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Optimization of goods transport for multimodal logistic platforms

Thesis

Presented to the obtaining of the diploma of doctor in automatic and production engineering

University of Lille

Faculty of Science and Technology

By

Said moh Ahmed

14 january 2021

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Optimisation du transport de marchandises pour les plateformes logistiques multimodales

Thése de doctorat

Présentée en vue de l'obtention du diplôme de docteur en automatique et productique

Université des Sciences et Technologie de Lille
Faculté des sciences et de la technologie

Par

Monsieur Said Moh AHMED

Thése soutenue Le 14 Janvier 2021

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Résumé

Ces dernières années, les problèmes environnementaux sont fortement associés à l'industrie des transports, les modes de transport de marchandises deviennent plus que la contribution la plus importante entre les autres secteurs. Malgré les avantages du transport intermodal, il a toujours des impacts négatifs, qui sont associés aux émissions. Cependant, la pollution est devenue intéressante entre les secteurs académique et industriel. Ainsi, pour atténuer les impacts négatifs du transport de marchandises, cela gagne de plus en plus en pertinence dans le domaine de la logistique. Pour répondre à ces enjeux et défis, pour identifier les apports de la logistique verte à l'optimisation du transport de marchandises, augmenter l'efficacité des opérations d'optimisation liées à la plateforme de transport multimodal. Le fonctionnement optimal du transport de conteneurs est particulièrement important lorsque le transport de marchandises de manière écologique peut être réalisé en combinant différents modes de transport et en coordonnant des activités telles que la recherche du chemin le plus court. Dans le système de transport multimodal de conteneurs, la sélection du mode de transport et de l'itinéraire a un effet important sur le processus de transport des conteneurs de transport. Dans cette thèse, pour organiser le transport multimodal de manière plus efficace, le facteur de routage des conteneurs est considéré avec le facteur de trajet du mode de transport. On étudie l'influence des caractéristiques incertaines du fonctionnement du nœud sur le mode de transport et le choix de l'itinéraire dans le processus de conversion du mode de transport du transport multimodal conteneurisé. Pour minimiser le coût total, un modèle de programmation mixte avec des contraintes de temps est introduit. La transformation graphique est utilisée pour transformer le problème en modèle de chemin le plus court avec des caractéristiques aléatoires et des contraintes de temps de transport dans les opérations de nœud. En vérifiant et en analysant les résultats, le chemin obtenu est acceptable d'un point de vue coût et temps. Ainsi, cela réduit la congestion du trafic et minimise les émissions. Dans le contexte de la congestion du trafic et de la réduction des émissions, cette thèse propose une technologie de peloton pour améliorer la consommation de carburant, la flexibilité routière et optimiser les opérations de transport de conteneurs. Dans cette thèse, un système de téléphérique pour le transport de petites marchandises est proposé et analysé afin de réduire la congestion du trafic dans la zone urbaine.La recherche conclue à l'optimisation des plates-formes de transport multimodal vise à réduire les impacts négatifs sur l'environnement et à maximiser la rentabilité en maximisant les services offerts qui minimisent le coût total de transport ainsi que le temps de transport entre chaque paire de nœuds Origine-Destination (OD) dans le réseau de transport. Ces travaux contribuent également à réduire les émissions de dioxyde de carbone en diminuant la consommation de carburants et en réduisant les coûts d'exploitation. Sur la base de ces travaux, des plates-formes de transport de conteneurs plus efficaces et efficientes peuvent être réalisées. Cette thèse introduit la base théorique de l'optimum de transport multimodal qui permet l'intégration entre différents modes. Parallèlement, il contribue à la logistique de l'efficacité du transport multimodal / intermodal.

Keywords:

Transport multimodal, Logistique (gestion), Transport durable, Transport de marchandises – Coût-efficacité – Économies d'énergie, Transport par câble, Programmation par contraintes, Optimisation mathématique

Abstract

In recent years, environmental issues are highly associated with the transport industry, modes of goods transport become more than contribution as largest between other sectors. Despite the benefits of intermodal transport, it still has negative impacts, which are associated with emission. However, pollution has become interesting between academic and industrial sectors. Thus, to mitigate the negative impacts caused by goods transport, that gains more and more relevance in the logistics domain. To meet these issue and challenges, to identify the contributions that green logistics to the optimization of freight transport, the increase the efficiency of the multimodal transport platform related optimization operations. The optimal operating of container transport is particularly important where goods transport in an environmentally way can be achieved by combining different modes of transport and coordinating activities such as finding the shortest path. In the multimodal container transport system, the selection of the transport mode and route has a large effect on the transport container transport process. In this thesis, to organize multimodal transport in a more efficient manner the container routing factor is considered along with the path factor of transport mode. The influence of the uncertain characteristics of the node operation on the transport mode and route choice in the process of converting the transport mode from containerized multimodal transport is studied. To minimize the total cost, an integer mixed programming model with time constraints is introduced. The graphical transformation is used to transform the problem into the shortest path model with random characteristics and transport time constraints in the node operations. By verifying and analyzing the results, the path obtained is acceptable from a cost and time perspective. Thus, this reducing traffic congestion and minimizing emissions. In the context of traffic congestion and emissions reduction, in this thesis a platoon technology is proposed to improve to reduce fuel consumption, road flexibility and optimize container transport operations. In this thesis, a ropeway system for the transport of small-scale goods is proposed and analyzed to reduce the traffic congestion within the urban area. The research concluded to optimization multi-modal transport platforms aims to reduce negative impacts on the environment and maximize profitability maximizing the services offered that minimize the total transportation cost as well as minimize the transportation time between each pair of Origin-Destination (O-D) nodes in the transport network. This work also contributes to reducing carbon dioxide emissions by decreasing consumption fuels and reducing operating costs. Based on this work, more effective and efficient container transport platforms can be achieved. This thesis introduces the theoretical base of optimal of multi-modal transport which can integration between different modes. Meanwhile, it contributes to logistics of multi/inter-modal transport efficiency.

Keywords:

Multimodal transport, Logistics (management), Sustainable transport, Freight transport - Cost-effectiveness - Energy savings, Cable transport, Constraint programming, Mathematical optimization

Related publications

Books, chapter

1. Saïd Hayat and Saïd Moh Ahmed : ISTE - Automation Challenges of Socio-technological System - Chapitre 7 ; Part 4. System Modeling and Decision Support ; 7. Fuzzy Decision Support Model for the Control and Regulation of Transport Systems, 28 pages. ISBN : 9781786304223 ; Publication Date : July 2019 Hardcover 360 pp**.**

Journal papers

1 **S.Moh Ahmed, Said. Hayat, Yassin El Hillali, Atika Rivenq:** "Green Freight Transportation Trends: Truck Platoon Application" (Manuscript Number: JCR-2020-06-1672 was accepted for publication in the Journal of Critical Reviews.

Communications

1. **S. Moh Ahmed, S. Hayat, Atika RIVENQ, Yassin ElHillali** Toward Green Road Freight Transportation Trends: Truck Platoon Application "International Conference on Global & Emerging Trends 2-4 May, 2018, Baze University, Abuja Nigeria"

2. **S. Moh Ahmed, S.Hayat, Atika RIVENQ , Yassin ElHillali** Contribution for Green Road Freight Transportation: Truck Platoon Application Based on Fuzzy Logic." 5th International Conference on Green Energy and Environmental Engineering - GEEE-2018- April 28 – 30, 2018 – Sousse, Tunisia.

3. **S. Hayat, S. Moh Ahmed, Atika RIVENQ, Yassin ElHillali,** Green application for transport system by câbles Project : 4th Dimension 1ère édition du Workshop International en Technologies de l'Information et de la Communication au service d'une Ville intelligente, May, 2018, Marrakech, Morocco.

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List of abbreviations

MLP	**M**ultimodal **L**ogistic **P**latform
GHG)	**G**reen**h**ouse **G**as
CO2	dioxide for carbon emissions
TEU	**T**wenty-Foot **E**quivalent **U**nit
CC	**C**ruise **C**ontrol
ACC	**A**daptive **C**ruise **C**ontrol
V2I	**V**ehicle to **i**nfrastructure
BDG	**B**icable **D**etachable **G**ondolas
DG	**D**etachable **G**ondolas
TDG	**T**ricable **D**etachable **G**ondolas
ART	**A**erial **r**opeway **t**echnology

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General Introduction

Introduction

With the acceleration of the process of global economic integration, the transport network has become increasingly complex, the transport of containers and goods by different transport modes have formed a multimodal transport system that combines major shipping lines and inland transport networks. In order to organizing the multimodal transport of containers in a more reasonable and efficient way, the authorities are forceful of increasing attention to reducing transport costs and improving the competitiveness of products on the market [1]. A characteristic feature of multimodal transport is using of two or more different modes of transport, such as roads, trains, airports or waterways as shown in figure 0.1, Thus, Multimodal Logistic Platform (MLP) is defined as the place where more than one transportation mode interacts with other mode(s) in an integrated way. This meeting point increases the transportation flow efficiency making it more reliable, flexible, and sustainable, its environmental benefits towards sustainable transportation. [2].

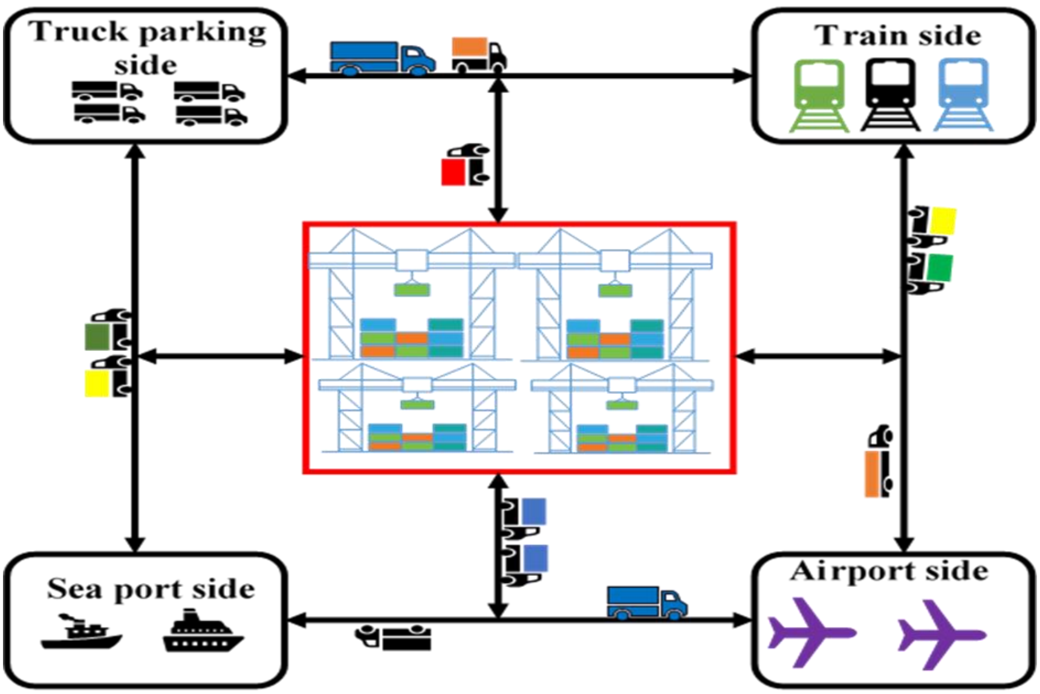

Figure 0.1: Network representation of Multimodal transport logistics platform.

