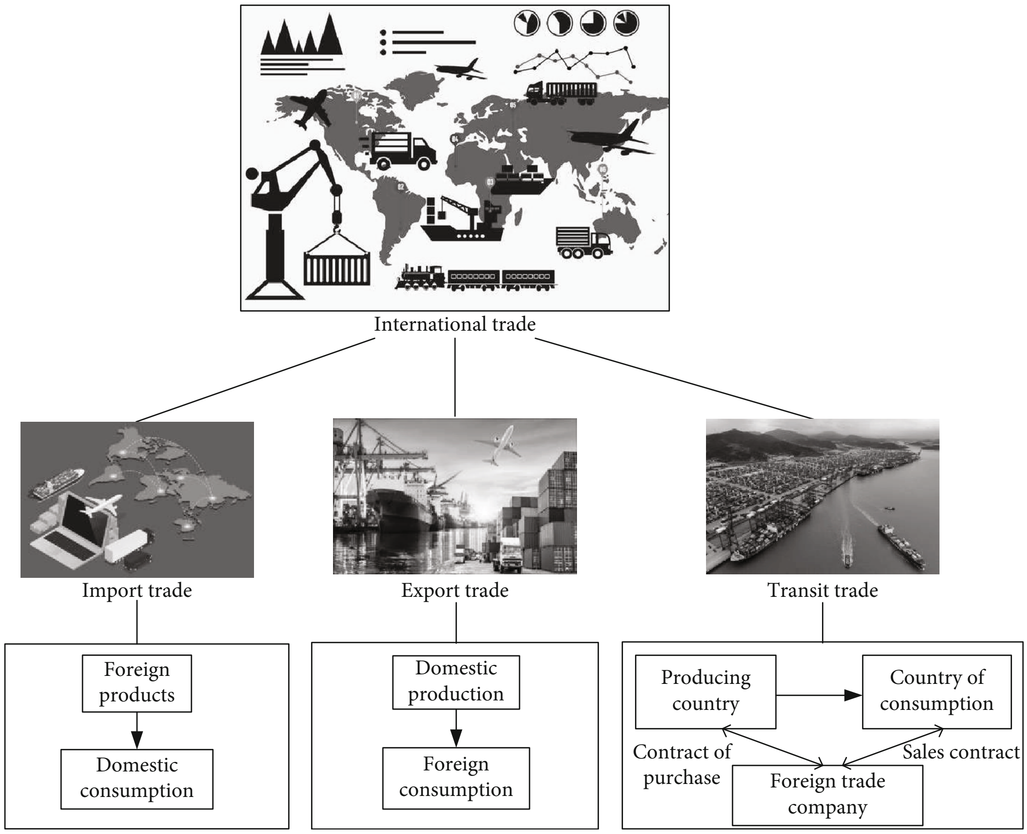


FIGURE 7: International trade.

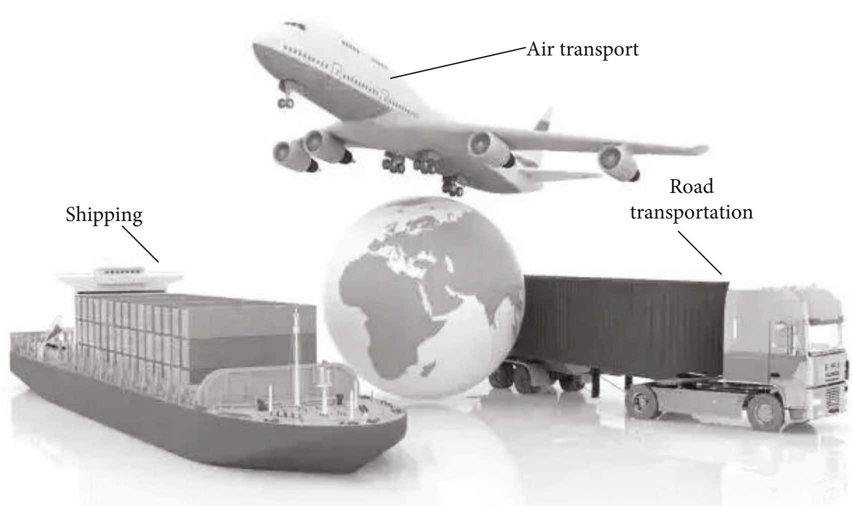


FIGURE 8: Types of transportation.

