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An effective way to push shipping E-commerce - maritime consolidation

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AN EFFECTIVE WAY TO PUSH SHIPPING E-COMMERCE ---- MARITIME CONSOLIDATION

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Foreword

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Abstract

Shipping E-commerce has become a heated topic of debate recently, accompanied by the release of Alibaba & Maersk's ''Cang Wei Bao''. However, it is still far from being a successful platform as commented by experts. One big problem of Shipping Ecommerce is the volume of transaction. So in the dissertation, the potential development of shipping e-commerce was studied. LCL business is a good way of development. It will expose the platforms to more individual or small customers other than big customers who reserve several container slots at a time. Accordingly, the business volume will begin to sour.

This thesis analyzed the background of LCL operation and reviewed the cost structure of LCL operation. Through the study, it was found that the costs of collection and transportation of LCL cargo might be a variable cost for the platform, which means it can be optimized.

Thus, the concept of Vehicle Routing Problem was introduced and a model was constructed to minimize the transportation cost. The model aimed at minimizing not only the transportation cost, but also the total delay time. In such way, the platform can provide services of good quality to the customer whiling maintaining at a lower cost.

After the model is constructed, a programming methodology was introduced to realize the function. In order to satisfy the core characteristic of Shipping Ecommerce, the transparency of business, the concept of 3D visualization was explained, which was able to show the detailed packing information for each batch of goods to the customers. After that, the thesis talked about the principle of various mathematical transformation and how it can be applied to realize this function.

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List of Abbreviations

LCL	Less than Container Load
FCL	Full Container Load
AHP	Analytic Hierarchy Process
SQL	Structured Query Language
ICT	Information Communications Technology
EP-HGA	Extended Priority Hybrid Genetic Algorithm
CBM	Cubic Meter
CY	Container Yard
CFS	Container Freight Station
VRP	Vehicle Routing Problem
VRPTW	Vehicle Routing Problem with Time Window
VB6.0	Microsoft Visual Basic 6.0

1. Introduction

Shipping Ecommerce was first introduced in 2001 when Maersk Line leaded the development of the famous platform INTTRA with a few other top shipping corporations. However, the concept of Shipping Ecommerce was not generally accepted in China until SinotransBooking, a Shipping Ecommerce platform owned by Sinotrans, was established in 2013. As Xu (2015) commented, it was due primarily to the even-worsening shipping industry since 2008, as well as the great success of E-business in China, that those huge domestic shipping companies began to show interest in Shipping Ecommerce. After that, there was a blossom of Shipping Ecommerce in China, and by now, around 20 platforms are competing with one another in the domestic market (Qin, 2015).

“Cang Wei Bao”, the product of Alibaba and Maersk Line, shocked the market when it was released at the end of 2016. It was mainly designed to solve the problem of the dumping of containers. A traditional shipping company will probably dump containers in peak periods because the slots are limited. Small and non-contractual clients often suffer and complain about the delay but they have no means to legally protect themselves. Maersk Line and Alibaba therefore promise that they will, under no circumstances, drop any slots booked on this platform as long as a small amount of premium for slot reservation is paid.

As known to all, Maersk Line occupies the largest share in shipping market, and is famous for its quality of service. Simultaneously, Alibaba is the most mature E-business platform in China regarding its operation, logistics and technology. Obviously, they both have the ambition to rule Shipping Ecommerce, and they stepped into the market with “Cang Wei Bao”.

Experts hold opposite opinions on the prospect of “Cang Wei Bao”. Advocates say that “Cang Wei Bao” not only helps avoid the risk of dumping for consumers, additionally, it fixes the freight at the moment of ordering so that the clients will not concern the market fluctuation. Others comment that it is not possible to 100% guarantee available slots for commodities, at least, there must be a certain restrictions for the statement. Moreover, the overbooking of slots scarcely happen currently in the depressed shipping market. Therefore, not until a revolutionary technology is developed by Alibaba, will “Cang Wei Bao” achieve success (Li, 2017).

So, the thesis will talk about and put forward a potential developing trend for Shipping Ecommerce platforms such as “Cang Wei Bao”. But before that, more information have to be collected regarding shipping e-commerce.

1.1 Background Information

1.1.1 Classification of Shipping Ecommerce platforms

Zheng (2014), and Tu & Zha (2015) categorized Shipping Ecommerce platforms into three kinds. The first one is named ‘Horizontal Ecommerce Platform Belong to Ship Owners’. As is meant literally, these platforms are developed by and serve for the shipping companies themselves, for example, Epanasia, and COSCO E-business. The second one is ‘Third-Party Freight Forwarding Ecommerce Platform’. These platforms are operated by third-party logistics companies, and offer slot reservation services. Jincheng Logistics is a representative. The last one is ‘One-stop Shipping Logistics Services Platform’. These platforms are based on administration departments of ports and integrate information from various companies, to provide all-in-one customs clearance services. Qin (2015) also numerated three categories of platforms, in which the last kind is defined as ‘Differentiating Shipping Ecommerce Platform’. Differentiation means that the platform can provide additional services other than slot reservation.

1.1.2 Main functions of Shipping Ecommerce platforms

With regard to the usage of Shipping Ecommerce platform, Feng (2016) illustrated three core functions, information, transaction, and service. Information platform aims at providing accurate and latest news, data or statistics, such as government notification, supply & demand information, and transaction receipt. Transaction platform supports online pre- & after-payment. Service platform offers value-added services such as inquiry and tracking. Li & Pi (2016) specified the main functions of Shipping Ecommerce platforms into schedule searching, vessel dynamics, online booking, document browsing, arrival notification, client complaint, commodity tracking, query statistics, and freight inquiry.

1.1.3 Bottlenecks of the development of Shipping Ecommerce

Xu K. (2015) and Xu W. & Jiang (2015) mentioned three main bottlenecks of the development of Shipping Ecommerce. Firstly, shortage of business volume at the beginning. Stakeholders expect large volume of business to attract more investors for capital and modify their platform. Secondly, lack of compound talents in this field. These personnel should be E-business experts who also master the shipping market. Thirdly, unknown business & profit model. The traditional mode of booking has lasted for decades of years. This online to offline business model is too young to reconstruct to market. Gu (2016) added two other factors. One is Variation of operational mode. E-commerce platform must indicate a relatively fixed freight, but the market fluctuates all the time, and generally, the freight is different clients is different. The other one is Difficulty of Risk Control. Small businesses which add to the risk of customs clearance and inspection will be attracted by these platforms. Moreover, the laws and legislations for transaction is not yet mature to mitigate the risk of cash flow and payment. Fang (2015) also explained four problems of Shipping Ecommerce. First, Standardization for Online Services. Shipping Ecommerce refers to intangible services which confront tremendous uncertainty in logistics. Each transaction should normally be confirmed manually again. Second, Opacity of Shared Date. Most shipping companies regard their freight as a trade secret, and are reluctant to share transparently. Third, Evaluation of Credit Risk. Regarding the suppliers, any change of the shipping companies may lead to the loss of clients. Regarding the clients, they undertake little risk to breach the contract of slot reservation. Fourth, Realization of Door-to-door Services. Shipping Ecommerce platforms are originally designed to reach the direct costumers without third-party freight forwarding companies. However, these platforms are far from capable of offering door-to-door services that direct costumers require. Hua (2014) analyzed the problems of Shipping Ecommerce from the aspect of the complexity of container transportation. He regarded the categories of containers, commodities, different routes, various surcharges, and the changing freight as the straw that broke the camel's back.

1.1.4 Predictions regarding Shipping Ecommerce development

With respect to the development of Shipping Ecommerce, Xu & Han (2014) demonstrated three concepts. First, to broaden the relevant products of shipping, such as warehousing, prime movers, and customs clearance on the platform. Second, to involve more supply chain services, such as insurance, economics, and multi-model transportation. Third, to build a big data base of the shipping industry. Jiang, Sun & Song (2016) predicted that there would be a clustering of shipping industry under the drive of Shipping Ecommerce. This clustered platform will spread to every department in the industry.

1.1.5 Solutions with regard to specific functions and products

Chen Y. (2016) illuminated the potential use of BIG DATA in Shipping Ecommerce. As he described, the shipping industry is strongly related to the development of economy and trade. And the property of data from shipping is exactly the same as BIG DATA. He mentioned six kinds of data, namely, product data, user data, searching data, dealing data, containers' dynamic data, and derived data. Furthermore, he constructed five models on the basis of these data that can reflect the customers' behavior. Hua (2014), Li (2014), and Chen (2015) also thought optimistically about BIG DATA with regard to Shipping Ecommerce. Through BIG DATA analysis, shipping companies will be able to supply specific products for specific customers. In addition, BIG DATA may help mitigate the influence of cyclical fluctuation of the market.

In terms of the mature of credit system, Wang & Yu (2015) put forward three suggestions.

Firstly, they encourage relevant associations to establish a credit data base so that defaulters will be banned from trading. Secondly, they advise that shipping companies should enact more sufficient legislations to supervise the credit risk. Thirdly, they suggest the companies to build a customers' ranking system to control the risk. He (2012) and Yue (2016) both adopted AHP methodology to build a credit evaluating system for B2B E-business platforms. These two models are different from existing credit evaluating systems that simply aggregate and average the evaluation of each factor. He's model is based on the combination of certification off line and credit evaluation, and the evaluation of estimate with trusted system according to the enterprises' credit degree and trade amount. Yue applied analytic hierarchy process and forced normal model to establish the credit assessment system.

Yao (2015) introduced a project called 'Zhi Qi Bao'. Normally, the demurrage for a container depends on its type, and days of delay. And the calculation of the amount is due to a considerably complex formula. This application enables clients to pay demurrage of containers online with simplified procedures, and at a fair, transparent price with a discount. Li (2017) explained the differentiated functions of "Cang Wei Bao". This platform powered by Alibaba group attempted to solve the customers' concerns about containers' dumping. Xie (2013) applied ASP.NET and designed a system to solve the insufficiency of manual LCL for an anonymous Ecommerce platform. In the implementation of the system, He defined and developed database operation. In the LCL work, combined with Dijkstra algorithm, he used C # programming language to achieve LCL by the shortest distance between the two cities and applied genetic algorithm to solve the technological realization of random scheduling of vehicles; combined a flow chart of the program to illustrate various modules.

1.1.6 Problem Definition

As mentioned by Xu K. (2015) and Xu W. & Jiang (2015), one of the most significant problems Shipping Ecommerce platforms confront, is the shortage of business volume. In other words, if Shipping Ecommerce platforms only provide services on slot reservation, though the price is transparent, they are still far from having a decisive advantage over the traditional booking systems. So if they can extents to services with regard to LCL, they will not only be more attractive for consumers, more importantly, the characteristics of LCL services will expose the platforms to more individual or small customers other than big customers who reserve several container slots at a time. Accordingly, the volume of business will begin to sour.