In actual operation, when freights are transshipped between different combined transportation modes, there are some problems with loading and unloading, handling at transport node (terminal/hub) in time and storage operation[3]. Despite Increasing and switching container transport volumes also places higher demand on capacity requirements and performance of yard land transport services with different delivery time windows, in this context, as the traditional transport has several problems, such as traffic congestion or other environmental problems which add unpredictable delay, this delay will increase waiting time and leading disturbance in the logistic operations. More efficient terminal transport may also help to release containers faster and reduce terminal traffic congestion at the multimode platform. Consequently, expansion mode for the container handling capacity of MPL. Due to the advantages of trucking transportation, such as flexibility and high frequency, the market share of trucking transportation is increasing around the world [4]. Effective and efficient are an important one characteristic of multi-modal transportation, effectively reducing and avoiding transshipment delay time are the important tasks of transport system, reduce the total cost of the multi-modal transportation system, delay risk and increase the effectiveness of freight transport services [5]. The logistics system can be defined as the integrated management of all activities necessary to ensure the transport of products throughout the supply chain[6]. In this context, with regard to logistics as a major economic activity that includes the process of planning, implementing, controlling, efficiency, effectiveness, and flow of goods, Thus, the multi-modal transport logistics is rapidly becoming an important component of logistics throughout the world [7]. Transport systems are one of the main logistics functions that play an important role in the different stages of production and distribution procedures, starting with the manufacturing process and ending with the delivery of finished products to consumers. The optimization of the transport system can considerably increase the efficiency of the entire logistics system overall, where demand for freight transport services is growing rapidly, which in turn leads to increased economic growth[8][9]. Moreover, enhancing the efficiency of transport operations by taking into account the principles of logistics management, This means optimizing transport flows ,The depot to the customers through an intermediate point [10]. Transshipment can directly affect transport cost and transit time. In particular, multimodal transport route selection is salient in international trade to minimize cost, risk. Through the discussion of the logistics industry, finding suitable methods to solve the problems in actual operation has become a topic that many experts and scholars are studying, and it is also an enterprise. Managers are very concerned about issues. The truck logistics studied in this chapter is a logistics method that uses commercial trucks as goods. The current research on container multimodal transportation assumes that the time and cost of the transportation mode conversion operation at the node are a certain fixed value. The change in the conversion time, operation cost, the influence of the choice of routes [11] . In actual operations, when containers are converted between different transportation modes, the time and cost of the conversion operation are often random due to waiting or other uncertain factors. Therefore, this thesis proposes an optimization method for the container inland distribution transportation, and when the node operation time has random characteristics[12][13][6]. This thesis study and analyses the available transportation routes and transportation mode combinations in the container multimodal transportation process to help container multimodal transportation organizers make decisions. the road transport mode through the trucks represents an important resource for container transportation and the development of logistic multimodal. However, the high proportion of truck transport can cause the pollution and increase congestion between nodes. Hence, the subsequent delays may greatly increase the transportation cost and emission[14][15]. Trucks platooning represents a promising method of reducing the road congestion and the fuel consumption in long-distance transport. Consequently, reducing emissions[16] [17]. In this context, within this thesis an operational of truck Platoon with time windows is formulated as a mixed-integer linear programming problem and solve it with exact solutions[18][19]. A highway network model and a group of trucks is used as Case state study in order to reduce total cost[20]. Using an aerial mode of transport and its application in the logistics transport system for a short distance, where the aerial transport mode can be realized as a part of multimodal transportation mode[21][22]. The aerial ropeway transit (ART) has gained more attention regarding its energy-efficiency in goods transporting modes at transhipment areas and limited spaces which reflect positively on the environmental issues[23][24]. Aerial ropeways are more economically and environmentally beneficial in short distance, especially in Case states when the terrain, high density of the housing and industrial development[22][25].

The research presented in this thesis is motivated by the fact that traffic congestion, in the port and road network as a multimodal transport system, is affected by large container transport flows and the extensive operations of the sector, where these operations create competition and growth in economic factors. Logistics operation through multimodal transport also has a positive effect on public infrastructure, reduction traffic congestion and the environmental impacts such as air pollution. As trucks have to travel to transition points where the containers are picked up by straddle carriers or cranes, the truck sequences at the gate and at the transition points need not be the same. The distance between the intermodal terminal and storage area causes an increase in the movement of trucks and equipment, thus increases the congestion from this equipment and trucks. thus, Inefficient intermodal transportation causes congestions at the peak period, because truck traffic is increasingly congested the reason for conducting the study was based on the desire to maximize the efficiency of the transshipment freight transport and minimize the negative impacts such as the delay in freight handling system which leads high CO_2 emission. Furthermore, Green logistics transportation impose new requirements on flow optimization over complex logistics network. Therefore, this thesis focusing on the optimal operating within the multimodal system in order to implement efficient transport mode. Therefore, we propose an optimization model where the total cost was minimised, including operation cost, fuel cost and relation to emissions. In addition, promote the construction of an efficient and green cargo transportation system, the realization of emission reduction in the freight industry, and realize the reduction of energy consumption and emissions while increasing the scale of freight transportation.

Objectives of the thesis

The reducing transportation costs is taking a significance increased due to the environment issues and fluctuating fuel costs. Optimal transportation routes that remove losses from supply chains are a source of competitive advantage. On the basis of enhance the operating of multimodal transportation system and reduce the fuel consumption, this thesis aims to achieve the route optimization of multimodal transport system and its logistics operating by:

- Minimize transportation costs and delivery time for Optimize the freight network, the conversion of cargo to energy-saving, and emission-reducing transportation methods by improving connectivity, optimizing routes.
- Promote the application of energy-saving and environmentally-friendly technologies such as platooning technology, cable car, as improve transport efficiency, save energy, and reduce emissions.
- Achieve new concepts of freight transport and logistics, minimize the truck travel individual, and the formation of the green transport corridors.

Research questions

1. When do many trucks use the same route at the same time on the road network?
2. How to minimize congestion of container yards in a multimodal platform?
3. How using new technology, the formation of green transport corridors?

Organization of the thesis

In view of this question and the objectives of this thesis and to present the different steps followed and the resulting outcomes, this thesis follows a sequential approach with a first, essentially theoretical phase, followed by a second, more practical phase. It is divided into five chapters.

The first chapter presents the context and problems of our research. First of all, we present an overview of the background and definitions used in the domain of transport logistics. Then, we list the main characteristics, such as structures, flows and management levels of the logistics chain and describe the transport activity. At the end of this chapter, we present the multimodal transport context of freight transport which motivated our study of compartmentalized transshipment problems and transport logistics.

The second chapter is a review of the literature on the various themes related to our problem. This is the literature on transport system and their mode related problems and their applications in the field of transport logistics. The objective is to review the basic concepts required to understand multimodal transport problems, both for modelling and for the most methods approaches to solving them.

The third chapter deals with the problem of transport optimizing. Therefore, this thesis proposes an optimization method for the container inland distribution transportation, and when the node operation time has random characteristics. This thesis study and analyzed the available transportation routes and transportation mode combinations in the container multimodal transportation process to help container multimodal transportation organizers make decisions. The study of this problem begins by describing the problem. The first step is to identify the company's real-world transport problem, also known as the problem of logistic service stations with time windows, before proposing a mathematical formulation. A short review of the literature is presented, focusing on a few similar a publication and allowing us to position our problem in this literature. Finally, construction and improvement methods were proposed in order to generate initial solutions and then improve them.

The fourth chapter: This chapter represents the outcome and findings of the study with a comprehensible form of a short explanation. This chapter apply the user truck platoon of the platoon technology as well as the functions available of it. The second part using overhead cable car system for transport goods

The fifth chapter: The last chapter of the study discusses the whole, which made the results and findings obtained from the previous chapter and create the main conclusion of this study with all suggestions for perspective works

Chapter 1. State of art and studied problems

The purpose of this chapter is to provide an overview of the multimodal logistic platform under study. Firstly, it provides a brief background on intermodal transport and logistics, followed by an alarming environmental and economic context. Secondly, it examines the trends in freight logistics from the transport practices of multimodal logistics platforms. Finally, it considers multimodal transport in the context of the main objectives of the study.

1.1 Introduction

The rapid development of world goods transport has brought severe environmental problems. In recent years, severe smog disasters and Acid rain have continuously erupted in many parts of the world, the whole of the world society has paid unprecedented attention to the environment[26]. The governments have also regarded economic, energy conservation /fuel consumption reduction and environmental as their main goals as shown in Figure 1:1. However, due to the lack of understanding of environmental pollution by transport enterprises, and the lack of effective guidance policies in the companies, the development of advanced transportation organization methods such as multimodal transportation, drop-and-hook transportation, and co-distribution in the world is still slow, and advanced energy-saving and environmentally-friendly transportation equipment is costly in the market[27][28]. There is still a large gap between green freight development level and the international level. Moreover, green freight is a systematic trad that requires scientific planning, continuous promotion, and sufficient. effectively promote the green freight process, and ensure the development of the transport[29]. The transport industries are facing a collection of challenges from a variety of causes, including environmental pressures to reduce emissions. Technologies have major's role to play in facing these pressures, not only leading greater efficiency, but also having a transformational impact on the transport industry [30][31] .

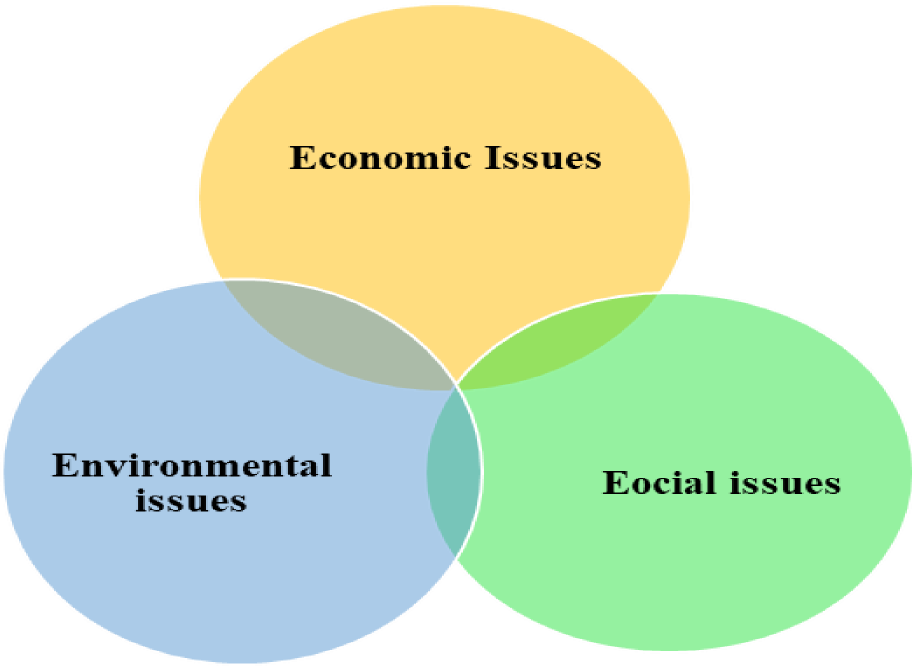

Figure 1.1: Green logistic transport included in these main domains.