transport ships for different goods. For example, oil tankers are used for the transportation of oil; chemical tankers are used for the transportation of different chemicals; ro-ro ships are used for the transportation of vehicles; bulk carriers are generally used for bulk cargo. Land transportation refers to road transportation of trucks. For special goods, there will be some differences in the vehicles used for transportation. For example, for meat products, a refrigerated truck is required; for concrete, a mixer truck is required; for mud and construction waste, coal, ores, etc., a sand truck is required. Air transportation refers to the use of aircraft for air transportation [27, 28].

Commodity type has a significant impact on shipping costs. Commodities with different time-sensitivities have different requirements for transportation mode and transportation speed, which has an important impact on transportation cost. Commodities can be divided into three categories: time-sensitive, relatively-sensitive, and generalsensitive. For time-sensitive commodities, due to their own characteristics, there are higher requirements for transportation conditions and transportation speed. If you do not pay a higher cost of space distance for such commodities, you will have to bear the greater cost of self-impairment; for more sensitive commodities such as manufactured products, it is required that their energy sources be continuously and rapidly transported to the destination, and the requirements for transport time and speed are relatively high; for generally sensitive commodities such as inputs, as an important source of raw materials for production, they need to be transported in large quantities.

When small countries conduct international trade, they should choose the mode of transportation according to the type of commodities involved in the trade. The choice of transportation mode directly determines the transportation speed, transportation time, and transportation volume and thus determines the cost for a complete transportation. Of course, the transportation of international trade is often borne by multiple modes of transportation. The choice of each method should follow the commodity's degree of time sensitivity and speed requirements. It is necessary to choose the means of transportation and the mode of transportation that are suitable for the commodity and make a reasonable match for the transportation speed and time. On the whole, it needs to weigh the cost of space distance and the cost of time distance and try to reduce the transportation cost in the selection of transportation methods to ensure smooth and efficient transportation.

Higher transportation costs will reduce the size of a country's trade and reduce export profits. If profits are made by raising the export prices of these commodities, it will inevitably increase the prices of these commodities in foreign markets, break the original demand elasticity of foreign markets for export commodities, and change the original consumption tendency of foreign consumers. They switch to consuming other commodities for substitution, which will greatly reduce the demand for these commodities in foreign markets, further worsening the trade situation. If the transportation cost of the traded goods accounts for a large proportion of its price, should we consider actively expanding domestic demand, digesting these commodities through domestic demand, and reducing the impact of the transportation cost brought by exports on welfare?

Therefore, whether to continuously expand trade or expand domestic demand in a timely manner should be considered rationally and comprehensively. But in the long run, getting rid of the dependence on trade as much as possible and increasing domestic demand is the direction of a country's economic development. Especially for a country with a large population and a vast territory, it itself has a large number of consumer populations and markets to digest commodities. Therefore, there is also a huge potential demand, and effectively and actively exploring domestic demand can promote economic development far more than relying on exports. At the same time, it can also greatly reduce the deficiencies in economic development. Regardless of the perspective of the transportation cost in international trade, or the research on transportation costs with different tools and methods, it is ultimately about how to reduce transportation costs and minimize the impact of transportation costs on international trade. This is fundamental.

3.3. Resource Optimization Algorithm Based on WNV. During the transmission process of the wireless network signal, it will weaken with the distance from the base station, and the degree of its weakening can be shown in Figure 9. Basically it is presented as a logarithmic function.

Under the circumstance of being blocked by large buildings or other objects, the receiving area of radio wave propagation will generate a half-blind area, and the signal strength will fluctuate slowly around the mean fluctuation. The spatial variation of the signal strength can be expressed as

$$R(\Delta r) = e^{-\ln 2|\Delta r|/d_{\text{link}}} = 2^{-|\Delta r|/d_{\text{link}}}, \tag{1}$$

where Δr is the distance displacement difference and d_{link} is the reference association distance.