Thus, the thesis will concentrate on the development of LCL system for Shipping Ecommerce platforms.

1.2 Objective

This thesis will study the potential on the development of LCL services for Shipping Ecommerce Platforms. First, literatures will be reviewed on the current researches about LCL problems, in order to determine an exact aspect to be analyzed. Then the thesis will talk about the background of the problem, minimization of operating cost, and construct a model to solve the problem. Finally programming methodology will be introduced to realize the LCL service with a differentiate function on computer.

1.3 Methodology

In the thesis, the concept of Vehicle Routing Problem with Time Constraints will be applied to build a model to minimize the cost of LCL cargo transportation. On the basis of this model, the concept of 3D visualization will be introduced as a methodology to program an application on computer to realize the function of LCL operation.

1.4 Outline

Chapter 1, Introduction, reviewing the background of shipping E-commerce, with a starting point of Ali-Maersk's 'Cang Wei Bao', and determine the learning goal of the paper, that is, LCL business on E-commerce platforms.

Chapter 2, Literature Review, talking about researches carried out in the field of LCL problems while finding a direction to study in the paper, that is, the minimization of operating cost of LCL.

Chapter 3, Background of Maritime Consolidation, studying the background information that might be needed to construct a model for LCL operation.

Chapter 4, Model Construction, formulating a model to minimize the cost of consolidation and the penalty due to delay, while considering a series of constrains.

Chapter 5, Realization of Maritime Consolidation with 3D Visualization program, introducing a methodology to realize the 3D visualization of the consolidation outcome with various mathematical transformation, and give some basic reference coding in C language.

Chapter 6, Conclusion and Recommendation, concluding the main findings of the whole dissertation and give recommendations for further researches.

2. Literature Review

In this chapter, literatures will be reviewed on the researches regarding LCL problems.

2.1 Problems of LCL Cargo Itself

Jiang S. (2007) pointed out that, due to the development of container liner and the shrinking of cargo transshipment liner which lead to the problem that, when the volume of international goods is small, because of its weight and size, it is not (economically) appropriate to use FCL container, as well as other means of transportation. Under such circumstances, it will lead to a failure in the transaction. Dong (2001) also figured out that, because of the insufficient resources of LCL cargo and high cost at some ports, freight forwarding companies that concentrate on LCL cargo would take minimum charge standard. Therefore, for goods that is of the characteristics of smaller volume or at distant ports, these factors should be taken into account. Qiu (2006) considered that LCL cargo transport can be divided into direct consolidation and transmit consolidation. Transmit consolidation refers to two times of loading and unloading of goods. If part of the LCL operation is delayed, it may lead to cargo detention, cargo damage and higher expenses. Quan (1998) mentioned that it is important to make full use of the container. It’s not good to leave the gap between the goods, and stacking should be neat and tight. If there is gap, cushion should be used to prevent the movement of goods. Becauce of the development of LCL cargo transportation on dangerous goods, Yan (2003) designed and introduced a process to tackle with LCL operation based on international and domestic standards. He pointed out that, dangerous goods consolidation must satisfy the general rual, that is, the dangerous goods in the container must be compatible.

2.2 Problems of LCL Cargo Transportation

Chen & Lie (2000) summarized that the main problems of LCL transport are: the structure of containers does not match with the structure of goods; the container transport network is imperfect; the infrastructure is not complete resulting in increased costs; LCL cargo billing system should be elaborated; LCL transport organization lacks specific and effective method. Zhou (2008) thought that LCL companies should both try to retain their LCL resources, in addition, they should attempt to attract goods using other transportation methods because of low transportation efficiency.

2.3 Problems of LCL Cargo Standardization

Shi (2001) proposed that the standardization of LCL market, is not just raising the rate of export LCL, but regulating the price of the entire freight forwarding market behavior. And the market standardization entirely depends on market behavior. Any human intervention is not conducive to the emergence of freight forwarding competition. Zhang (1999) thought that the government should deal with LCL rate with macro-control, using the regulations to regulate the market, to prevent unfair competition. Freight Forwarders Association should play the role that communicates between enterprises, and coordinates the relationship between various parties. Freight forwarding companied should deal with the relationship between freight rate and volume properly to ensure its long-term profits and development. Xiang (2001) pointed out that although the management has achieved some success and the overall market conditions can satisfy the needs of China's import and export trade. But overall, China's international freight market business activities are still not standardized and orderly. Investment risk and freight business risk still prevails. This will not only lead to a direct impact on the enterprises, additionally, it is not conducive to the maintenance of the national economic order, and the LCL market situation is one of the reflection of the situation.

2.4 Problems of LCL Cargo Optimization

Wang X. (2001) wrote that, in practice, LCL freight rates are usually based on "cubic meters", which is because LCL cargo is generally "light bulky goods", as well as because of the provision, that is, the billing standard of " M ". However, theoretically, the billing standard can be "W", that is, the gross weight of the goods. It can also be a certain percentage of the FOB price of goods. Or it can be the bigger value between “M/W”. And if "M" is not clearly indicated as the billing standard, "M / W" shall be adopted. Jin (2008) achieved the optimal container loading method by establishing the linear optimization model, and then using EXCEL linear programming solution. Bu, Pu, & Yin (2004) applied the genetic algorithm, considering the loading constraints such as loading weight, loading volume, loading priority and non-simultaneous loading, adopting the appropriate individual coding method and constructing reasonable fitness function, in order to optimize the LCL stowage. The results showed that the rate of utilization of the container was 83.18%. Thus, by using genetic algorithm, the loading results were optimized. Huang, Chen, & Yang (2004) studied LCL arrangement based on SQL technology and density algorithm to design an automatic consolidation software system. They usd VB6.0 and SQL sub-module for the design of its data entry module to complete the entry and editing of data; LCL module to filter the containers and list the inventory; inquiry module to quote the inventory data and print out. Zhong (2011) designed and implemented a web-based optimization system to simulate Philips’ LCL business of transportation and procurement process. In addition, the system provided an optimal allocation plan for Philips to make decision in order to minimize the logistics cost in this paper. Jamrus & Chien (2016) developed an extended priority-based hybrid genetic algorithm (EP-HGA) for the present LCL problem to determine the loading patterns. In particular, the proposed approach integrates the encoding based on cargo priority and cargo layer via the deepest-bottom-left fill method and the adaptive auto tuning parameters of the proposed EP-HGA to improve the efficiency and effectiveness.

A significant barrier to an efficient container consolidation at port terminals is the reduced visibility and information exchange between related stakeholders on real-time location and status of a container and its contents. Thus, Tsertou, Amditis, Latsa, Kanellopoulos, & Kotras (2016) proposed a cloud-based information portal as an ICT enabling technology used as a single point of reference by supply chain stakeholders; the latter used this portal to feed it with real-time information from existing platforms so that a better visibility for all parties was enabled. This portal implemented accessible interfaces with parties of each step of the transport process (e.g. interface with the customer, warehouse, next-leg carrier) using standardized formats as far as possible. Liu, et al. (2017) addresses the container loading problem with multiple constraints that occurred at many manufacturing sites, such as furniture factories, appliances factories, and kitchenware factories. All of the items in an order must be placed in one container, and the volume of the container should be maximally utilized. A heuristic algorithm is proposed to standardize the packing of (order) items into a container.

In summary, a number of researches have be conducted about LCL cargo domestic, but few researches have been carried out on an international basis. In addition, a number of researches have been done about different kinds of optimization regarding LCL problems, but few studies talked about the optimization of operational cost of LCL. Therefore, in this thesis, the minimization of cost of LCL operations will be analyzed from the aspect of Shipping Ecommerce platforms. But before that, the background and cost structure of LCL services have to be studied.

3. The Background of Maritime Consolidation

3.1 Overview of Maritime Consolidation Model

Maritime Consolidation refers to Carrier or Agent who accepts commodities that less than container loads (LCL), and classifies these commodities according to the category and property of goods and their destination. Carrier gathers the goods that go to the same destination to a certain quantity, and then assembles and arranges them into containers. It refers to goods that belong to different consignors and different consignees.

There are two main ways of maritime consolidation:

1. Direct consolidation, which means that the LCL commodities in container cargo loaded in the same port will not be unpacked before the arrival of the goods to the port of destination, that is, the goods for the same port of discharge. This type of LCL service is quick and convenient.
2. Transmit consolidation, which means the goods in the same container to different port of destination that need to be unloaded or transshipped to another liner during the whole shipment period. Because such goods vary in port of destination, and commonly have to wait for a long time, the transport period is therefore longer, and accordingly causes a higher freight.

As a result of the pressure of logistics costs, currently, most of the domestic freight forwarding companies tend to choose consolidation to deal with inland transport in order to avoid empty transportation or half-loaded transportation. Its operating principle is the same as maritime consolidation. However, because it is inland transportation which means that there is no complex transshipment, custom clearance and other processes, the operation process is relatively simple. Anyway, the general meaning of the consolidation refers to the maritime consolidation. Its biggest feature is the saving of transportation costs, and the improvement of container utilization. But for consignees, such a way of consolidation packing is the general meaning of bulk transport, which will still result in high costs, and the difficulty of the controlling of transportation time.

3.2 The process of LCL cargo operation

LCL cargo operation can be divided into three kinds regarding the process according to different carrier, namely, information flow that refers to the changes of the property of goods such as weight, packaging and displacement in different stages of transport; cargo flow, which refers to the goods that travels to the consignee's warehouse or factory from the production point through a variety of transportation methods; and cash flow that refers to various costs incurred due to the transportation of goods from the beginning to the end.

Information Flow

The carrier of information flow is document. Documents accompanies the entire logistics operation. Many people involved in the transport of goods cannot see the actual goods, while they can only check the document. The accuracy and punctuality of documents is essential in the transportation.

LCL cargo documents for import and export has three important stages in its entire delivery process:

Export booking, customs clearance stage

The main documents are: (1) booking note; (2) customs power of attorney; (3) customs declaration; (4) commercial invoice; (5) packing list; (6) export license; (7) commercial inspection certificate; (8) certificate of origin (9) insurance policy; (10) other relevant documents (such as certificate of exchange, entrust letter of inspection, letters of credit, Chamber of Commerce contract, etc.).

In the export booking and declaration phase, LCL Company shall accept customers' booking notes as a carrier. And according to the physical properties of goods, LCL Company should ensure that the arrangement of slots and departure time meets the requirements of the consignor. The LCL Company should produce a delivery blueprint that indicates the delivery number, the name, gross weight, volume and number of goods, as well as, packaging, marks, codes, CFS related contact, and shipping instructions. Moreover, the estimated sailing time and expected flights should be indicated. The delivery blueprint should be sent back to the customer as a proof of delivery, and they should inform the physical properties and delivery number of goods to the terminal.