The main work presented in this thesis corresponds to real need study the world of the goods transport modals. In order to the use of optimizing the multimodal in the context of transport of products. In order to better understand the context and the problem of the research, this chapter is the subject of an overview and the background, definitions used by the scientific research community working in the field of multimodal transport system, thus Transportation is crucial to society and economy, and road freight transportation accounts for nearly 60% of all surface freight transportation [32][33]. With the rapid growth of logistic and transport and the continuous increase in passenger and cargo transportation, low-carbon transportation has undoubtedly become an important factor in energy conservation and emission reduction, speeding up the construction of low-carbon logistics systems, and developing a low-carbon economy. In Figure 1.2 , The function of road infrastructure and road transports is to improve the logistic utility to make sure that commodities are where and when they are demanded by the customers[34]. If for some reason road freight transports came to a complete cessation over the period of a week the consequences would be very dramatic, as shown by (McKinnon et al., 2013). similar study was performed by (Sveriges et al., 2015). A Logistic is rapidly becoming a major economic activity which comprises the process of planning, implementing and controlling the efficiency, effectiveness of flow and storing of valuables, services and other necessary information from origin to consumption point for the purpose of meeting up with customer requirements, Multimodal logistics has become an important component of logistics worldwide [35]. The transport of goods between origin and consumption point in order to meet some requirements is known as Logistics, for example, customers or corporations. Examples of resources managed in logistics are physical items, like equipment, liquids, materials and people, as well as items that are abstract like energy, information, particles and time. Physical items logistics normally involves integration of information flow, handling material, production, packaging, inventory, transportation, warehousing, and often security[36].

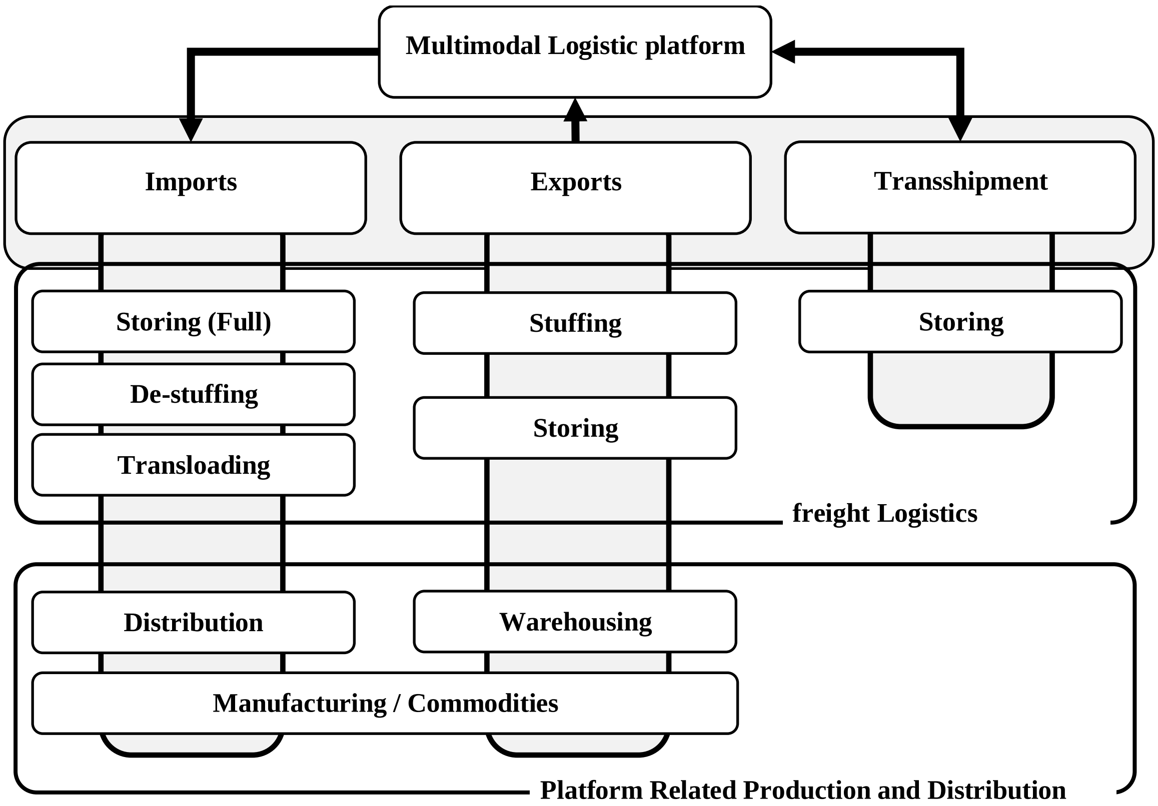

Figure 1.2: Multimodal logistic functions.

Current management of freight type of transportation has many of the same outcome as the past, that is why new technologies are been manage and streamline ships operations. The Green and sustainable freight transportation are increasingly important issues in point view of rising fuel costs and environmental concerns. Although all forms of transportation contribute to greenhouse gases and congestion, trucking has the largest impact, Congestion on the Road due to traffic leads to uncertainty in travel time [37]. Transport is one of the key logistic functions that combine separate types of production procedures, from manufacturing to delivering products to consumers. Optimization of transport can largely determine the efficacy of the entire logistic system; the demand for mobile service is fast growing and closely related to the economic growth [38]. Multimodal transportation is gaining popularity and is significant in international trade. Because the chains of transportation in this area are always long and combines different elements, their coordination are in need of effective solutions to ensure that the goods are delivered to the customer's satisfaction [37]. Studying the choice of multimodal transport to achieve cost and time savings has important practical significance for improving the service level, competitiveness and social comprehensive economic benefits of transportation. Consequently, In general, Congestion of route traffic is a major problem that affects daily life, causing delays and traffic disruptions with its negative impacts on economic, social and environmental levels [39]. In recent years, the need for optimization using methods of operations research in goods transport operation.

1.2 Definitions

1.2.1 Logistics

Logistics is the term widely used to describe the total process of the effective flow of the planned implementation and control of the effective flow of raw materials, intermediate inventory, final products and related information from the starting point to the place of consumption and the effective flow of control to meet the needs of consumers[40]. thus, it's an integrated flow of goods, services and information in the supply chain process. The characteristics of modern logistics and its realization conditions. Although there are so many different concepts about modern logistics at present, after examining various definitions, their meanings have the following common points: Modern logistics is a customer-centric "full service" concept. [29] It is no longer concerned with the quality and efficiency of individual links, but the quality and efficiency of the entire logistics system.

1.2.2 Green freight

Green freight is the use of advanced science and technology, management methods and transportation modes in the process of cargo transportation to reduce fuel consumption and exhaust emissions during transportation, improve transportation efficiency, reduce pollutant emissions, and achieve cost reduction, resource conservation and environmental protection. In order to achieve the purpose of sustainable development of transportation activities, and related to the reasonable setting and improvement of the freight transportation system[28][3].

1.2.3 Transshipment

This is The transfer of goods from one transporter to another transporter and/or from one mode to the other, to the transshipment of inbound containers between inbound mode and multimodal and the unloading operation related to outbound containers.

1.2.4 Platooning

The original meaning of the word 'platoon' refers to a subdivision of soldiers that forms a tactical unit (English Oxford Living Dictionaries, 2018). This definition has been expanded to define the formation of transport units to help develop a more efficient transport system, leading to the reduction of operating cost for different modes of transport[41]. Which is to group multiple truck such that they drive closely in the same lane.

1.2.5 Multimodal logistic platform

Defined as the place where more than one transportation modal meets in an integrated way, This meeting point increases the transportation flow efficiency making it more reliable, flexible, and sustainable its environmental benefits towards sustainable transportation[42]. The term was often used in isolation. For example, Platform may indicate a railway platform up to a logistics platform, a computing platform, an oil platform, etc. Adjectives adjacent to each other specify exactly what the noun Platform means. For example, multimodal transport platforms can help decision makers choose the best transport option and was not only related to the physical movement of goods and the associated direct and indirect costs. They also aim to create a technical, legal, commercial and regulatory framework that emphasizes the integrated services that will be provided to all agents in the supply chain. Multimodal transport also takes into account logistics, transport, transport infrastructure, informatics, telecommunication infrastructure and ancillary activities related to logistics[43] . In Figure1.2 shows Logistics activity refers to the transportation, storage, loading and unloading, handling, packaging, circulation processing and information processing in the logistics process. In the logistics operation process, transportation accounts for the largest proportion of costs and is also the operation process with the largest carbon emissions[44].

Logistics activities have experienced the evolution of carbon emissions from low to high. According to the roles of the logistics service provider and the platform operator. the platform is the place in which these activities can be organized most effectively, where the activities related to the production, transport, logistics, and goods distribution, ensuring their integration and coordination[45].

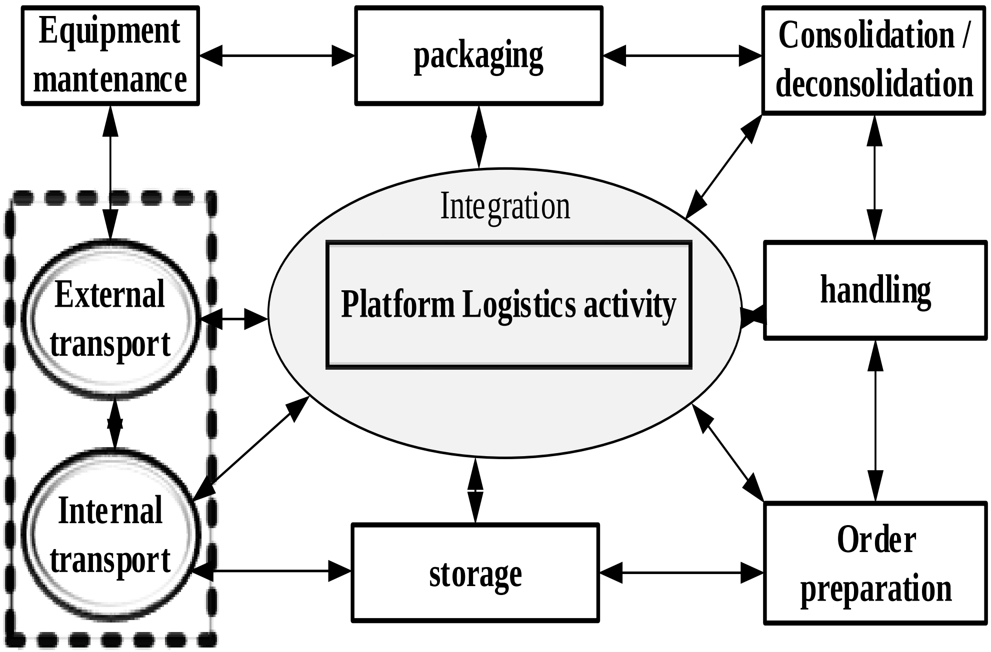

Figure 1.3: Different activates and logistic functions.