If the variance of the variable G is the same as ρ, then the reduction of the ith signal is

$$L_{SH}^{i} = \sqrt{\rho}G_0 + \sqrt{1-\rho}G_i. \tag{2}$$

In two dimensions, it is

$$L_{SH}^{i} = \sqrt{\rho}G_0(x, y) + \sqrt{1-\rho}G_i(x, y). \tag{3}$$

When the regional frequencies are different, there is no interference between the regions; then, the signal-to-noise ratio of the nth permeable wall in the c region is

$$\text{SINR}_{k,c,i}^{n} = \frac{P\sigma_{k,c,i}^{n}}{\sum_{l \neq c}\sum_{n=1}^{N_i} P\sigma_{k,c,i}^{n} + N_0}. \tag{4}$$

In the equation, k represents the kth user. N_0 represents the noise power.

The area load is represented by ρ, then

$$\rho = \frac{N_{\text{GE\_PRBs}}}{N_{\text{PRBs}}}. \tag{5}$$

Among them, N_{PRBs} represents the total number of permeable walls in the community, and $N_{\text{GE\_PRBs}}$ represents the occupied walls.

For region C, its signal-to-noise ratio is

$$\text{SINR}_c(u_k) = \frac{P_C H_x x^{-\alpha}}{I_c + N_0}. \tag{6}$$

Among them, u_k is the user, P is the transmit power, x is the distance from the user to the signal station, H is the signal increment, and α is the signal loss value.

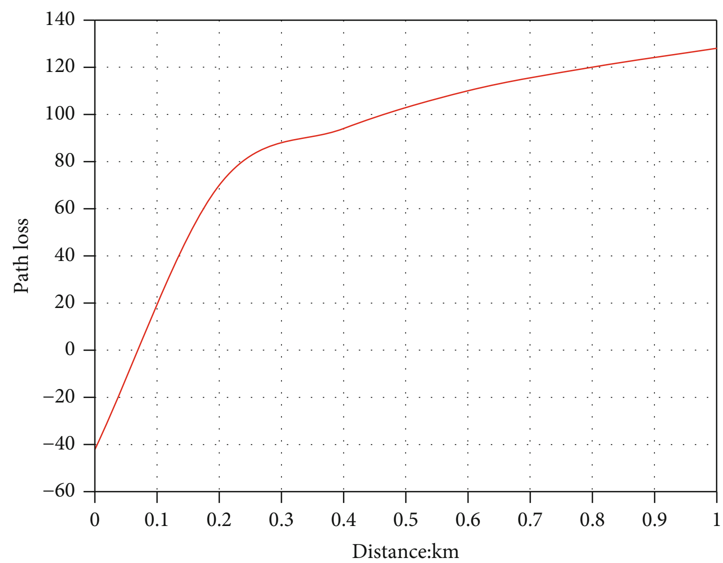


Figure 9: Distance vs. path loss.

If there is interference in the area, the interference value is

$$I_C = \sum_{C' \neq C} P_{C'} H_y y^{-\alpha}, \tag{7}$$

where y represents the distance from the user to the area.

In order to prevent the signal-to-noise ratio from being greatly reduced due to wireless network virtualization, a virtual switch entry $\mathrm{SINR}_{\mathrm{thres}}$ is set, which is

$$\mathrm{SINR}_c(u_k) - \mathrm{SINR}_{c'}(\mathrm{u_k}) > \mathrm{SINR}_{\mathrm{thres}} \tag{8}$$

The trigger setting value is θ; then, the trigger condition is

$$N_v > \theta, \tag{9}$$

where represents the number of users.

User satisfaction is represented by a utility function.

$$U^S(r) = \begin{cases} \beta_1 e^{p_1 \left(r - r^d\right)}, 0 \leq r < r^d, \\ 1 - \beta_1 e^{p_1 \left(r - r^d\right)}, r \geq r^d. \end{cases} \tag{10}$$

Among them, β_1, p_1 are the adjustment coefficients of the function and r represents the rate. In order to balance the signal conditions of each user, the utility function for the specific demand of the object is

$$U^B(r) = 1 - (1 - \beta_2) e^{p_2 \times r}, \tag{11}$$

where β_2, p_2 are the adjustment factor of the function.