LCL Company should pay attention if the customer changes data on the booking note. If so, the company should correct the delivery blueprint and inform the relevant people. The company should also pay attention if the declaration documents matches with the power of attorney, that is, one document for one batch of goods.

Picking, loading and charging stage

1. In this stage, besides the important documents needed for declaration, LCL Company should also be familiar with many domestic customs regulations. LCL Company needs to prepare FCL packing list for the second declaration. The consignor of FCL packing list is LCL Company, and the consignee is the agent of the LCL Company in the port of destination or transshipment. LCL Company should also be responsible for filling out the bill of lading number, mark, code, packaging, name, gross weight, volume and other related data of all the goods clearly.
2. Further verify if the declaration documents matches with the power of attorney, and if the documents match with the actual goods.
3. If the name, weight, or quantity of the goods doesn’t match with the actual situation or the relevant laws and regulations, LCL Company should contact with the owner and the relevant parties timely, to change the document and match with the actual situation. If not reported, any issue that happens in the follow-up transport and customs clearance will be in the charge of the LCL Company. Take the inconsistency in quantity of goods as an example, if the actual number of goods shipped is 20CTNS, but the documents indicated 21CTNS, then the consignee at the port of destination will have the right to claim 21CTNS of goods according to the bill of lading.

Cargo departure, and customs clearance at port of destination stage

1. LCL Company should prepare for master bill of lading whose main contents are: the name and address of the consignor (LCL Company), the name and address of the consignee (the agent of the LCL Company at the port of destination), the date, and place of the bill of lading, the place where the goods were delivered, the name and mark of the goods, packages, quantity, size and weight of the goods, the condition of the appearance of the goods, the number of bill of lading issued, and the clause of carriage and freight.
2. LCL Company should prepare for House bill of lading. LCL cargo is composed of goods from a number of consignees and consignee. LCL Company should prepare for small bill of lading according to its packing list. Its main content is the same as the master bill of lading.
3. Bill of lading. LCL consignee exchange the bill of lading with small bill of lading after paying the fees to the agent assigned by the LCL Company at the port of destination, and conduct customs clearance with the relevant documents accordingly.

Cargo flow (LCL / LCL)

Generally speaking, LCL cargo does not choose a designated shipping company, and the shipping company does not directly accept LCL cargo booking as well. Only through the freight forwarders, will slots be booked after LCL goods is consolidated as FCL goods. (Very few shipping companies do this through its own logistics company). Almost all of the LCL cargo is transported through the freight forwarding company following the concept "centralized consignment, centralized distribution". Take the most widely demanded operation in the market, LCL / LCL operation, for example, the goods flow as follows:

The consignor is responsible for transporting the goods to the designated container freight station (CFS) of the LCL Company. The field personnel of the LCL Company or the on-site staff of the container freight station will work as an agent of the LCL Company to measure, arrange and sign the goods. When the consignor sends the goods to the freight station, the station is responsible for doing the following work:

1. Proof of scale. Measure the size of the goods one by one, and make a record.

2. Weighing certificate. Weighing the goods one by one, and make a record.
3. Verifying if the mark is correct.
4. Arrival record. Record if the packaging of goods is intact, damaged or not, and if it arrived on time or not, and so on.
5. Summarize the above information and upload it to the relevant website or make it into a form and submit it to the person responsible for the route. If there is any error, the responsible person of the route shall promptly contact the consignor and notify the freight station to correct the handling measures.

Container freight station is responsible for preparing the container in accordance with the equipment interchange receipt provided by the LCL Company. They shall confirm the LCL Company's container allocating plan, and according to the allocation plan, they load the container with the confirmation of the tally company and the LCL Company. Take the following notes when packing:

1. Ensure that the goods do not exceed the weight limit of the container itself, the route, and the terminal to guarantee the safety of container handling and maritime transport. The weight distribution of goods in the container should be balanced to prevent deformation of the bottom of the container.
2. Goods in the container should be arranged neatly, and try not to leave gaps, in order to prevent damage of the packaging due to collision under transportation.
3. If wood support or litter separation is needed, ensure that it is clean, dry, non-polluting, and meets the requirements of the import and export quarantine and related regulations. After packing, the number of goods in the container, the bill of lading number, the mark and other information should be tackled according to the cargo manifest, and the related personnel of the container freight station shall report the packing situation and the amount of inventory accurately. The container freight station is responsible for transporting the loaded container cargo to the container terminal.

According to FCL / LCL clauses, the LCL Company must pick up the goods at the designated place provided by the consigner; Or the consignor can directly send the FCL cargo to the designated terminal provided by the ship owner; Or the consignor can send the goods to the agreed warehouse confirmed by both the LCL Company and the consigner. Then the LCL Company will arrange for field loading, and deliver the FCL cargo to the terminal. According to the yard plan, the container will be temporarily stored in the yard of the ship, waiting for loading. According to the loading plan, the container cargo will be loaded on the ship. Through the maritime transportation, the container will be discharged after arriving at the discharging port. According to the unloading plan, the container cargo will be unloaded from the ship. According to the yard plan, the container cargo will be temporarily stored in the yard, waiting for agents from LCL Company at the port of destination to pick up. According to the clauses of the LCL / FCL, FCL cargos shall be sent to the consignee's designated place or the consignee takes initiative to pick up the FCL cargo by himself. The container freight station assigned by the LCL Company at the port of destination should be responsible for tallying and delivering the goods. The agent at the port of destination is responsible for the return of the empty container.

Cash flow

Regarding the billing aspects, the characteristics of the LCL goods and notifications of balance are roughly shown as follows:

LCL goods are charged in accordance with its tonnage. The so-called billing tons is the larger number within its gross weight (tons) and volume (in cubic meters). For example: the goods is 2 tons in weight, and 1 cubic meter in size, then the goods will be charged for the 2 freight tons; if the goods is 2 tons in weight, but 3 cubic meters in size, then the goods will be charged for 3 freight tons.

LCL Company take the minimum charges for goods with less quantity. If the lowest starting charge is from 1 freight ton, then any goods less than 1 freight ton will be charged as one freight ton.

Maritime freight rules: containers are divided into 20 feet, 40 feet, 40 feet high cabinet and so on in accordance with the size. Under normal circumstances, the bearing capacity is 22 tons, 27 tons and 29 tons respectively. The maximum internal effective volumes are 28 CBM, 58 CBM and 68 CBM respectively. Thus, if the absolute value of the volume (CBM) divided by the absolute value of the weight (T) is less than 2, the freight rate will be higher than cost (the ratio of individual countries such as the United States and Canada who have strict restrictions on weight will be higher). This will ensure that the weight and volume of the container can reach the equilibrium point. Of course, in the stowage process, the price of the goods should be adjusted based on real-time cargo situation.

Charging clauses: In addition to maritime freight, due to different FCL surcharges of different routes, LCL goods has a corresponding surcharge in the port of departure and destination. In addition, there will be bills for the document fee, manifest declaration fee, customs clearance fees, insurance, etc. Yard service fee and LCL service fee on the basis of tonnage will also be charged, including inland freight, port surcharges, unloading charges, loading charges, de-vanning charges, operating charges, and warehousing charges and so on. The charging standard of different LCL Companies may vary greatly. In different port of departure, for different routes and whether it is designated goods, LCL Company uses itemized charging and lump sum charging respectively. But at the port of destination, the charging standard of basic port for different routes will not be itemized.

The revenue ton of LCL cargo should be calculated accurately. Before the delivery of LCL cargo, the factory should measure the weight and size of the goods as accurately as possible. When the goods is sent to the warehouse designated by the LCL Company, it will normally be re-measured, and the size and weight of the re-measured outcome shall be the adopted for charging. In case the factory changes the packaging, the factory should be notify the LCL company promptly so as not to delay the declaration, or lead to extra customs clearance fees and special wharf charges and so on.

3.2 The cost structure of LCL transportation

According to the different services provided, the cost structure of LCL goods is as follows:

FCL / LCL: Consignor’s "door" → loading port CY → unloading port CY → LCL company agent designated CFS

Its cost structure: Collection and transportation costs + loading yard service charges + maritime freight + unloading yard service charges + LCL service charges

LCL / FCL: LCL company's CFS → loading port CY → unloading port CY → consignee's "door"

Its cost structure: LCL service charge + loading yard service charges + maritime freight + unloading yard service charges + collection and transportation costs

LCL / LCL: LCL Company's CFS → loading port CY → unloading port CY → LCL Company agent designated CFS

Its cost structure: LCL service charges + loading yard service charges + maritime freight + unloading yard service charges + LCL service charges

The table below shows the information more clearly:

FCL / LCL		LCL / FCL		LCL / LCL	
cargo flow	cost structure	cargo flow	cost structure	cargo flow	cost structure
Consignor's "door"	Collection and transportation costs	LCL company's CFS	LCL service charge	LCL Company's CFS	LCL service charges
loading port CY	loading yard service charges	loading port CY	loading yard service charges	loading port CY	loading yard service charges
Shipping	maritime freight	Shipping	maritime freight	Shipping	maritime freight
discharging port CY	discharging yard service charges	discharging port CY	discharging yard service charges	discharging port CY	discharging yard service charges t
LCL company agent designated CFS	LCL service charges	consignee's "door"	collection and transportation costs	LCL Company agent designated CFS	LCL service charges
Fixed Cost	loading yard service charges; discharging yard service charges; maritime freight; LCL service charges				
Variable Cost	Collection and transportation costs				

Table 1 --- Cost Structure of LCL Services

The thesis will analyze and build a model to minimize the costs. This means that the core of the cost structure will be collection and transportation costs. Other charges or costs can be defined as fixed cost. So the minimization of LCL operation cost can be downsized to the minimization of collection and transportation cost. And these activities are on the basis of the port. So the analysis will start with the primary attributes of the port, that is, the container.

3.4 Classification of port containers

In order to play the basic functions of the container terminal, the port, as a container transport transfer hub, storage, warehousing and the place of provision of services, must be equipped with certain facilities and equipment. It usually includes berths, wharf frontier, yard, gate, shore-bridge, horizontal transport machinery, and so on. The container, as a port operating unit, its production operations in the port play an irreplaceable role.

Containers are large-scale loading boxes with certain strength, stiffness and aims at the use of specified turnovers. With the use of container to transport, goods can be loaded in the consignor's warehouse, shipped to the consignee's warehouse and unloaded. In addition, during the process of transportation, goods do not need to be removed from the containers when transshipped.