1.2.6 Green Logistic management

logistics management is the established level of customer service under the lowest possible total cost conditions[46]. That is, "seek a balance of service advantages and cost advantages," like efficiency, reliability, controllability, flexibility, sustainability, and environmental friendliness. According to this goal, logistics management to solve the basic problem, simply put, is to the right product, in the right quantity and price, at the right time and place, to provide customers[47].

1.2.7 Green transportation

Green transport is defined as the concept of logistics that takes into account the impact of the transport and environmental sectors on the overall process of logistics activities,Green transportation refers to the development of clean energy trucks and other environmentally friendly means of transport to reduce the large amount of energy consumption in the transportation process[33]. Thus, Fuel consumption and exhaust emissions during transportation are one of the main causes of environmental pollution caused by logistics activities [14][48].Therefore, in order to create a green logistics, planning of transportation routes, and reduce energy consumption and exhaust emissions.

1.2.8 Green transport corridor

The green transport corridor is the concept of integrated transport development which binds short-distance navigation, railway, inland waterway and road transport with the aim of ensuring the functioning of environmentally friendly transport system.

1.2.9 Intelligent transportation system

Intelligent transportation system (ITS) is a combination of advanced information technology, positioning and navigation technology, and data communication transmission technology, automatic control technology, image analysis technology, computer network and information processing technology are effectively and comprehensively applied to the entire traffic management system to establish a real-time, accurate, and efficient system that works in a wide range and individual positions Comprehensive transportation management system[49]. The goal of Industrial ITS is to establish a fast, punctual, safe, convenient and comfortable the transportation system is to ensure the sustainable development of society and economy, and to establish a good transportation system that is in harmony with the human living environment, to have greatly simplified the operating environment [50][51].

1.3 Transport and the concept of transportation

Transport is a kind of logistics activity that moves the place and space of goods. Because of its very important significance and visible cost, transportation has received a lot of attention from management over the years. Transport demand can be achieved in three ways, which are commonly referred to as private transportation, contract transportation and public transportation. The specific transportation methods include road transportation, railway transportation, water transportation, air transportation and pipeline transportation. To realize the transportation function of logistics activities, we must first consider the three most important factors, namely cost, speed and consistency of operation[52]. Transportation is the movement of physical goods between logistics locations (such as warehouses, shopping malls, distribution centers, and logistics centers) by means of transportation such as trains, automobiles, ships, and airplanes. Transportation has social and economic functions such as expanding the market, stabilizing prices, promoting social division of labor, and expanding the scope of circulation. Modern production and consumption are realized by the development of transportation. Goods transported from place A to place B can produce location or place effect, and it is transportation that produces this effect[53]. Transportation is generally divided into transportation and distribution. Generally speaking, the movement of all items is transportation, but in general, it refers to the movement of items over a long distance, while distribution refers to short-distance, small-batch transportation. As part of the transportation process. Used as a means of moving goods between logistics bases Roads, railways, domestic shipping, aircraft, etc. The choice of transportation means is of great significance to improving logistics efficiency. When deciding on the means of logistics transportation, the factors to be considered are: the level of freight; the length of transportation time; the number of transportation and distribution within a fixed period; the size of the transportation capacity; the safety of the goods; the accuracy of time; whether it is suitable for various types of goods transportation ; Whether it is suitable for a variety of transportation needs; Whether the connection with other means of transportation meets the needs of multimodal or consistent transportation; Whether the information of the location of the goods can be effectively obtained. Which of these factors is the key factor must be determined according to different transportation needs, It is generally believed that freight and transportation time are the most important selection factors, and the specific selection should be comprehensively weighed from different perspectives of transportation needs[54]. It must be noted here that there is a "benefit contradiction" between transportation services and transportation costs, and between transportation costs and other logistics costs. Because there is also a "benefit contradiction" relationship between transportation costs and other logistics costs, when choosing a means of transportation, the overall cost should be used as the basis, not just the transportation cost. When deciding the means of transportation based on transportation needs, respond some understanding of the characteristics and problems of various means of transportation. There are many more innovative inventions in transport goods technology[55].

1.4 Transport modals

1.4.1 Railway transportation

Railway transportation is one of the main modes of cargo transportation in different countries. It is connected with main waterway transportation and various short-distance transportation to form a transportation network with railway transportation as the main mode. Most of different countries railway facilities are invested and managed by the state to provide transportation services to all sectors of society[56].

- Advantages
- Large carrying capacity.
- Faster than others mode and speed.

- Less pollution. Compared with automobile transportation, railway transportation has dedicated routes, and there is no congestion problem.
- Less restricted by weather conditions, safe and reliable

➢ Disadvantages

- Poor flexibility. Railway transportation is restricted by fixed lines, and door-to-door service cannot be realized
- Higher requirements for packaging.
- There is a danger of theft of goods.
- The one-time investment cost for the construction of railway facilities is relatively high.

1.4.2 Road Transport

The facilities used in road transportation include roads, road stations and vehicles running on roads.

➢ advantages

The density of the global road network is the highest among all modes of transportation.

- Flexibility. The complete road transportation network and the relatively small unit vehicle volume make it flexible, in most cases, door-to-door transportation from shipper to consignee can be realized.
- Fast and controllable.
- Freight vehicles is low, and one vehicle can usually carry different routes on multiple routes goods.
- Makes roads more adaptable in freight transportation

➢ Disadvantages

- Low transportation capacity.
- The unit freight is high.
- There is a high risk of theft of goods.
- Road congestion and pollution.

1.4.3 Waterway transportation

➢ The advantages

The high transportation capacity, and save fuel and energy.

➢ Disadvantages

slow transportation; circuitous transportation routes; affected by weather conditions; bulk cargo There are more damages; long transportation time, difficult to guarantee, and high loading and unloading costs are all the shortcomings of water transportation. water Transportation (especially inland water transportation) is restricted by natural waterways, and it is often difficult to take the shortest route. The distance between two points long tends to be the first of all methods. In particular, shipping is extremely vulnerable to wind, waves and inclement weather. And other factors make it difficult to guarantee transportation time.

1.4.4 Air Transport

- Advantages
  - Fast transportation.
  - Less restricted by terrain conditions.
  - The air transportation service is of high quality, safe and reliable.
  - The transportation time is short, higher flexibility.
- Disadvantages
  - The transportation cost is high. Due to the high cost of aircraft and high fuel consumption, air transport is still the most an expensive method of transportation.
  - The carrying capacity of air transportation is still quite limited, and the volume and weight of air cargo are restricted.
  - Air transport is prohibited for some goods.
  - Largely affected by weather.

1.4.5 Pipeline transportation

Pipeline transportation is a new type of transportation developed in recent decades. In the gas pumping station of the world, the goods are transported directly in the pipeline, and there are no transportation tools such as cars and trains. Use pipeline transportation for transportation, the cargo moves through the pipeline under the pressure of the high-pressure air pump to reach the destination. Three types: liquid pipeline (mainly transporting petroleum and its products), gas pipeline (mainly transporting natural gas)[57].

- The advantages

  • The pipeline transportation are not affected by the ground climate, and can be used 24hours a day, all year round Continuous operation for 365 days; the goods do not need to be packed; the goods move in the pipeline, and the cargo damage rate is very low; energy consumption Less, less land, safety, and less pollution; relatively simple operation and management; low unit operating cost, pipeline operation Only a few maintenance personnel of the gas pump station are required, and the labor cost is very low.

- The shortcomings of pipeline transportation are limited to the transportation of liquid, gas and a few homogeneous solid cargoes. Single; small mobility, limited to transporting goods in fixed pipelines, and one-way transportation; pipelines the initial fixed cost of construction is high. Pipeline transportation has distinct characteristics and extremely limited scope of application.

1.5 Multimodal transport

Multimodal transportation originated in Europe more than a hundred years ago. By Since the emergence of multimodal transport is later than that of a single mode of transport, the appellations are not uniform, and some Combined transportation or multimodal transportation, some are called integrated transportation, some are called compound transportation, and some are called one Consistent transportation.[30][58] From the terms of the relevant international conventions, although the name of multimodal transport is not uniform, Its connotation is no different. Multimodal transportation refers to the use of multiple transportation methods, using various transportation methods and their own internal economics. Economic, providing comprehensive services at the lowest cost. This way of trying to combine different modes of transportation the integrated method is also called "one-stop" transportation. The earliest multimodal transport was railway and highway the combination of road transportation is usually called the piggyback transportation service[5] [48].Now people are getting stronger Really realize that multimodal transportation will become an important means to provide efficient transportation services.

➢ Advantages

- Reduce the time loss and the risk of damage and theft of traditional block transportation;
- Reduce the complexity of relevant documents and procedures for segmented transportation;
- Reduce all kinds of transportation Related expenses;
- The owner only needs to contact the multimodal transport operator, and the multimodal transport operator Take full responsibility for the shipper’s goods;
- The full freight provided by the multimodal transport operator is more convenient the cargo owner reaches an agreement with the buyer on the freight rate;

- The reduction in transportation costs helps the total logistics of the product Cost reduction, thereby enhancing the market competitiveness of products.

With the rapid development of global trade, long-distance transportation is becoming more and more important, and a single transportation mode can no longer meet this rapidly expanding transportation demand. Therefore, the effective construction and management of multimodal transport has important theoretical and practical significance. Multimodal transport can not only use its scale effect to obtain economic advantages, but also can alleviate traffic congestion and has certain environmental advantages[3][59]. The United States is an early country that developed multimodal transportation. At present, its total multimodal transportation accounts for About 40% of the volume, occupy an important position in the entire transportation industry [60]. At present, multimodal transportation is highly valued. It is an advanced development stage of logistics transportation. However, the complexity of multimodal transportation network requires timely response to the changing dynamics and uncertainties of upper operations. Transportation also needs to take into account multiple objectives, such as cost, Time, capacity constraints and low carbon. However, different modes of transportation have different technical and economic characteristics, so that there is a certain degree of benefit between these goals. Therefore, the problem of multimodal transportation is more challenging than single mode transportation[61]. On the one hand, in multimodal transportation, the optimal route is not necessarily the shortest route, because some additional costs such as time and money must be considered; On the one hand, a series of new constraints also need to be considered. These constraints are related to changing the mode of transportation at nodes, such as a series of problems caused by the operation of transferring goods from trucks to trains or ships[62].According to the World Bank (2018), container throughput has increased from around 224 million twenty-foot equivalent units (TEUs) in 2000 to more than 701 million TEUs in 2016.