The average signal-to-noise ratio is

$$\mathrm{SIN\bar{R}}_{k,c,i} = \frac{\sum_{n=1}^{N_i} \mathrm{SINR}_{k,c,i}^n}{N_i}. \tag{12}$$

Before virtualization, the penetration wall is measured and optimized. The goal is shown in

$$\max_{\alpha} \sum_{k=1}^{K_{c,i}} U_{k,c,i} \left(\sum_{n=1}^{N_i} \alpha_{k,c,i}^n r_{k,c,i}^n \right). \tag{13}$$

Among them, $\alpha_{k,c,i}^n$ is the parameter that the nth permeable wall divides the i signal to the c area for the k user and has

$$\sum_{k=1}^{K_{c,i}} \alpha_{k,c,i}^n \leq 1. \tag{14}$$

Then, the user's rate is

$$r'_{k,c,i} = r_{k,c,i} + B \log \left(1 + \mathrm{SINR}_{k,c,i}^r\right). \tag{15}$$

The final optimization objective is

$$\max_{\alpha} \sum_{i=1}^{M} \sum_{k=1}^{K_{c,i}} U_{k,c,i} \left(\sum_{i=1}^{M} \sum_{n=1}^{N_i} \alpha_{k,c,i}^n r_{k,c,i}^n \right). \tag{16}$$