With the development of container transport tasks, in order to meet various types of differentiated cargo transportation needs, different categories of containers appeared. Such containers not only differ in shapes, and structures, more importantly, the size of the parameters are also different. According to the characteristics of different types of goods, container types can be divided into: grocery containers, open-top containers, desktop containers, platform-based containers, tank containers and others.

1. Grocery container

Grocery container, also known as dry cargo container, is a general purpose container that can be used to load commodities other than liquid cargos, and goods that require temperature control, which is used in a wide range. According to statistics, in the world container, grocery containers accounted for about 85%. Some of the grocery containers also install side door on its side wall in addition to the back door outside. This setting can help the loading of goods.

2. Open-top containers

This type of container's top plate can be removed. The top of the container can be divided into hard top and soft top. Hard top means that the ceiling is made of whole steel plate. Soft top refers to the top that is made of canvas, or plastic cloth and is supported detachable and extendable bow beam. Other components are the same as grocery containers. This type of container is suitable for the transportation of large cargos or heavy goods, such as steel, wood and so on. These goods are often hanged into the container with the use of crane from the top. This can guarantee not only that the goods will not be easily damaged, but also reduce the labor intensity of the loading. In addition, it is also easy to fix the goods in the container.

3. Flat rack containers

Flat rack container is characterized by no top and side walls, which can be loaded from the top with a crane or can be loaded from the side with a forklift truck. It is suitable for loading large pieces and heavy pieces such as heavy machinery, steel, steel glaze, wood, ingots, lathes and various equipment. It is also possible to use two or more pallet containers combined, to form a platform for loading extra-large pieces of cargo. There are also containers whose side panels can be folded up to reduce the loss of the tank capacity when the container is empty. In order to maintain its longitudinal strength, the bottom of the container is thicker and the strength of the bottom of the container is greater than that of a general container, and its internal height is also lower than that of a general container. In order to fasten the loaded cargo, there is a collar on the lower side and the corner post. To prevent the collapse of the goods during transportation, both sides of the container also has a column or fence. Flat rack containers are not watertight, so goods that fear of damp cannot be shipped. When transported on land or stored on a tower, it should be covered with organic cloth to prevent the damp.

4. Platform containers

Platform container is a container with no upper structure but only bottom structure. The length and width of the platform is the same as that of the international standard container. It can be operated with the same fasteners and lifting devices as other containers. Platform container is divided into two types: platform container with top corner piece and bottom corner piece, and platform container with only bottom corner piece. Platform containers are commonly used in Europe.

5. Tank containers

Tank containers are specially designed for the shipment of liquid goods such as alcoholic beverages and oil, and can also carry dangerous goods such as alcohol and other liquids. Tank containers are mainly composed of two parts, the body and the frame. The frame is generally made of high strength steel, whose strength and size should meet the requirements of international standards. Corner column is also equipped with international standard corner pieces, and loading and unloading should be the same as the international standard container. The tank is the main body of the cargo. Its shape and size is not specified in the international standard. The top of the tank is designed with a hole (that is the loading port). The lid of the loading port must be watertight and the exhaust valve is put at the bottom of the tank. The tank structure should be easy to disassemble and easy to clean. Some liquid goods' temperature changes, and its viscosity will increases as the environment changes. When loading and unloading, the container need to be heated, so some of the tanks are equipped with a heater at the bottom. The tank is also equipped with a thermometer so that the cargo temperature can be observed at any time from the outside. In addition, the tank should also be equipped with safety valves and ladders. The top of the tank is suggested to be equipped with a pedal to facilitate the operation of the container for workers.

Container is a derivative demand of the transportation of goods, and it can be called "freight containers." As the development of container transport, and the ever-increasing efficiency of transport, the use of containers is also more and more widely. After the continuous promotion and use in transportation, containers are now used not only for civilian systems, but also in military systems. In addition to cargo containers, there are mobile power station containers, mobile cabin containers, and mobile office containers and so on. According to the different status of their goods in the box, the container transportation can be divided into FCL transport and LCL transport. FCL transport is applied when a customer's goods is enough to fill the entire container. LCL transport may be adopted when a number of customer goods can be filled in a container. Therefore, it is of practical value to study the number of vehicles arranged in the LCL, the travel route of the vehicle, and so on. Taking this paper as the starting point, this paper will study the distribution of container packing.

3.5 Mixed packing problem of LCL cargo

In terms of the essence of port container logistics, no matter if it is traditional or Just-in-time, the distribution of port container logistics is to realize the effective movement of port cargo from the ship to the customer. Port logistics operations include the handling of cargo, packaging, distribution and other processes. It is mainly conducted by third party logistics companies who undertake the responsibility of the delivery of goods. The process of delivering the cargo directly to the customer from the port, is an effective link between the port and the customer. According to the number of cargo owners regarding the commodities in a container, container distribution can be divided into FCL distribution and LCL distribution.

With the continuous optimization of China's economic structure, the improvement of people's consumption level, the development of collective economy, individual economy and private economy, the overall social supply structure shows a trend of increasing in the proportion of multi-species, small batch and high value-added goods. The development of e-commerce provides a new opportunity for the production and transportation of such goods. These goods are generally smaller, and need to be consolidated to achieve the transportation. Therefore, these objective transportation needs not only put forward new requirements in the LCL transportation, but also provide a new space for development and opportunities. Port container LCL distribution process, as a process that directly influence on small goods transportation efficiency and quality, also ushered in a new challenge. Efficient, low-cost, and convenient container LCL distribution is an inevitable trend of port logistics.

LCL transport is also called "one box multiple batches" transport, which gathers multiple batches of small commodities shipping to a number of cargo owners in one container. This enables the efficiency, security and other property of container transportation during the process of cargo transportation. This can minimize damage, loss, wetting, pollution, theft and other losses, to prevent misplacement of cargo. As a result of the various characteristics of the LCL, it differs from FCL cargo in arranging and equipping, and the handling of documents. The operation process is more troublesome than FCL cargo, so extra care should be taken. In addition, there are some skills with regard to the arrangement and loading of cargo.

These mainly includes:

1. Master the physical and chemical properties of goods. Cold goods and dangerous goods should be loaded alone. Wet goods and day goods should better be separated. When it is unavoidable, generally, wet cargo should be placed below, and dry cargo should be placed on the top, and additionally, a dry pad cloth should be used to separate the aforementioned goods. Goods that will easily get damped, sweated, and wet goods should be loaded in the same container.
2. For goods that differ greatly in weight, heavy goods should be put at the bottom, and light goods should be put on the top. For heavy goods such as lathes, etc., special attention should be paid to the uniform the distribution of weight within the container. It is not feasible to put heavy cargo on one side in the container, while putting light cargo on the other end of the container, so as to avoid lifting or transport dangerous;
3. Reasonable arrangement should be applied for difference kinds of packing, for example, cartons should be placed on wooden box, barrels and iron goods should be separated by appropriate use of cushion, so as not to move after the collision. In addition, stacking layer should be determined by the strength of packaging.
4. Make full use of box capacity. Do not leave gaps between goods. Stacking should be neat and tight. Cushion material should be used to prevent the movement of goods if there is gap between goods.

LCL goods can be assembled according to the distribution of customers, that is, goods belong to the same group of customers should be loaded into the same box. In addition, the principle of "goods arrived first should be loaded at last" should be adopted.

After studying the background of packing problem, the thesis will attempt to construct a model to minimize the collection and transportation cost.

4. Model Construction

4.1 Introduction of LCL cargo transport problems

Mathematical abstraction of LCL cargo transport

To deliver goods to customers on a timely, and cost-effective basis, it depends considerably on the problem of efficient routing arrangement. The optimization of the distribution route arrangement has a great influence on the efficiency of distribution, cost and service level.

Regarding the port optimization problem of LCL cargos, this report will abstract it as a vehicle routing problem with time window (VRPTW). Logistics distribution problem is a typical example of combinatorial optimization. It is generally defined as organizing the appropriate driving routes on the basis of a series of loading points and unloading points, so that the vehicles can pass through them orderly, whiling meeting a certain constraints (such as cargo demand, delivery volume, delivery time, vehicle capacity limit, mileage limit, time limit, etc.), to achieve a certain goals (such as the shortest distance, the least cost, time as little as possible, the number of vehicles used as much as possible). The practical problems of VRPTW include distribution, bus route development, correspondence and newspaper delivery, aviation and rail timetable arrangements, and industrial waste collection.

VRPTW can be described as follows: There is a station (depot), a total of K trucks, vehicle capacity of Q, and a number of N customers who need services. Vehicles depart from the station to provide the customer with delivery service and finally return to the station. This requires that all customers should be served within their specified time window. Customers' requirements should be satisfied within a single delivery while obeying the limitation of vehicle capacit. The purpose is to minimize the total driving distance of all vehicles.

The main factors that constitute the problem of LCL cargo distribution include: goods, vehicles, logistics center, customers, transportation network, constraints and objective functions, etc., as follows:

1. Goods

The goods are the object of distribution as well as the main factors that constitute the demand. The demand or supply of each customer can be regarded as a batch of goods. Each batch of goods includes the name, packaging, weight, size, time and place to be sent or taken, and whether this batch of goods can be distributed separately. The name of the goods and packaging, is the foundation that determines the type of distribution vehicles, and if this batch of goods and other goods can be loaded on the same vehicle.

2. Vehicle

Vehicle is the tool that carries goods. Its main attributes include: the type of vehicle, the amount of goods loaded, the maximum travel distance of a single distribution, the parking location before the distribution and the parking position after the completion of the task.

3. Logistic center

Logistics center, also known as logistics base, mainly refers to the operation centers, warehouses, stations, ports that conduct the collection of goods, the picking of goods, distribution, and delivery. In the specific VRPTW, the number of logistics centers can be one or more; the location of the logistics center can be determined or underdetermined; for a certain logistics center, the supply of goods may be one, or may be a variety; the number of goods supplied may be able to meet the needs of all customers, or only meet the needs of part of the customers.

4. Customers

Customers are also called users, and the customer's attributes include the number of goods demanded or supplied, the time of the goods demanded or supplied, the number of times of the goods demanded or supplied, and the requirements for the service. In VRPTW, the customer is the most important factor. The attributes of customer determines the planning of VRPTW. The customer's needs are the main source of VRPTW constraints as well as the object to be emphasized.

5. Transportation network

The transportation network is composed of vertex (referring to the logistics center, the customer, and the parking lot), the undirected and the directed arc. The properties of edge and arc include direction, weight and traffic flow restrictions.

6. Constraints

The constraints that logistics VRP must meets include:

(1) Meet all customers' requirements on the goods varieties, specifications, and number;

(2) Meet the customers' requirement of time range of the goods to be sent;

(3) Conduct the distribution in the allowed time of passing (for example sometimes trucks cannot pass during the day).