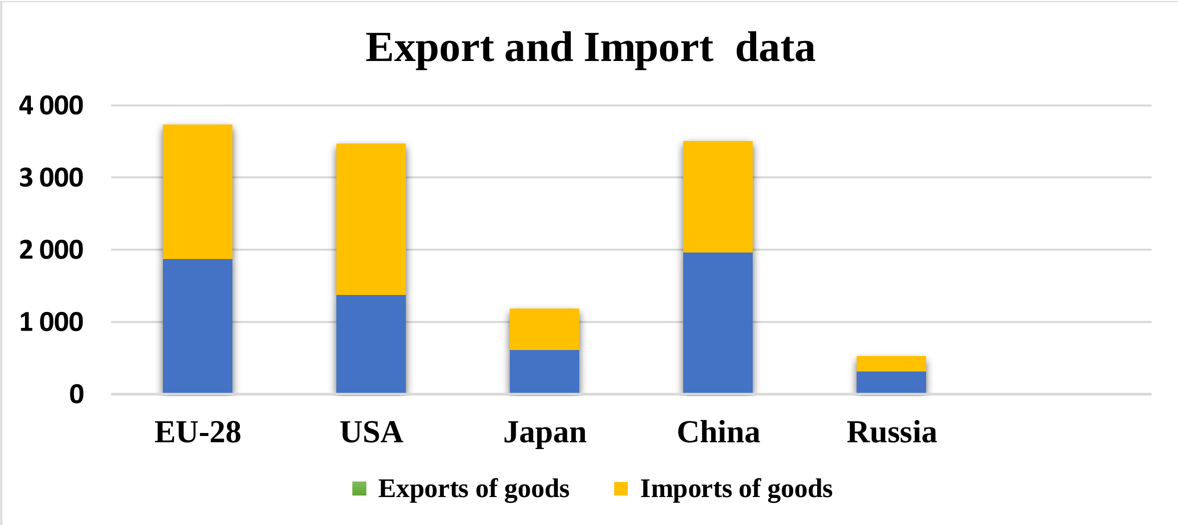

Figure 1.4: Import and export of goods in different country in the world. Source: Eurostat.

Transport cost is the largest part in the composition of logistics cotransport is the core and important part of the logistics system. Its rationalization has become the key to logistics rationalization. Its low-carbon emission reduction has also become an effective guarantee for low-carbon emission reduction in logistics and the development of a low-carbon economy. The transport system is often described as the essential part of modern society. Roads constitute an important part of this system for both passenger and freight transports. Freight transport is expected to increase throughout the world by 80% until 2050 (EU, 2011). Multimodal transport is a form of intermodal transportation organization that aims to achieve the optimal benefits of overall cargo transportation[27][63]. Among the various methods of multimodal transport, combined iron and water transport have become the mainstream of the global logistics transportation industry due to its advanced, efficient, energy-saving, and environmentally friendly advantages Development direction and got the Multimodal transport wide attention of science and researchers [64]. containerized goods have proved to be cheaper, faster, safer, and more efficient[65]. The road freight an important component of the modern service, logistics industry, and as consider the integration of modern transportation, warehousing, freight forwarding, and information industries, that accounts for nearly 60% of all freight transportation However, the transport sector faces many challenges that threaten its development. These range from congestion and high operating costs to pollution and major problems related to safety and security [66]. In Figure 1:4 transport challenges can be included in these four main domains. From the perspective of transporters, the raising alertness of the need for environmental-friendly transport modes may directly influence the freight transport modal choice, the environmental impact of freight transport is closely related to the amount of energy consumed.

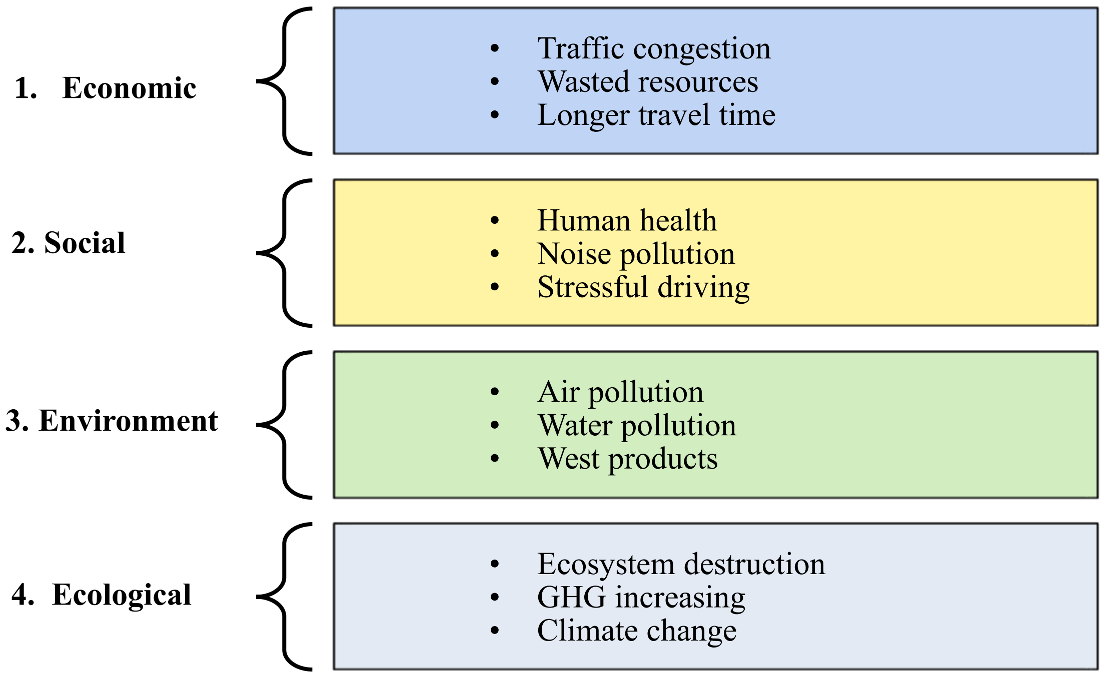

Figure1.5: Transport negative impact.

1.6 Logistics and Characteristics of logistics

Logistics is carried out in the Definition, "Logistics is the physical flow process from the place of supply to the place of receiving. According to actual needs, Basic functions such as transportation, storage, loading and unloading, handling, packaging, circulation processing, distribution, information processing, combination. In modern logistics management and operation, it is widely used to represent the development of today’s productivity Level of management technology, engineering technology and information technology, etc. With the progress of the times, logistics the modernization of activities and management will continue to increase. Modernization is the recent process, so "modern logistics" will give it different connotations in different periods[50]. Present the characteristics of generation logistics can be summarized in the following aspects:

- Systematization.

Modern logistics is not a simple superposition of transportation, storage and other activities, but system formed under a common goal through the internal connection with each other, constitutes the functions of the system. There is an interactive relationship between the elements. Modern logistics must be customer-centric, the concept of "full service". It is no longer concerned with the service quality and efficiency of a single link, but it is the quality and efficiency of the entire logistics system. In addition to pursuing the efficiency of natural circulation of commodities, modern logistics[67]. It's also strive to improve user service levels through various channels to maximize the total system cost. Small; or by investing a certain amount of resources to achieve the best service level.

- Logistics Information.

This is the most essential feature that distinguishes it from traditional logistics. The information is real now logistics systematization and integration play an important role. Modern information technology, communication technology[68]. And network technology is widely used in the processing and transmission of logistics information, so that various logistics information transfer between festivals, between logistics departments and other related departments, and between different enterprises and processing can break through the constraints of space and time, and maintain a high degree of unity of physical logistics and information flow and real-time processing of information.

- Logistics modernization.

The rapid development of modern technology is the realization carrier of modern logistics. In modern logistics activities, advanced transportation tools, loading and unloading equipment, storage facilities and Packaging technology. The application of these technologies can promote the coordination of all aspects of logistics and improve the overall service efficiency.

1.7 The relationship between multimodal transport and logistics

Multimodal transportation is an organic part of modern logistics the entire modern logistics activities are composed of transportation, inventory management, loading and unloading, distribution processing, packaging and it is composed of distribution and other activities, of which transportation is the main part of logistics activities and the core of modern logistics Link. Multimodal transportation in a certain in a sense, it greatly eases the pressure of international cargo transportation due to the time and space gap. Can be like this In other words, without multimodal transport, the development of modern logistics across national boundaries will be difficult. Modern logistics is based on transportation technology and information technology[69]. Multimodal transport is the basis for building a modern logistics network system Modern logistics involves a wide range of business and diverse transportation methods. Can the transport organization adapt New requirements determine the smooth operation of the logistics system. Multimodal transport is a modern logistics network. The main body and link of the network operation, and the multi-modal operation is the basis for building a modern logistics network.

The specific manifestations are as follows:

- Reasonably control costs:

Transportation costs account for a large proportion of the total cost of modern logistics. Reasonable control of transportation costs determines the effect of total cost control of modern logistics. Multimodal transport can in order to reasonably adjust the transportation cost control system, Integrate, adjust the relationship of various transportation links to reduce transportation costs and reduce the total logistics cost. Simultaneously, multimodal transportation can effectively coordinate the joint operation of various transportation links and optimize the total logistics cost[70].

- Increase efficiency:

The efficiency of modern logistics depends not only on technology and equipment, but also on important factors. In the process of logistics transportation, multimodal transportation can be combined Organize and coordinate the whole process to make the connection between different transportation methods faster and save more Time, while effectively reducing risks.

- Optimize the logistics network system:

A modern logistics network system with multimodal transport, it has the characteristics of complete functions, appropriate scale, and can effectively use informatization Assist the operation of modern logistics network system.

1.8 Freight transport processes

Freight transportation is a key supply chain component to ensure the efficient movement and timely availability of raw materials and finished products (Crainic, 2003). Freight transport is an energy-intensive process. Since the traditional way of freight transport to change the spatial displacement of goods as the only content, its quality and efficiency are less than ideal. Based on the study of freight logistics energy-saving strategies, it is necessary to synergize multidimensional interests in a large system, scope and environment of multiple subjects, multiple cargo sources and resources, using new technologies, and introducing advanced logistics integration organization

The rational approach, vigorously reduce the energy consumption of the transport link, so as to truly achieve the goal of energy saving and emission reduction in freight transport. The rational approach, vigorously reduce the energy consumption of the transport link, so as to truly achieve the goal of energy saving and emission reduction in freight transport. From an integration point of view, strategies can be developed in terms of vehicles, information, fuel, personnel and so on. Demand for freight transportation results from producers and consumers who are geo- graphically apart from each other. Following trade globalization, the conventional road mode is no longer an all-time feasible solution, necessitating other means of transportation (and their combi- nations). In this regard, in 2010 about 45.8% of total freight transportation in European union countries were transported via road, 36.9% via sea, around 10.2% via rail, and 3.8% via inland waterways[71][30].