In

$$\sum_{i=1}^{M} \sum_{k=1}^{K_{c,i}} \alpha_{k,c,i}^n \leq 1, \tag{17}$$

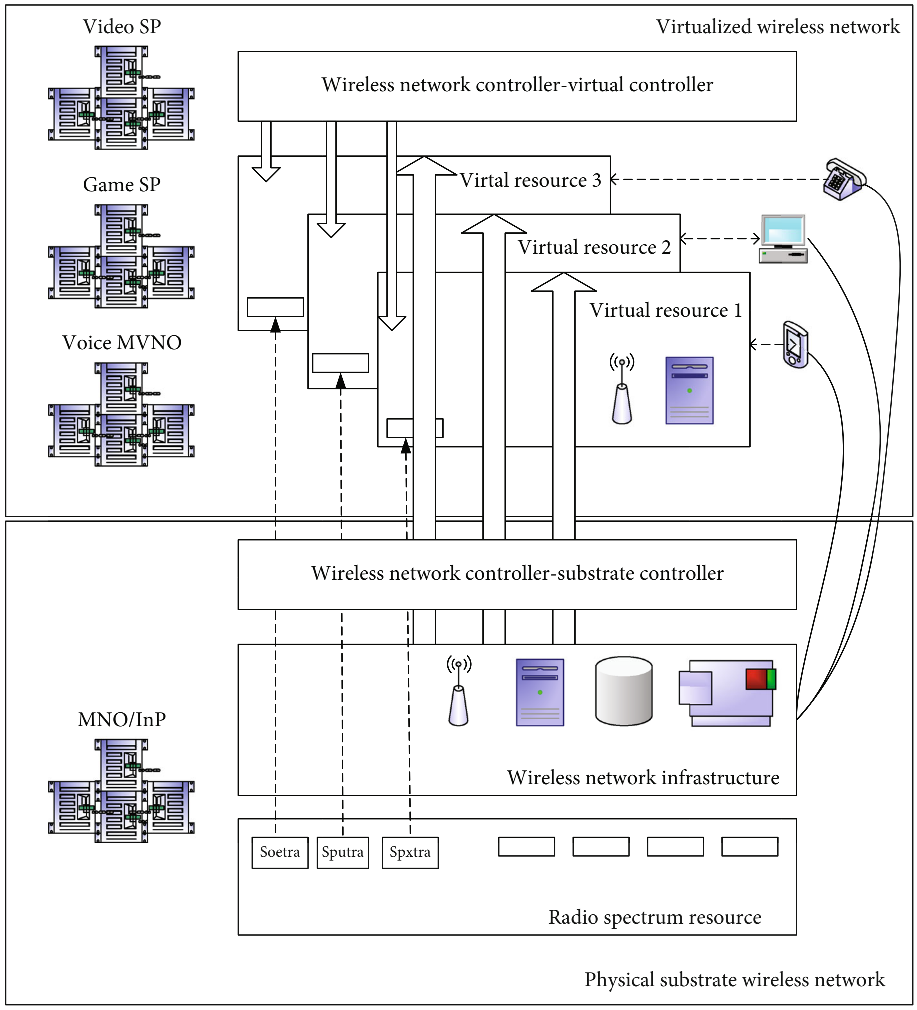


Figure 10: IoT-assisted WNV model architecture.

$$U_{k,c,i}\left(r_{k,c,i}^{n}\right) \geq U_{k,c,i}^{wv} r_{k,c,i}^{n}. \tag{18}$$

In the equation, $U_{k,c,i}^{wv}$ is the signal utility when no virtualization is performed.

Then, if the utility of wireless network virtualization is represented by U_i^{gain}, then

$$U_i^{\text{gain}} = \beta_i \sum_{i=1}^{M} U_i^{\text{gain}}. \tag{19}$$

In

$$\beta_i = \frac{N_i}{\sum_{i=1}^{M} N_{c,i}}. \tag{20}$$

4. WNV's Transportation Cost Model Test

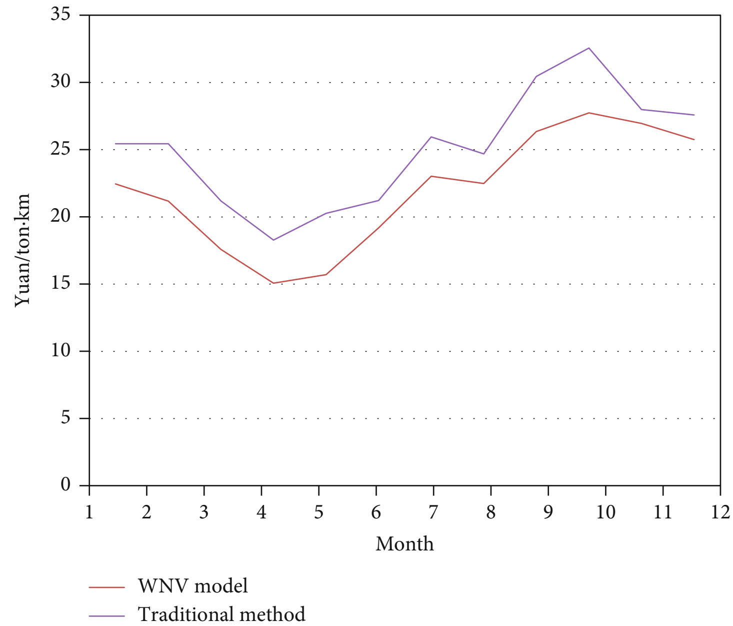
4.1. Design of WNV Model. The WNV model designed in this paper is divided into physical substrate wireless network and virtual wireless network. The physical substrate wireless network mainly includes MNO/InP modules, and the virtual wireless network mainly includes video, audio, and entertainment modules, as shown in Figure 10.

Table 3: Test environment parameter values for the WNV model.

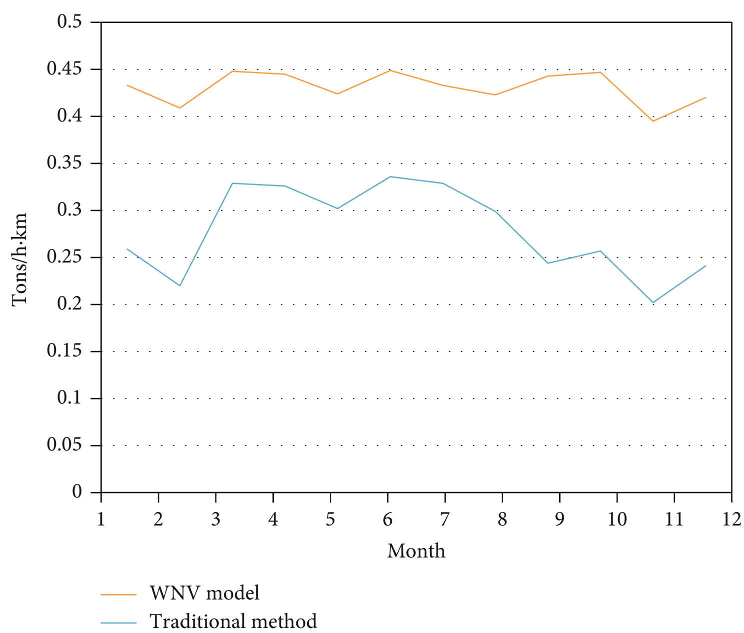
Parameter	Value
Wireless network environment	WiFi
Frequency	2.4 GHZ
Testing computer system	Intel Core i9,64OS
Testing power	65 W