(4) The actual carrying capacity of the vehicle during the transportation shall not exceed the maximum allowable loading capacity of the vehicle or the sum of the volume of the cargo cannot exceed the volume of the vehicle;

(5) The logistics center should be capable of dealing the transportation.

7. Objective function

With regard to the logistics distribution scheduling problem, one target can be used, and multiple targets can also be used. Commonly used objective functions mainly include: the shortest total mileage of delivery, the least tonnage kilometers of distribution vehicle, the lowest overall cost, the highest punctuality, the most reasonable use of capacity, and the lowest consumption.

4.2 The classification of LCL distribution problems

LCL cargo distribution is a basic type of transportation problem. According to different classification criteria, it can be divided into a variety of categories. Classification criteria are mainly based on the difference in the type of tasks and constraints. In order to better understand the scheduling problem, its classification status will be introduced briefly as follows:

1. Categorize according to the number of logistics centers. There may be a single logistics center (only one logistics center in the distribution system) or multiple logistics centers (there are multiple logistics centers in the distribution system).

2. Categorize according to the customers' requirements on the time to take or send goods. It can be divided into hard time window problem (customer requirements must be strictly in the specified time window to send or take, which cannot be delayed or tackled in advance); Soft time window problem (customer requirements should be satisfied as far as possible within the specified time window to send or take, but is allowed to be delayed or tackled in advance. This may bring some loss to the customer, so customers should be compensated as a penalty to the responsible forwarding companies); Hybrid time window problem (some customers belong to hard time windows, others belong to soft time windows. For the same customers, both soft and hard time window may be applied simultaneously). In fact, a hard time window cargo distribution problem can be regarded as a special form of soft time window goods distribution problem, where the penalty coefficient can be set to largest if the hard time window constrains are breached.

3. Categorize according to the vehicle loading conditions. It can be divided into full load problem (customers' demand or supply of goods is greater than or equal to the vehicle's load, so the completion of a distribution task requires one or more distribution vehicles, and thus, distribution vehicles need to be fully loaded); Non-full load problem (customers' demand or supply of goods is less than the vehicle load, so a number of distribution tasks can share a distribution vehicle, and thus, the vehicle in the distribution process is often in a non-full load state) and hybrid fully and non-fully loaded problem (part of the customers' demand or supply of goods is greater than or equal to the vehicle's load, and the other part of the customer demand or supply is less than the vehicle's load, causing some distribution vehicles need to run at full load, while others are often non-full loaded status).

4. Categorize according to the characteristics of distribution tasks. It can be divided into pure

delivery problems (only picking from the logistics center to deliver to the customers, also known as the pure unloading problem); Pure picking problem (only consider picking the customers' supply of goods to the logistics center, also known as pure loading problem); Hybrid picking and delivering problem (consider both the need of the delivering goods from the logistics center to the various customers, and taking the customers' supply of goods from the to the logistics center, also known as hybrid loading and unloading problem, or integration of goods gathering and delivery issues)

5. Categorize according to the type of vehicle. It can be divided into single-vehicle problem (the load of all distribution vehicles are the same) and multi-vehicle problem (the load of distribution vehicles is not exactly the same).

6. Categorize according to the relationship between the vehicle and the yard. It can be divided into vehicle opening problem (that is, the vehicle cannot return to the yard after the completion of the distribution task); Vehicle closure problem (that is, the vehicle must return to its departing yard after completing the distribution task).

7. Categorize according to the optimization target number. It can be divided into single target problem (only consider one distribution target); Multiple target problem (considering multiple distribution targets).

8. Categorize according to the characteristics of customer and road network classification. It can be divided into static problems (customer number, customer demand, weather conditions and other factors are determined in advance); Dynamic issues (customer number, customer location, customer needs, weather conditions, etc.), there are static problems (customer number, customer location, customer needs, weather conditions and other factors are not pre-determined, but randomly changing).

The classification method used in this paper is different from the above classifications. As the paper deals with the distribution of container cargo transport, the classification is considered from the different states of the container. Container cargo transport can be divided into FCL and LCL. FCL cargo transport means that a customer's goods can be filled within a container. In this case, for the LCL / FCL structure, "delivering to the consignee’s door" is taken, that is, the company pulls the container to the customer's warehouse with trailer, and then transports back to the yard after the container is unloaded. LCL cargo transport means that the goods in a container are belong to several customers. In this case, the company normally gather the goods and deliver to the yard to load the container. When delivering the goods, they also unload the goods in the yard at first and then complete the distribution.

4.3 Analysis on factors influencing the distribution of LCL cargo

For the research of cargo distribution scheduling problem, the main issue is the optimization on the distribution line and the sequence of distribution customers, which will help achieve the best system objectives. The development of the scheduling program must take into account the combined impact of port size, customer attributes, infrastructure, economic distance and other factors.

1. Port size

The main indicator of the size of the port is the port throughput. The larger the port, the greater the corresponding throughput. Thus, the flow of the traffic in the distribution area of the port will increase. Therefore, it is critically important to arrange the reasonable time and the reasonable order of the vehicles. If not, it will lead to port congestion, delay in delivery of goods and other consequences.

2. Customer attributes

The influence of customer attributes on vehicle scheduling problem is mainly reflected in the differences in the sensitivity of arrival time of customers and the differences of the customers’ importance to logistics companies. How to properly arrange the vehicle so that it can meet the important customers’ requirements as far as possible, while taking full account of other customers' time sensitivity characteristics, is the main issue.

3. Infrastructure

Different infrastructure conditions in each port will lead to differences in routing options. Take the New York port and the port of Rotterdam as examples, it can be observed from the distribution methodologies of these two ports that, the biggest difference is reflected in the proportion of waterway collection and transportation. Through the comparative analysis of the actual situation of the two ports, the reason for this phenomenon is due to the difference of the construction of the water transportation infrastructure of the port. The port of Rotterdam relies on the well-developed Rhine River, and a large number of small wharves are distributed along the Rhine River, with highly developed waterways and a wide range of small terminals providing protection for the development of intermodal transport based on inland waterways in the port of Rotterdam. Although the port of New York has a Hudson channel network, it is relatively more isolated, as there are no wide range of terminals and waterways, resulting in the relatively low share of waterway transportation of the New York port.

4. Economic distance

Economic distance is the economy of various modes of transportation. The difference of economic distance between distribution methods leads to the difference in transportation mode selection in container distribution process, and correspondingly leads to the difference of path selection. For example, for domestic container cargo transport of China, at least 20% of the container shipments are located in inland provinces, or more than 600km in far port area. Short-distance transport are suitable for road transport, while long-distance transport can choose waterways, railways - highways, highways - waterways and other modes of multi-model transportation.

5. The rationality of the mode of transport

The adaptability of the distribution methods for different types of cargo are different. It means that the methods of distribution in the port will be influenced by the type of goods transported and the amount of the goods. Accordingly, the choice of transport routes will be affected. For example, pipeline transportation can only be used for oil, natural gas and other liquid, gas or solid particles. Customers that need door-to-door distribution services cannot be separated from road transport, so road transport, or road transport combined with other modes of transport are generally chosen.

6. Environmental factors

With the deepening of economic and trade between countries, the gradual increase of port cargo throughput has brought great challenges to the port management. Meanwhile, the expectations of the community on the establishment of environmentally friendly port development, require that the port should reduce the emission of pollutants while developing business, in order to improve the quality of the environment. An important part of green port construction is the consideration of low-emission port distribution, and reducing the proportion of high-emission freight distribution.

4.4 Model assumptions

The model mainly studies LCL cargo distribution from the port, and how to arrange a reasonable route, making the total cost of logistics activities the smallest. In order to abstract the problem of container cargo distribution in the port as a mathematical model, the following assumptions are given:

1. Customers are served in strict accordance with the production schedule for production operations, that is, all distribution should be successfully conducted in one attempt;
2. Containers are transported from the same port, and starting and ending in the same location;
3. Each target customer has a best delivery time;
4. Each target customer can only be served once;
5. The distribution vehicles' are of the same capacity;
6. The traffic is good, no congestion and traffic accidents would occur.

4.5 Model objectives

This paper mainly considers the logistics cost of the LCL Company in the transportation of container cargo and the satisfaction degree of the customer to the delivery time, and constructs the optimal cargo distribution model with the lowest cost and the total delay of distribution. Due to the strong constraint of the distribution mode on the time, the distribution problem in this model often result in a failure in achieving a solution. And in the actual production operations, requiring the LCL Company to serve every customer within a specified time is too harsh to realize, and often lead to a waste of transport capacity, resulting in unnecessary increase in costs. Therefore, the paper takes into account the requirements of LCL delivery on time, while combining with the actual situation of logistics operations. Thus, the distribution requirements will be divided into two parts, ‘’early arrival’’ and ‘’delay’’, to be considered.

For the situation that the vehicle arrive in advance, considering part of the transportation costs, regarding the early arrival of the vehicle, a certain penalty function will be set, to produce a certain waiting cost for vehicles arrived in advance. Further, when a distribution plan contains too many times of early arrival which will lead to a dramatic increase in operating costs, the plan will be rejected. For the situation that the vehicle delays, because the time characteristics of logistics distribution is an important criterion for the evaluation of service quality, it will be taken into account as a part of total delay. According to the importance of different customers to the enterprise, the vehicle delay penalty function will be introduced with regard to the importance of customers, to prevent the loss of important customers. Therefore, the model’s goal is to minimize the operating cost as well as the total delay.

1. Minimum operating costs

The operating costs mainly comprises vehicle driving costs on the road, vehicle start-up costs and stopping cost, and waiting cost considering the timing requirements regarding early arrival of the vehicle. For vehicle’s delay, it will be considered in delay function. After the vehicle arrives at the customer's warehouse to unload, it will depart to the next customer or return to the port. The process of vehicle docking is the reverse process of the vehicle's start-up.

Therefore, the vehicle's start-up and stopping costs are assumed to be the same. Assume that the time window of service for customer i is [c_i, e_i]

The LCL Company's operating costs will be:

$$\min \mathrm{C} = \mathrm{i}\sum_{v=1}^{V}\sum_{a=0}^{N-1}\sum_{b=0}^{N-1} d_{ab}x_{abv} + 2j\sum_{v=1}^{V}\sum_{a=0}^{N-1}\sum_{b=0}^{N-1} x_{abv} + k_1\sum_{a=0}^{N-1}\max(c_a - t_a, 0)$$

Where:

C --- the operating costs of the LCL Company; i --- the cost of the vehicle driving a unit distance; V --- the number of vehicles transferred by the LCL Company; N --- the number of customers served by the logistics activities (The port is also abstracted as a distribution node in order to facilitate the analysis); d_{ab} --- the distance traveled between customer a and customer b; j - the cost of a single start or stop of the transport vehicle; x_{abv} - vehicle v travels on the route from customer a to customer b, to deliver goods to customer b, and when $x_{abv} = 1$, it indicates that there is vehicle running on the road from a to b, and when $x_{abv} = 0$, it indicates that there is no vehicle running from a to b; k_1 --- the loss of cost of the vehicle due to a unit time of early arrival; c_a --- the earliest service time scheduled with customer a; t_a --- the time the vehicle arrives at customer a.