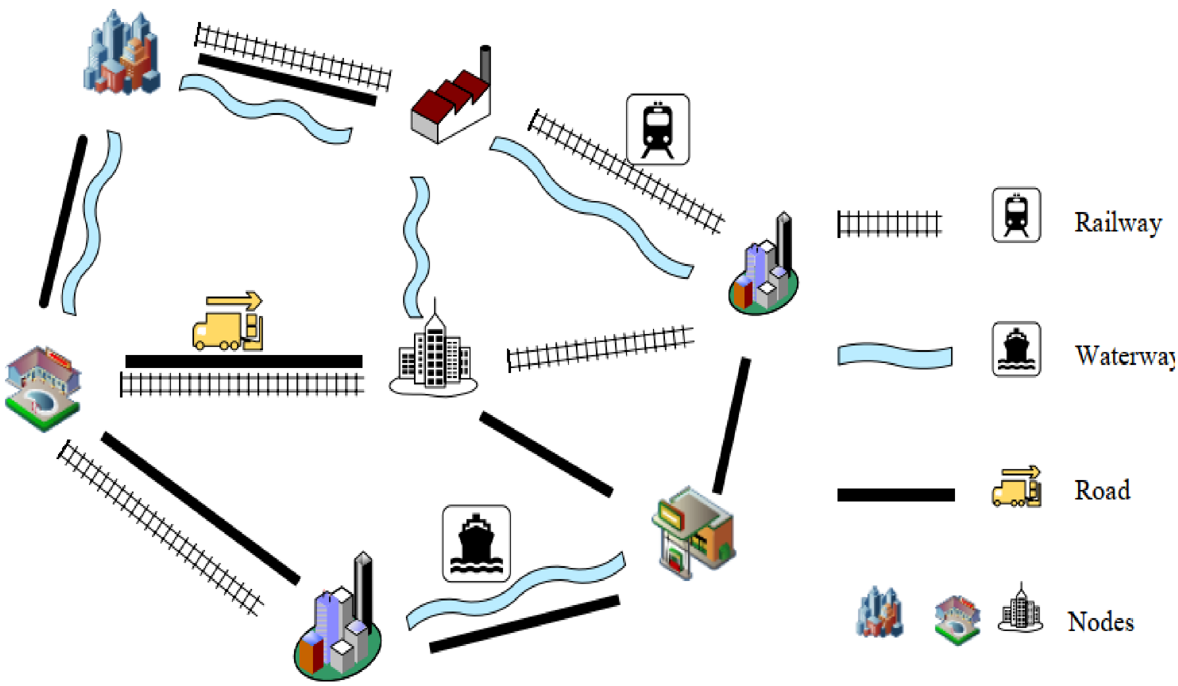

Figure 1.6: Multimodal transport system [15]

The freight transport network consists of three essentially components including pre-haulage, main-haulage, and end-haulage, as illustrated in Figure 1:4. While pre-haulage and end-haulage are usually provided by road transport for short distances, the main- haulage is carried out by using other types of transport such as rail, sea, and inland water for longer distances. It is known that multimodal transport is competitive during main-haul transportation, if the transported distances are beyond 300 km which is longer than one day of trucking (SteadieSeifi et al., 2013) [72]. Transport can be processed in several forms (either directly or by making use of several modes of transport) and it is therefore necessary to specify these processes more clearly. Transport processes can be initially classified into direct and non- direct transport. In the Case state of a non-direct transport process, the transshipment of goods takes place, whereas in direct transport no such transshipment is needed. Goods are transported directly from a point of departure to the destination. For this reason, it is also called door-to-door transport. In this Case state, the means of transport (truck, vessel or railway) is not changed and there is also no change of transport mode (rail or inland waterway). Direct transport can always be classified as goods are transferred from the starting point to the end point by one mode of transport. Road freight is the main mode of cargo transportation in development country. Is has the characteristics of strong mobility, easy to adapt to changes, and has low facility requirements for receiving stations. Compared with railways, water transport and other modes of transport, it can adopt the door-to-door mode of transport, which directly transports goods from the door of the sender to the door of the consignee without transshipment, avoiding repeated loading and unloading and handling, and ensuring the quality of goods.

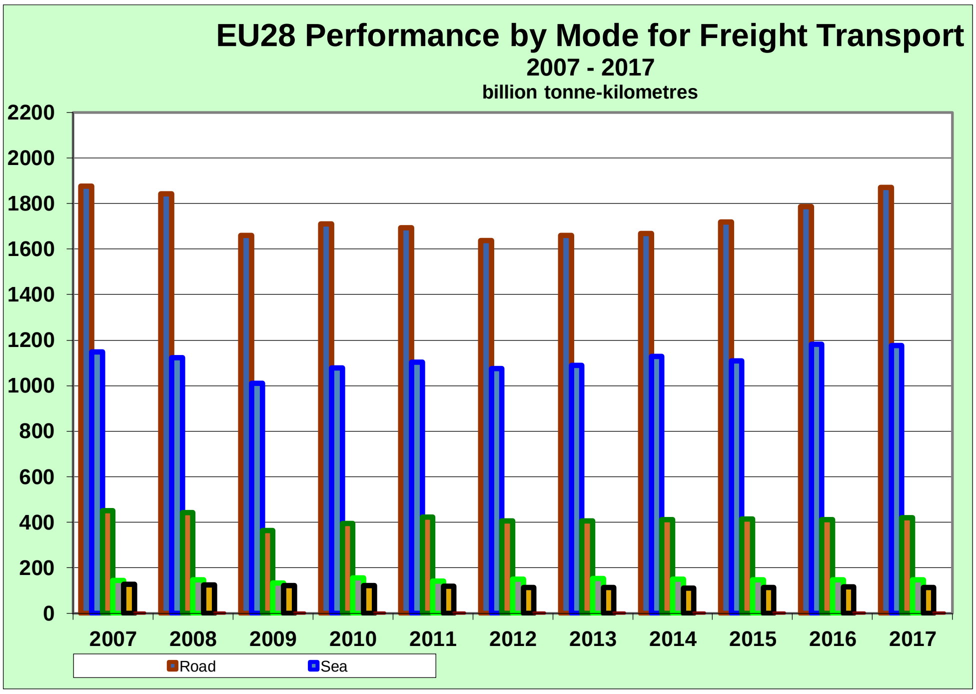

Figure 1.7: Mode for Freight Transport Source: European Environment Agency (EEA),(2019)

In figure 1.6, shows. Road freight transport accounts for nearly 80% of the world overall freight volume is the main mode of transport logistics transport, road freight transport industry fuel consumption and carbon dioxide emissions in the overall transport system accounted for a relatively large [17]. Reducing fuel consumption in the overall road freight industry is the main purpose of promoting green freight transport. The current fuel consumption limit values for heavy trucks in The world adopt the single-truck fuel consumption limit value [18],[73]. In figure 1.8, shows Modal split of freight transport road transport is still main mode in transport goods.

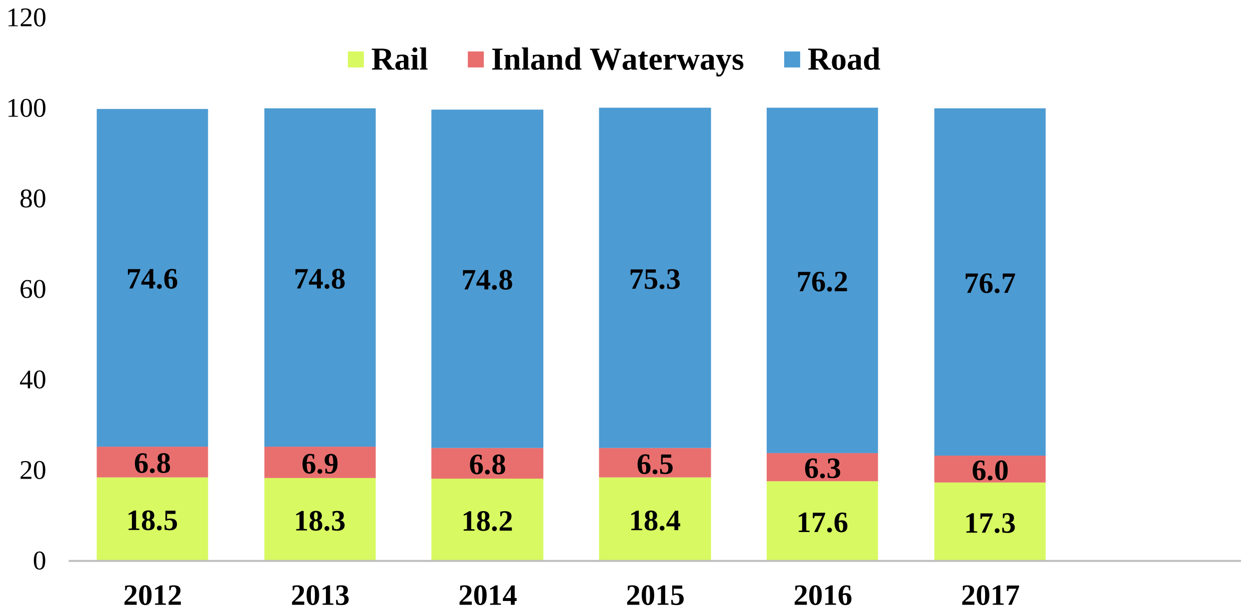

Figure 1.8: Modal split.

1.9 Freight trip multimodal Transport

The mode of transportation was modernized, and modern transportation based on railway transportation, road transportation, water transportation, air transportation, and pipeline transportation appeared. Modern transportation also includes ropeway transportation and conveyor belt transportation. With the advancement of science and technology, new modes of transportation will emerge.

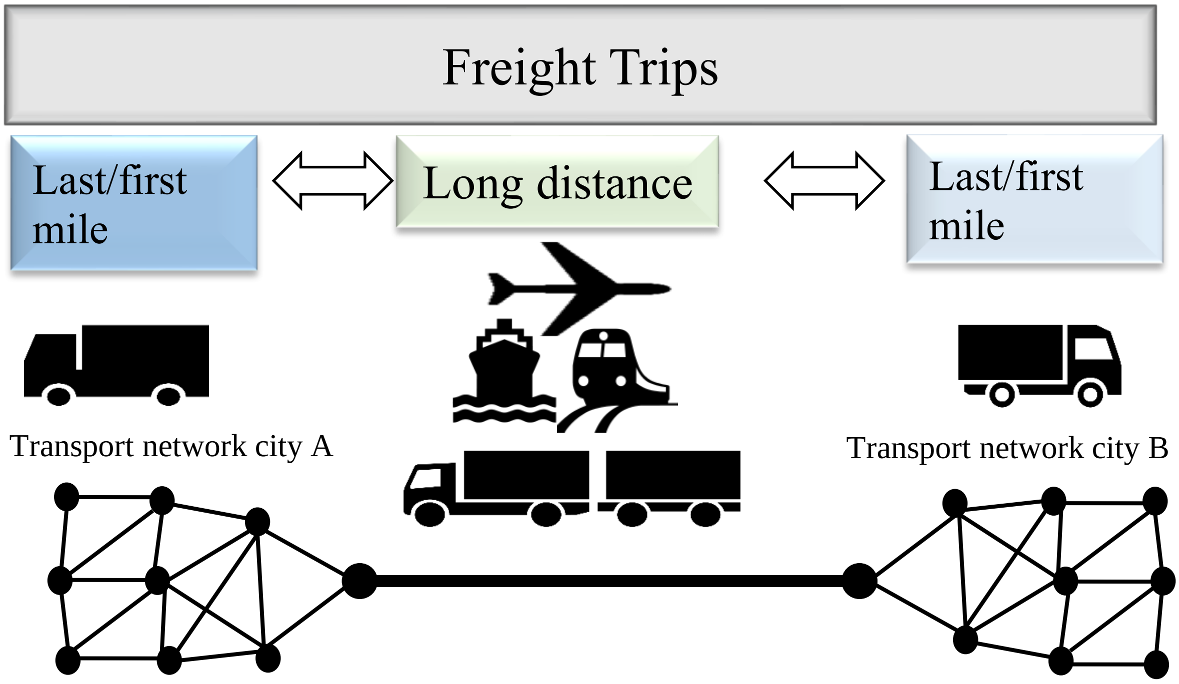

Figure 1.9: Freight transport trip between cities.