4.2. Model Testing. The WNV model is tested using the previous algorithm, and the test environment is shown in Table 3.

In this paper, the same goods of a company are divided into two batches with the same quantity and price, and different transportation methods are used for calculation and analysis, and the cost is compared with the cost obtained by the traditional calculation method. We obtain multiple data samples within a year and make statistics on the transportation price cost and time cost.



(a) . Company transportation price cost



(b) . Company transportation time cost

FIGURE 11: Transportation cost statistics.

4.3. Data Results. The final statistical results obtained in this paper are shown in Figure 11.

As can be seen in Figure 11, in this year, the company's transportation price per ton per kilometer, the cost calculated by using the WNV model is lower than the traditional computing cost, and the company's transportation speed per hour per kilometer is higher than the traditional cost. The transportation speed is faster, that is, the time cost will be lower, and the final difference is shown in Table 4.

It can be seen from Table 4 that in this year, the transportation price cost reduced by using the WNV model reached an average of 3.13 yuan per ton per month, and

TABLE 4: Transportation cost difference between the WNV model and traditional algorithm.

Quarter	Shipping cost price difference	Shipping cost time difference
The first quarter	10.86	0.482
The second quarter	9.79	0.354
The third quarter	9.23	0.427
The fourth quarter	7.69	0.562
Total	37.57	1.825
Average	3.13	0.152

the improved transportation efficiency was an average increase of 0.152 tons per kilometer per hour, that is, time costs are also reduced.

5. Discussion

Due to my limited knowledge and ability, the Internet of Things is in the early stage of development, and a lot of information is not complete. The objective reasons are that when the paper is completed, it is found that the paper has the following deficiencies.

The application development research of the Internet of Things summarizes the application field of the Internet of Things: With the gradual penetration of the Internet of Things into various fields, the summary results may not be comprehensive in the future. The scope of the Internet of Things application field needs continuous updating.

For the forecast of the Internet of Things market in this article, since the development of the Internet of Things in China has just started, there is no detailed statistical data on the market size of the previous years. Therefore, this paper collects the market scale data as the core technology of the Internet of Things and makes a gray forecast, hoping to reflect the market size of the domestic Internet of Things from the side [29, 30].

The domestic Internet of Things development strategy suggestion put forward at the end of this study is based on the theoretical research results of the whole paper. Whether the suggestion can really promote the development of the domestic Internet of Things industry remains to be verified by future practice.

6. Conclusions

This paper firstly summarizes the research purpose and content of this paper in the abstract section. The background meaning of this article and some key contents are introduced in the introduction section. Secondly, some scholars' research results on the main content of this paper are listed in the related work part, so as to understand the common methods and current situation of transportation cost analysis.

In the theoretical research part, this paper firstly introduces the content of the Internet of Things, including its concept, origin and development, core technology, status quo, and application. Secondly, it introduces WNV, including its concept, source and development, application field, architecture, and main requirements. Then, it introduces the concept and characteristics of international trade and transportation. Finally, the resource optimization algorithm based on WNV is explained.

This paper firstly introduces the overall architecture of the WNV model in the experimental test. Secondly, test according to the environment is set by the test and finally illustrates the test results with the chart. The final results show that, based on the WNV algorithm model assisted by the Internet of Things, the transportation price cost and time cost have decreased.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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