2. Minimum total delay

The delay time is an important evaluation index of the satisfaction of distribution activities. Customer satisfaction is the index that the customer compares between the perceived effect of a product or service and its own expected effect. According to the characteristics of container logistics and distribution activities, this study aims at minimizing the total delay cost in the whole logistics and distribution activities by considering the requirements of accurate delivery time in accordance with the importance of different customers for the difference between logistics enterprises and ports. The minimum delay objective function is:

$$\min \mathrm{D} = k_2\sum_{a=0}^{N-1} u * \max(0, t_a - e_a)$$

Where: D --- the overall delay time of logistics activities; k_2 --- the loss of cost due to the unit time of delay of vehicle; u --- the importance of a customer to logistics companies; e_a --- the latest agreed delivery time with customer a; t_a --- the time the vehicle arrives at customer a.

3.3.3 Constraints

During the process of operating LCL cargo at port, the service will be subject to the number of port vehicles, service type of a single customer, the characteristics of transportation process and other factors. Therefore, while ensuring that the scheduling service can meet the cost and satisfaction requirements, the limitation of aforementioned factors on the services should also be considered. Based on the above factors and the practical value of the model solution, the above description is described as the following seven constraints.

1. Vehicle total constraint

According to the rule that the number of trailer vehicles should not be greater than the largest number of vehicles the distribution company can provide for the transport activities in container distribution process, there is:

$$\sum_{b=0}^{N-1} x_{0bv} \leq V$$

Where: x_{0bv} - if vehicle V exist on the route from the port to customer b

2. Customer point constraints on number of services

According to the vehicle delivery activities, each customer can only be served once, so the number of vehicles starting with customer a must be equal to the number of vehicles stopping at customer a.

The constraints of the number of vehicles with a starting point at a:

$$\sum_{v=1}^{V}\sum_{b=1}^{N-1} x_{abv} = 1 \ a \in \{1, \dots, N-1\}$$

The constraints of the number of vehicles with a stopping point at a:

$$\sum_{v=1}^{V}\sum_{b=1}^{N-1} x_{bav} = 1 \ a \in \{1, \dots, N-1\}$$

3. Vehicle load constraint

The total demand of vehicles for the customers in the distribution activities should be less than its rated load, that is:

$$\sum_{a=0}^{N-1}\sum_{b=0}^{N-1} R_a x_{abv} \le L \ v \in \{1,2,\dots,V\}$$

Where: Ra --- customers' demand; L --- the rated load of the vehicle.

4. The vehicle starting and stopping point constraints

The dispatch of container vehicle must ensure that the transport vehicle depart from the distribution center or port, and then return to the distribution center or port after the customer service, that is:

$$\sum_{a=1}^{N-1} x_{a0v} = \sum_{a=1}^{N-1} x_{0av} \le 1 \ \ v \in \{1,2,\dots,V\}$$

5. Same vehicle distribution

The vehicle distribution process must meet the requirement that the customer is served by the same vehicle, for example, the number of vehicles that start serving from customer a must be equal to the number of vehicles that end serving at customer a, that is:

$$\sum_{a=1}^{N-1} x_{abv} - \sum_{a=1}^{N-1} x_{bav} = 0 \ b \in \{0,1,\dots,N-1\}$$

6. Self-distribution prevention

In order to prevent the route from client 'a' to client a when solving the model, there should be:

$$\sum_{a=0}^{N-1} x_{aav} = 0 \ v \in \{1,2,\dots,V\}$$

7. Vehicle arrival time

In order to judge whether the vehicle arrives within the customer's service time range, it is necessary to calculate the time that the vehicle arrives at customer a. The vehicle's arrival time can be defined as the vehicle's driving time and unloading time. If the vehicle arrived in advanced during the process of previous services, then it should be added to the vehicle's arrival time, that is:

$$\sum_{v=1}^{V}\sum_{a=0}^{N-1} x_{abv}(t_a + t_{ab} + s_a + w_a) = t_b \; b \in \{0,1,2,\dots,N-1\}$$

$$w_a = c_a - t_a \; a \in \{0,1,2,\dots,N-1\}$$

Where: t_{ab} --- travel time from customer a to customer b; s_a --- vehicle v's stay time at customer a, that is, service time; w_a --- vehicle v's waiting time if it arrives at customer 'a' ahead of schedule.

4.6 Application of the Model on Shipping Ecommerce

Before explaining the application of the model on Shipping Ecommerce platforms, a system module design for Shipping Ecommerce will be introduced. In the previous part of this dissertation, a module design was quoted. Xie (2013) defined the LCL system into five modules according to the functions, namely, Order Management Module, Consolidation Management Module, Dispatch Management Module, Goods Tracking Module, and System Design Module. This will be a reference for the application of the model as is shown below:

LCL System On Platform	Order Management Module	➢ Add Order ➢ Edit Order ➢ Delete Order ➢ Inquire Order ➢ Audit Order
	Consolidation Management Module	➢ Edit Consolidation ➢ Revise Consolidation ➢ Audit Consolidation
	Dispatch Management Module	➢ Automatically Generate Dispatch ➢ ~~Edit Dispatch~~ ➢ Revise Dispatch ➢ Audit Dispatch
	Goods Tracking Module	➢ Cargo Tracking ➢ Inquire Order
	System Design Module	➢ Client Management ➢ User Management

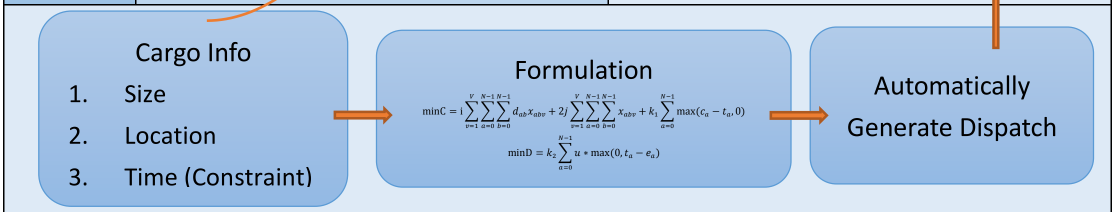


Table 2 --- Application of VRPTW Model on Shipping Ecommerce Platform

The upper part of the table was the original module design of LCL system given by Xie (2013). In this system, the dispatch arrangement has to be edited manually. The thesis talked about an optimized model that can be applied in the system. As the arrows flow in the table, by using the formulation to calculate the minimum cost while satisfying the time constraints, the dispatch will be generated automatically.

5. Realization of LCL operation with 3D visualization

Regarding the realization of LCL operation on computer, previous researches have given some discussions about the module design. More importantly, it is worthwhile to display the consolidation result to the clients clearly and transparently. As known to all, the essential problem of traditional slot booking is the insufficiency in transparency. Customers cannot acquire the latest rate directly, instead, they commonly have to ask for quotation by e-mail, tax or telephone. When it comes to LCL services, the same problem exists. Thus, in addition to the latest rate Shipping Ecommerce platforms can show regarding the LCL services, it is considered the same crucial to show the detailed consolidation arrangement, for example, which place and which container a customer's commodities are arranged. And this, can be realized with 3D visualization. It is believed that the realization of 3D visualization will help improve the volume of business of Shipping Ecommerce platforms. So in this chapter, the thesis paper will introduce how 3D visualization can be realized by various mathematical transformation and programming.

5.1 3D geometric modeling

Visualization 3D graphics container system is a graphics processing software that works based on the realization of three-dimensional geometric modeling. Geometric modeling is a technique that stores the shape of an object in a computer and forms a three-dimensional geometric model of the object. The three-dimensional geometric model is a true simulation of a state of the original object or an exact mathematical description of the original object, which provides a variety of information for a particular application, such as the ability to display the shape, center of gravity, volume, and inertia of the object in any direction at any time. Geometry is composed of basic points, edges, faces, rings, bodies, voxels and other elements, which includes geometric information and topology information. Geometric information is a description of the spatial position and size of geometric elements such as points, lines, faces, etc. Topological information reflects the relationship between geometric elements. The generation and representation of geometries are related to these two kinds of information, geometric information and topology information, to store and use the graphical data structure.

5.1.1 Figure storage model

Three-dimensional figure has three storage models in the computer: wireframe model, surface model and solid model.

Wireframe model includes two-dimensional wireframe model and three-dimensional wireframe model. It mainly uses the vertex and edge to represent the three-dimensional object, and the data structure of the object is stored by the coordinate value of each vertex and the edge. The wireframe model is simple and convenient to construct. It occupies less disk space, but can produce any view, any point or axis mapping and perspective. But the wire frame model has no surface information, so it cannot express objects with curved surfaces, and cannot generate blanking map, section view, color map. Moreover, it cannot directly show the true shape of the object, and complex shape of the object can easily lead to fuzzy understanding, so it is prone to ambiguity.

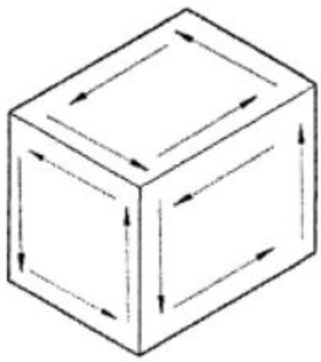
Surface model utilizes a set of surfaces to represent object. It expands the scope of the application of wireframe model, to achieve the realization of line blanking, face intersection, coloring, and CNC machining. However, in the surface model, with only a single piece of information, it cannot clearly define which side a surface of an object is on, analyze and calculate the surface area, volume of the object, and other properties. Thus, the surface model still lacks topologies between surface and body, which sometimes generates an ambiguity of understanding of the objects.

Solid model can fully represent the shape information of the three-dimensional object, and clarifies which side the entity exists. The data structure of the solid model records all the geometric information and the topological information of points, lines, faces and bodies, which can realize blanking, trimming, coloring, illumination and texture processing. So the three-dimensional objects have strong visibility, and it has a wide range of applications regarding graphics processing.

Because the wireframe model is prone to ambiguity, which will cause fuzzy understanding regarding complex shape, and the surface model sometimes lacks integrity regarding figure. Therefore, solid model is used in the system design. The data structure of the solid model records all the geometric information and topology information. It is a geometric model that can fully reflect the structure, size and properties of the object, which is the fundamental advantage against wireframe and surface model.