1.10 Components of transport system

For transportation to take place, four components are present in figure 2.2 components of fright transport essential[73]:

- **Modes:** They represent the conveyances, mostly taking the form of trucks that are used to support the mobility of passengers or freight. Some modes are designed to carry only passengers or freight, while others can carry both.
- **Infrastructures:** Physical support for means of transport, the most important elements of which are routes (railways, canals or roads) and terminals (ports or airports). Infrastructure also includes superstructures, which are often mobile assets with a short lifespan. Thus, in the case of airports, infrastructure would be assets such as runways, while superstructures would be terminal buildings and control facilities. For the port, the infrastructure would be quays and waterways, and the superstructure would be cranes and equipment for the shipyard.
- **Networks:**
  A system of interconnected places that is used to represent the functional and spatial organization of transportation. This system shows which places are connected, and how they are served. In a network, some places are more accessible (more connected) than others (less connected).

- **Flows.** goods, People, and information move through their networks; movements have origins, intermediate stations and destinations. The trip from the origin to the destination often requires an intermediate location. For example, a flight from one airport to another may require a stopover at a hub airport.

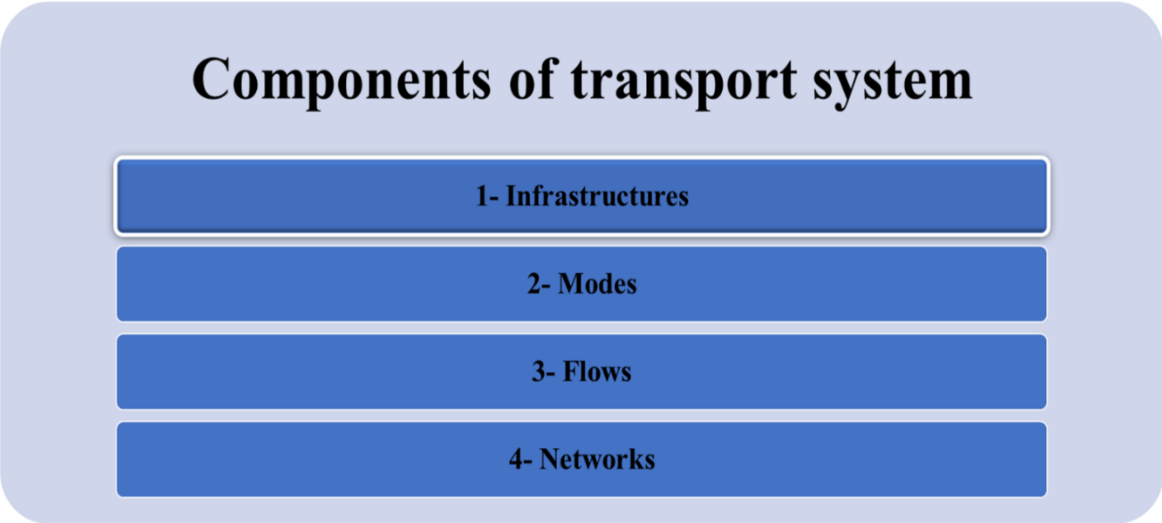

Figure 1.9: Components of fright transport.

1.11 Factor transport system

In the process of intermodal container transport, it is necessary to consider many influencing factors, mainly in the following three areas: transport time, transport costs, transport social benefits. These factors will affect the multimodal container network to varying degrees, in order to make the constructed network model more rigorous and reasonable, but also to facilitate the development of subsequent research and development of the intermodal container network.

The main factors as

- Time – There are many parameters that affect intermodal transport times, such as environmental characteristics, mode of transport, distance travelled, traffic state, as well as transport strategies and transit times during transport.
- Cost – Multimodal transport costs are costs incurred during transport. It mainly includes the costs of transport between the nodes, the costs of reloading in the nodes and the costs of waiting time in the nodes. Another factor in reducing costs is. Consolidation of shipments with similar destinations and characteristics to allow cost sharing among carriers responsible for transportation.
- Energy conservation and emission reduction

Emissions reductions and energy efficiency refer to carbon emissions and total energy consumption in transport. Another factor in reducing costs is Consolidation of shipments with similar destinations and characteristics to allow cost sharing among carriers responsible for transportation A full understanding of MLPs reduces costs by providing an intermodal structure consisting of ground and air transportation in addition to road transportation.

In general, cost versus service creates trade-offs, and service can be broken down into more specific elements, such as transit time and inventory. Cost versus transit time is the most common but most important compromise in long-haul transportation. As shown in Table 1.1, this compromise can be well illustrated by the different characteristics of sea transit and air transport: the advantages of one mode of transport are the disadvantages of the other.

1.1 A general evaluation of the importance of the different models.

factors	Roadway	Railway	Waterway	Airway
Cost	High	Low	Very Low	Very High
Speed	High	Low	Low	Very High
capability	Very High	Low	Very Low	Low
Reliability	Very High	High	High	Very High
Security	Very High	High	High	Very High
Safety	Safe	Very Safe	Safe	Very Safe
Flexibility	Very High	Low	Low	Low
Availability	Very High	Low	Very Low	Low

1.12 Rationalize of transport

The concept of transport rationalization, Rationalization of transport means organizing the transportation of goods in accordance, the shortest mileage of goods transportation, through the least number of links, with the fastest time, with minimal loss and lowest cost, the goods from the starting point to the location of customer requirements. As transportation is one of the most important functional elements of logistics, logistics rationalization to a large extent depends on the rationalization of transportation. There are many factors that influence the rationalization of transportation, and the following five factors play a decisive role[74][73][20].

- Transport distances

At the time of transport, a number of technical and economic indicators of transport, such as transport time, transport loss, freight, vehicles are proportionally related to the distance travelled. Therefore, the length of the transport distance is one of the most basic factors for transport Shorten the transport distance has benefits.

- Transport links

Each additional transport increases the freight costs of total freight costs, but also increases the activities ancillary to the transport, such as handling and packaging, and thus decreases the technical and economic indicators. Therefore, reducing the number of transport links, especially those of the same type of means of transport.

- Means of transport

All kinds of means of transport have their advantages, the optimal selection of means of transport, according to the characteristics of means of transport for loading and unloading transport operations, to maximize the role of the means of transport used.

- Transport time

Transportation is the part of the logistics that take more time. Especially for long-distance transport, the transport time accounts for the majority of the total logistics time. Therefore, the shortening of transport time has a decisive role in the shortening of the entire circulation time. Short transport time, it is conducive to the transport line through the ability to improve the transport rationalization of a great contribution.

- Transport costs

Freight costs in all logistics costs accounted for a large proportion of the freight costs in a large extent to determine the competitiveness of the entire logistics system. Transportation cost reduction is an important goal of transportation rationalization.

Conclusion

This chapter has illustrated the general background, environmental concern with particular emphasis on its transport emission, roles of Multimodal Transport and, logistics development. platforms logistics is well positioned as one of the top-leading elements of transport industry with particular strengths in long-distance transport, transshipment, and assembly operations. Apart from the operation status the platform logistic, logistic platforms have attracted several transport companies in establishing global transshipment due to its advantage in services centrality of multimodal location. This has benefited the reputation of the logistic platforms which allows freight transport to develop its role in the international arena. However, several unresolved issues relating to environment have most importantly, its logistics and transport developments. With the intensity of trade competitiveness in the global market, Furthermore, a thesis has aimed to ‘establish a world-class logistics system’ through proliferating its logistics facilities and technology infrastructure, and to assure faster and higher freight handling capacity. With the incorporation and promotion of Multimodal Transport, multimodal logistic transport that will be one of the main catalysts. However, not to hinder the progressiveness of its trade developments, obstacles in improving freight logistics services while reducing logistics cost would still be remaining as major challenges in uplifting trade performance. Apart from the importance of cultivating trade and logistics activities through development of Multimodal Transport platforms, seamless business collaborations between shippers and MTOs are critical in the improvement of logistics management and operations. Under the condition of its high transport cost.

Chapter 2. Different transport systems using in goods transportation

2.1. Introduction

This chapter provides Discerption of technology and methods used in multimodal freight. It pays particular attention to the differences between the theoretical and empirical literature as well as pros and cons of the existing me the findings from this review of significant extant literature on the specifics of parts important the topic of investigation for this research. This chapter was being based on a literature review on multimode transport system, terminal container and multimodal freight transport. We conclude that transport technologies and logistics system tend to develop towards expert transport orientation, and logistic applications development is a problem-oriented domain. The ability to continually change and obtain new understanding is the power of logistic transport technologies and will be the application of future works.