5.1.2 Figure representation

In this paper, the design mainly simulates the container loading situation. The geometric model used in the graphics system is mainly cuboid. The rectangular box model is shown as below. Using the right-hand rule and the outside surface vector, the consistency of the topological can be checked. According to the topological law, the direction of the two sides of the adjacent public boundary of the rectangular box is opposite, as is shown in the figure below.



5.2 3D graphics transformation

The goal of this project is to develop a smart boxing software, and establish a three-dimensional complex container optimization model to simulate the actual cargo loading in the container. In the process of 3D modeling, any kind of image must be displayed through the graphics transformation. The main content of the project is to use VC6.0 in the computer to achieve three-dimensional graphics modeling and simulation, in order to flexibly apply it on the graphics assembly system. The drawing of 3D graphics is based on the two-dimensional graphics, but no matter how complicated the graphics are, it is realized by the basic graphics transformation. Graphic transformation means that the geometric information of the graph is geometrically transformed to produce new graphics. In computer graphics, the commonly used transformations are geometric transformations, projection transformations, and coordinate system transformations. Through graphical transformations, simple figures can be generated to complex graphics. Also, 2D graphics can be used to represent 3D graphics.

5.2.1 Geometric transformation

The geometric transformation of the three-dimensional figure is a transformation with respect to the coordinate axis and the origin. The essence of the geometric transformation is the change of the coordinate position of the graph. The basic elements of the figure are points, points constitute line, line forms the surface, and surface forms body. So as long as the coordinates of each point are changed, the geometric transformation of the entire graphics also occurred. It is convenient to use the homogeneous coordinates to represent the transformation of the points. The fourth coordinate is introduced into the three-dimensional vector of the three-dimensional figure, that is, the coordinates of the homogeneous coordinates, so that the three-dimensional geometric transformation can be unified with the matrix in the four-dimensional homogeneous coordinates.

The geometric transformation of a three-dimensional graph is a 4-order square matrix if represented by a homogeneous coordinate:

$$[x' \quad y' \quad z' \quad 1] = [x \quad y \quad z \quad 1] * T = [x \quad y \quad z \quad 1] * \begin{bmatrix} a & b & c & o \\ d & e & f & p \\ g & h & i & q \\ u & v & w & k \end{bmatrix}$$

Where T can be divided into four matrixes, which are:

$T_1 = \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix}$, which conducts rotation, scaling and shearing transformation on 3D graphics;

$T_2 = [u \quad v \quad w]$, which conducts translation transformation on graphics;

$T_3 = [k]$, which conducts scaling transformation on graphics as a whole;

$T_4 = \begin{bmatrix} o \\ p \\ q \end{bmatrix}$, which conducts perspective projection transformation matrix on graphics.

The basic transformations of 3D graphics include translation transformations, rotation transformations and scale transformations, and other complex transformations are also implemented by a combination of the basic transformations. Translation and rotation can be achieved by manually editing the movement and rotation of the goods in the module. It is the most important two transformations of the manual editing function.

(1) Translation transformation

In a three-dimensional graphics system, translation is a very important transformation, and the movement in all three-dimensional scenes is based on the translation transformation. The translation transformation is to move a point under the space axis in the direction of the coordinate axis to obtain a new coordinate point. For example, point P(x, y, z) is shifted u, v, w, on the x, y, z direction to get the new coordinate point P'(x', y' z'), then the translation transformation will be:

$$x' = x + u \quad y' = y + v \quad z' = z + w$$

$$[x' \quad y' \quad z' \quad 1] = [x \quad y \quad z \quad 1] * T = [x \quad y \quad z \quad 1] * \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ u & v & w & 1 \end{bmatrix}$$

Where,

$T = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ u & v & w & 1 \end{bmatrix}$, is the matrix of translation transformation.

(2) Rotation transformation

Rotational transformation is also a very important transformation of the three-dimensional scene. Only if the rotation function is completed, the observation of each angle in three-dimensional scene can be achieved. The three-dimensional rotation transformation includes rotation around the x,y,z axis and rotation around any axis. For example, point P(x, y, z) is rotated around an certain axis with an angle of ɑ to get the new coordinate point P'(x', y' z'), then the rotation transformation will be:

Under the case of rotation around X axis:

$$[x' \quad y' \quad z' \quad 1] = [x \quad y \quad z \quad 1] * \mathrm{T}_x = [x \quad y \quad z \quad 1] * \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & cos\alpha & sin\alpha & 0 \\ 0 & -sin\alpha & cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Where,

$\mathrm{T}_x = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & cos\alpha & sin\alpha & 0 \\ 0 & -sin\alpha & cos\alpha & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$, is the matrix of rotation transformation.

Under the case of rotation around Y axis:

$$[x' \quad y' \quad z' \quad 1] = [x \quad y \quad z \quad 1] * \mathrm{T}_y = [x \quad y \quad z \quad 1] * \begin{bmatrix} cos\alpha & 0 & sin\alpha & 0 \\ 0 & 1 & 0 & 0 \\ -sin\alpha & 0 & cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Where,

$\mathrm{T}_y = \begin{bmatrix} cos\alpha & 0 & sin\alpha & 0 \\ 0 & 1 & 0 & 0 \\ -sin\alpha & 0 & cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$, is the matrix of rotation transformation.

Under the case of rotation around Z axis:

$$[x' \quad y' \quad z' \quad 1] = [x \quad y \quad z \quad 1] * \mathrm{T}_z = [x \quad y \quad z \quad 1] * \begin{bmatrix} cos\alpha & sin\alpha & 0 & 0 \\ -sin\alpha & cos\alpha & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Where,

$\mathrm{T}_z = \begin{bmatrix} cos\alpha & sin\alpha & 0 & 0 \\ -sin\alpha & cos\alpha & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$, is the matrix of rotation transformation.

Under the case of rotation around any axis:

Point P(x_p, y_p, z_p) is rotated around axis AB with an angle of β to get the new coordinate point P'(x_p', y_p' z_p'), where AB is determined by point A'(x_r', y_r', z_r') and its direction (a, b, c), then the rotation transformation will be:

$$[x_p{}' \quad y_p{}' \quad z_p{}' \quad 1] = [x_p \quad y_p \quad z_p] * \mathrm{R}_{rb}(\beta)$$

Where,

$$\mathrm{R}_{rb}(\beta) = T^{-1}(x_r\ y_r\ z_r)R_x{}^{-1}(\alpha)R_y{}^{-1}(\gamma)R_z(\beta)R_y(\gamma)R_x(\alpha)T(x_r\ y_r\ z_r)$$

To achieve the rotation of point P, we need to move point A to the origin of the coordinates, and then rotate AB around the X axis and Y axis with appropriate angles so that it coincides with the Z axis, and finally rotate around the Z axis with an angle of β. The reverse operation of the above transformation enables AB to return to its original position so as to achieve the rotation of point P. Here, α and γ is the angle between of AB with regard to plain YOZ, and between AB with regard to the projection of plain YOZ respectively.

(3) Scaling transformation

Through the scale transformation, objects or scenes can be enlarged or reduced, so that the observation can be easier. Assume that the scale of point P(x, y, z) on x, y, z axis is (k_x, k_y, k_z), then the scaling transformation will be:

$$[x' \quad y' \quad z' \quad 1] = [x \quad y \quad z \quad 1] * \mathrm{T}_k = [x \quad y \quad z \quad 1] * \begin{bmatrix} k_x & 0 & 0 & 0 \\ 0 & k_y & 0 & 0 \\ 0 & 0 & k_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= [k_x * x \quad k_y * y \quad k_z * z \quad 1]$$

And,

$\mathrm{T}_k = \begin{bmatrix} k_x & 0 & 0 & 0 \\ 0 & k_y & 0 & 0 \\ 0 & 0 & k_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$, is the matric of scaling transformation for the 3D graphics with regard to the origin.

5.2.2 Projection transformation of 3D graphics

To display the three-dimensional effect of the container on the screen, it will refer to the projection transformation of three-dimensional object. Projection transformation is the process of projecting the geometrical representation of the three-dimensional coordinates onto the projection plane to obtain the two-dimensional plane pattern. It is the basis of the multi-view representation of the product model and one of the most important techniques for displaying the 3D graphics onto two-dimensional devices. Projection transformation is a very important principle transformation in the process of 3D modeling. The 3D coordinates of any spatial object must be converted to a coordinate that can be displayed on the coordinate system. Then, it is possible to display the 3D geometry on the plane coordinate system on the computer screen.

Depending on the distance between the projection center and the projection plane, the projection transformation can be divided into perspective projection and parallel projection. The distance between the projection center of the parallel projection and the projection plane is infinite, indicating that the projection line direction is given only when the projection is parallel, and the size of the object after projection is independent of the distance between the object and the viewpoint. In terms of perspective projection, the distance between the projection center and the projection plane is limited, and the position of the projection center needs to be clearly defined. When conducting three-dimensional packing view design, the distance of the point of view can be altered by the changing of image magnification. And through the perspective projection, the visualization of the box can be achieved, in order to check the loading effect in all directions.

1. Orthographic projection

Through orthographic projection, we can get the three-view drawing of an object. The projection of 3D graphics on plain XOZ is called front view, while the projection on plain XOY is called vertical view and the projection on plain YOZ is called side view.

Front view

Front view can be shown by conducting vertical projection for the 3D graphics on plain XOZ, in other words, assuming that Y is equal to zero. The transformation matrix will be:

$$T_x = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Vertical view

Vertical view can be shown by conducting vertical projection for the 3D graphics on plain XOY, in other words, assuming that Z is equal to zero. The transformation matrix will be:

$$T_y = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Side view

Side view can be shown by conducting vertical projection for the 3D graphics on plain YOZ, in other words, assuming that X is equal to zero. The transformation matrix will be:

$$T_z = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

2. Axonometric projection

By rotating the object around the Z axis counterclockwise with an angle of γ, and around the X axis clockwise with an angle of ɑ, and then conduct the orthographic projection and plain XOZ, you can get the axonometric drawing of the object. The axonometric projections that are used widely in engineering problems are isometric projection and diametric projection. The transformation matrix of axonometric projection is:

$$T_a = \begin{bmatrix} cos\gamma & 0 & -sin\gamma sin\alpha & 0 \\ -sin\gamma & 0 & -cos\gamma sin\alpha & 0 \\ 0 & 0 & cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Isometric projection

When the scaling of axonometric projection on x, y, z direction is the same, it is called isometric projection. In such case, γ=45°, and α=35° 16’. Substituting the value of matrix T_a with γ &α, the transformation matrix of the isometric projection will be:

$$T_i = \begin{bmatrix} 0.707 & 0 & -0.408 & 0 \\ -0.707 & 0 & -0.408 & 0 \\ 0 & 0 & 0.816 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Diametric projection

When the scaling of axonometric projection on x, z direction is the same, it is called diametric projection. In such case, γ=20° 42’, and α=19° 28’. Substituting the value of matrix T_a with γ &α, the transformation matrix of the diametric projection will be:

$$T_i = \begin{bmatrix} 0.935 & 0 & -0.118 & 0 \\ -0.354 & 0 & -0.312 & 0 \\ 0 & 0 & 0.943 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The aforementioned tools may probably be used in the realization of 3D visualization of LCL arrangement.

5.2.3 Coordinate system transformation

Coordinate system transformation is a very important transformation in 3D modeling and simulation. Because 3D objects can only be observed in the corresponding observation coordinate system, the realization of the conversion of coordinates can only be achieved by projecting the 3D system coordinates (of the three-dimensional space system) onto the observed plane coordinates system.

1. Coordinate system

World Coordinate System (WC), also known as user coordinate system, is the most commonly used coordinate system which defines the users’ objects in two-dimensional and three-dimensional world. Its domain is real field, infinite and continuous. The device coordinate system (DC) is a coordinate system of a graphic output device (such as a plotter or a display). It is a two-dimensional plane coordinate system whose domain is integer field and is bounded.

For example, the limit range of the coordinate system of the display is its resolution. The Normalized Device Coordinate System (NDC) is a standard device defined for the ease of graphics processing because different graphics devices have different device coordinate systems, which is not convenient for the processing of graphics and the porting of applications. The range of the normalized device coordinate system is: from the lower left corner (0.0, 0.0) to the upper right corner (1.0, 1.0). Transforming the user's graphical data into value in normalized device, can isolate the application from the graphics device, and thus, enhance the portability of the program.

2. Window and viewport transformation

A window is a visible part of a graphic in a computer. It is a rectangular area used to display the contents defined in the user coordinate system. Only the graphics in the rectangular area can be output in the device coordinate system, and the part outside the window will not be output. The size and position of the window is determined by the coordinates of the lower left corner and the upper right corner of the rectangular area. By changing the position, size and scale of the window, you can control the size of the graph and observe the local pattern more easily.

The viewing area is usually a rectangular area defined in the screen, and is mainly used to output the graphics in the window. The viewing area determines the location and size of the graphics on the screen, and its area should be less than or equal to the screen area.

The window and the viewport are often defined in different coordinate systems. To transfer the graphics from the window to the viewport, the coordinate transformation, that is the window-view transformation, must be performed. The transformation matrix will be:

$$\mathrm{T}_{wv} = \begin{bmatrix} \frac{V_{xr} - V_{xl}}{W_{xr} - W_{xl}} & 0 & 0 \\ 0 & \frac{V_{yt} - V_{yb}}{W_{yt} - W_{yb}} & 0 \\ V_{xl} - \frac{V_{xr} - V_{xl}}{W_{xr} - W_{xl}} * W_{xl} & V_{yb} - \frac{V_{yt} - V_{yb}}{W_{yt} - W_{yb}} * W_{yb} & 1 \end{bmatrix}$$

Through the window-view transformation matrix, the coordinate values in the user coordinate system can be transformed into coordinate values in the device coordinate system, and the graphics in the window of the user coordinate system are be transformed into the graphics of the viewport in the output device.

5.3 Reference coding for the realization of functions

To define the eight vertex of the rectangular, we can use the following code

```
void CBaseClass: : ReadVertexOfGraphics ()
{
x[1] = x_1; y[1] = y_1; z[1] = z_1;     c[1] = l;
x[2] = x_2; y[2] = y_2; z[2] = z_2;     c[2] = l;
x[3] = x_3; y[3] = y_3; z[3] = z_3;     c[3] = l;
x[4] = x_4; y[4] = y_4; z[4] = z_4;     c[4] = l;
x[5] = x_5; y[5] = y_5; z[5] = z_5;     c[5] = l;
x[6] = x_6; y[6] = y_6; z[6] = z_6;     c[6] = l;
x[7] = x_7; y[7] = y_7; z[7] = z_7;     c[7] = l;
x[8] = x_8; y[8] = y_8; z[8] = z_8;     c[8] = l;
}
```

If we try to do various mathematical transformation with C language, the coding might be:

```
void CBaseClass: :Calculate(array B)
{
ReadVertexOfGraphics(); //The origin vertex of graphics
for (int i = 1; i <= 8; ++i) //Calculating the new vertex of graphics
{
xT[i]=3*x[i]*B[1][1]+3*y[i]*B[2][1]+3*z[i]*B[3][1]+c[i]*B[4][1];
yT[i]=3*x[i]*B[1][2]+3*y[i]*B[2][2]+3*z[i]*B[3][2]+c[i]*B[4][2];
zT[i]=3*x[i]*B[1][3]+3*y[i]*B[2][3]+3*z[i]*B[3][3]+c[i]*B[4][3];
```

```
}
}
```

If we want to output the graphics, the coding might be as follows (for front view):

```
void CBaseClass::OutputGraphicsFront(CDC* pdc, CRect rr)
{
xx=rr.right/2;
yy=rr.bottom/2;
Calculate(A); //Conduct projection transformation for the graphics
moveto(xx-xT[1], yy-zT[1],pdc);
for(int i = 2; i<=8; ++i) // Draw the graphics
lineto(xx-xT[i], yy-zT[i]5pdc);
moveto(xx-xT[4]s yy-zT[4],pdc);
lineto(xx-xT[1], yy-zT[1],pdc);
lineto(xx-xT[6], yy-zT[6],pdc);
moveto(xx-xT[5], yy-zT[5],pdc);
lineto(xx-xT[8],yy-zT[8],pdc);
lineto(xx-xT[3], yy-zT[3],pdc);
moveto(xx-XT[2], yy-ZT[2],pdc);
lineto(xx-xT[7], yy-zT[7],pdc);
}
```

5.4 Application of 3D Visualization on Shipping Ecommerce

The same as chapter 4.6 does, the paper shows Xie's system module design at first, and then illustrates how 3D Visualization can be extended in that system. The detailed design is indicated as follows:

LCL System On Platform	Order Management Module	➢ Add Order ➢ Edit Order ➢ Delete Order ➢ Inquire Order ➢ Audit Order
	Consolidation Management Module	➢ Edit Consolidation ➢ Revise Consolidation ➢ Audit Consolidation ➢ 3D Visualization (Administrator)
	Dispatch Management Module	➢ Automatically Generate Dispatch ➢ Revise Dispatch ➢ Audit Dispatch
	Goods Tracking Module	➢ Cargo Tracking ➢ Inquire Order ➢ 3D Visualization (Customer)
	System Design Module	➢ Client Management ➢ User Management

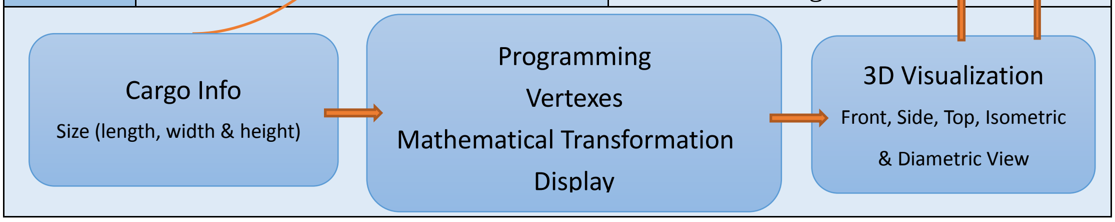


Table 3 --- Application of 3D Visualization on Shipping Ecommerce Platform

The upper part of the table was the original module design of LCL system given by Xie (2013). 3D Visualization was applied as an extension of function on the basis of that system. It is divided into two parts to display various Three-Dimensional Views to the administrator and the customers respectively in two different module. By collecting the basic cargo information, the system generates the Vertexes of it. Through various mathematical transformation, and a certain means of programming, 3D Visualization can be realized by using different kinds of views.

6. Conclusion and Recommendation

6.1 Main Findings

This paper studied the current situation of shipping e-commerce. Through the study of the background, it was found that the development of LCL business for e-commerce platform is worthy to be researched.

By studying the cost structure of LCL operations, it turned out that most processes in the flow of cargo will contribute to a fixed cost, while the cost of collection and transportation of LCL goods from the port to different customers' warehouse may be variable.

It is of great theoretical and practical significance to explore how to plan the distribution of container goods reasonably, reduce the logistics cost effectively and improve the quality of logistics service.

In this paper, the issue of container LCL cargo distribution is explicitly analyzed. The thesis paper put forward the concept to involve timely production of port container cargo in distribution operations. The report studies the current research progress, and analyzed how the use of time-standardized production bring advantage to the container LCL cargo distribution management. Its impact on the LCL cargo distribution operations was considered, and a model to minimize the cost of LCL cargo distribution was established.

This paper expatiates on the development process of cargo from distribution problem with no time window to distribution problem with time window constraint. On the basis of the research on commonly used distribution operation, this paper puts forward the concept to abstract the problem of LCL cargo transportation problem to container transportation problem under soft time window.

In order to construct the model for LCL distribution, firstly the operational processes of container distribution at port was analyzed from macro perspective. Then the disadvantages of traditional port container distribution logistics was illustrated, and the advantages of on-time production into the container logistics management was introduced. After that, the paper talked about the port scale, the customer attribute, the infrastructure, the economic distance and other factors that influence container cargo distribution. Finally, combined with the punctuality requirements of on-time production of container cargo distribution, a model that aimed at minimizing the operating costs and delays was constructed, while satisfying the constraints of the number of vehicles, the routes, and the number of services, and so on.

After the construction of the model, the thesis paper introduced the concept of 3D visualization. This can be achieved by using various kinds of mathematical transformation on a certain software. The paper illuminated how these transformation can be conducted with matrix, and the steps how 3D visualization of LCL cargo mapping can be realized. The paper also indicated some simple programming on the core of the realization of functions.

6.2 Limitations of research

When considering the cost structure of LCL transportation, emphasis was put on the variable cost, that is collection and transportation cost. Further researches can be done to study the other costs and if these costs can be optimized.

When constructing the model, the thesis paper mentioned the factor, importance of clients, but didn’t involve this factor into the model. So, if further researches are conducted, the importance of clients can be considered.

After finishing building the model, the dissertation talked about a general structure how to program and realize the 3D visualization of the outcome of LCL operation, which is the mapping of the cargo. However, the paper only talked about the concept and gave some basic programming ways. It did not really go through programming and coding. If the project is proved worthwhile to be further studied, a discussion on the detailed programming of connection between the 3D visualization and different modules can be a recommendation.

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