2.2. Modeling of carbon dioxide comparable pollution

The transport industry represents considerable stress on the environment, causing various types of damage such as air pollution, global warming and the depletion of resources. As CO_2 is the largest human-made greenhouse gas (GHG), certain gasses may also calculate their effects on carbon equivalent emissions (CO2) (Demir et al. 2015). CO_2 emissions leads to climate changes and ecologically sustainable degradation of habitats and well-being threats (Dekker et al. 2012; Demir and others 2014; Bektas et al. 2016.). Because shipping in the sector is a major contributor to CO_2 emissions, the (Demir et al . study (2013) found that pollution calculation is still being increasingly used in transport plans. Although contaminants are included in the preparation of programmes, they are mentioned only as a by-product and not included as an optimisation target. Normally, only cost optimization is considered and costs are time, distance, combined with service, etc. for multiple purposes. A variety of reasons could be linked to making it impossible to measure emissions. The potential causes are listed below. The amount of emissions depends on how much fuel a car requires to turn from diesel to petrol. Although energy usage is simple to calculate after travel, it is difficult to quantify energy use before travel begins because a number of variables are not fully understood. The following criteria include truck characteristics (resistance to weight, moving), transport and moving features (distance, stop) and quantity of transport (Eichlseder et al . 2009). The following factors include: several models were built to estimate emissions involving detailed inputs, as shown by (Demir et al. (2011) between Demir and the others. (2014). Aside from complete versions of these, emissions calculators are also available on the basis of measurements in the life and prescribed principles for standard cars (see, for example, IFEU 2011; Boulter and McCrae 2009;). Nevertheless, each model and simulator focus on overly simplistic assumptions that lead to variations between real and expected emissions. Pollution can be separated into three normal functional areas of GHG. This includes capital pollution from industries, emissions conditional from electricity, and all other contaminants, many supply chains contained processes [e.g. Suppliers, logistics, warehouses (Toffel & Sice 2011; Hoen et al. 2014). Pollution can be calculated as direct diesel contamination in the truck (tank-to-wheel, TTW) and fuel system (WTW) pollutants. The lack of waste for fuel production is especially important when it comes to electric trucks, since carbon emissions are zero equal (Kranke et al . 2011). Economic value of CO_2 e emissions are uncertain. For the long run impact of pollution on climate change and quality of pollutants emitted cannot be accurately calculated, a number of factors are needed to calculate carbon costs, including varying discount levels for potential incidents and risk attitudes of decision-makers. In the basis of the model, the social costs of pollutants are calculated to be between EUR 0 and EUR 700 per ton of contaminants (Anthoff et al . 2011; Nordhaus 2011). Nevertheless, the numerical advantages of pollution cannot compare quickly to transport costs. In the road Case state transport, the Emission Model for Passenger and medium goods trucks (PHEM) TU Graz built is a fundamental basis for the Road Traffic Emission Factors Manual (HBEFA) for trucks operating in similar routes. Both assumptions are based on real-world equations that approximate a fixed travel period and includes both empty and fully driven cars (Eichlseder et al. 2009). The load ratio and engine fuel usage have a linear relationship and thus the gas use will safely be accomplished determined for various payloads. Besides the road type and the the load factor is also an essential aspect of the gradient. In accordance with Kno ̈r et al . (2011), the impact of the gradient on the fuel consumption of road transport is between 5% and 10%, which means that for hill and mountain countries, emissions estimated for flat countries should be increased between 1.05 and 1.1.

Rail pollution is based on multiple variables, including rolling resistance, resistance to aerodynamic, altitude and gradient (McCrae and Boulter 2009). Nevertheless, the use of train capacity, as shown by the comparison of actual values, is the total weight in tons (Knorr et al. 2011). The use of gasoline equation can also be defined in hilly and combined countries by 0.9 in open and mountainous nations 1.1s (Kno ̈r & al. 2011). The amount must be multiplied by a specific pollutant factor in order to determine the volume of energy use pollutants. In this context, a distinction should be made between a diesel train that emits diesel fuel and an electrical train, where emissions are due primarily to the generation of electricity and not to the use of energy (Kranke et al . 2011).

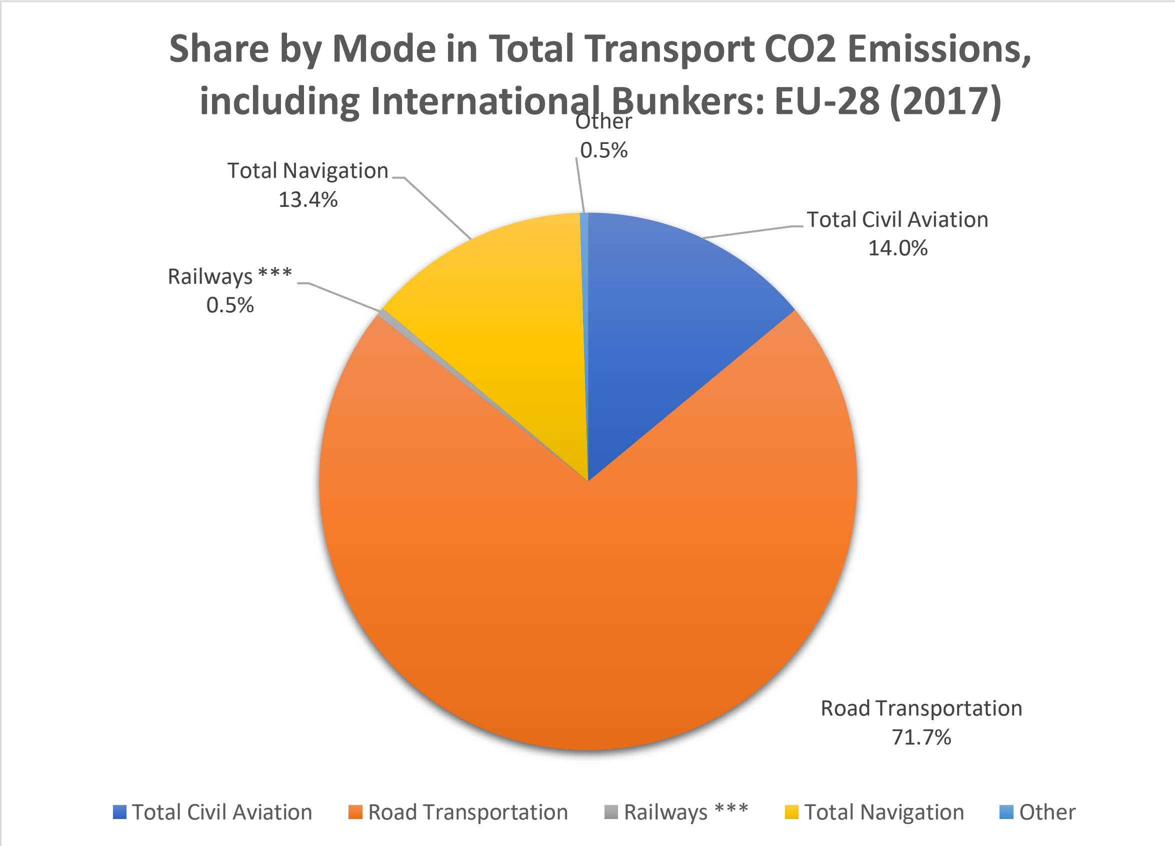

Figure 2.1: Mode Transport CO_2 Emissions, Source : EEA, (2019).

In the Case state of internal shipping, emission measurements typically have the same average emission factor ($_{tkm}$) or the same IWT and maritime transport (NTM 2008) methodology (see, for example, (Kno ̈r etal. 2011; IFEU 2011). These methods are used since a large volume of input data is not always sufficient for the accurate measurement of IWT emissions. Nonetheless, the findings are deceptive and do not reflect the true results of the IWT. For this purpose, Boulter and McCrae Design ARTEMIS (2009) are used for our research. The data input for this model consist of the features of the vessel (height, length, width, draught, engine capacity), the characteristics of the vessel's transport (depth and width of the vessel, vessel reach, speed and position) and the features of the cargo (shape and weight). Both parameters of data are either supplied by the system for a particular vessel itself or manually calibrated, allowing for more precise emission measurements.

In accordance with the corresponding national emission ratio (Kno r et al., 2011), the terminals are equipped with a transmission ratio of 4.4 kWh. The German Federal Environmental

Authority has proposed a value of EUR 70 per ton of CO_2 e emissions to be used as cost expression (PLANCO 2007).

We note that the volume of pollution emitted by a 20-foot container (TEU) is heavily dependent on the power of the truck. The load-to-emission ratio is linear to lorries, but the emission functions are exponential for trains and inland boats. As a result, TEU emissions based on the use of 80 per cent for inland trains (PLANCO 2007) and 90% (via donau 2007) were calculated to reduce complexity. [72].

2.3. Literature review of multimodal transport

In this regard, domestic and foreign scholars have also done a lot of research on multimodal transport network planning in recent decades, and most of the model construction is based on the shortest path or the lowest total cost. (Tong Lu et al 2014). used ant colony algorithm to solve the multimodal transportation route selection problem with the shortest transportation time and transportation path as the optimization objective.

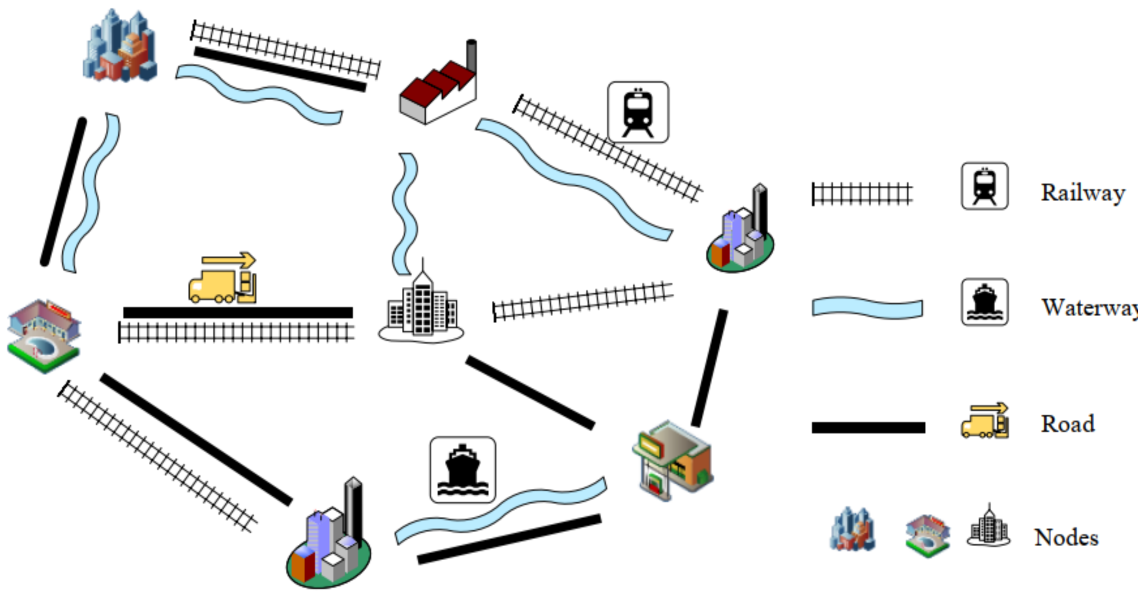

Figure 2.2 : Multimodal transport system [15]

(Li Shuanglin et al.2012) have solved the multi-objective location-multimodal transportation problem with the shortest total delivery time and the smallest total loss of unsatisfied materials, a multi-objective genetic algorithm is used, in which two-dimensional coding non-dominant sorting is used.(Yang Qiuqiu et al.2013 , Yanmei et al.2015) constructed a dual-objective multimodal transportation shortest path selection model with the lowest cost and shortest time as the optimization goals. (Huang Lixia et al.2016). With the goal of minimizing the total cost and the total risk in the multimodal transportation process, a binocular 0-1 linear programming model was constructed. The above are all dual-objective optimization models based on Pareto analysis. Some articles consider many factors. (Bhatta-Charya et al. 2017) used mixed integer programming to optimize the multimodal transport network schedule considering multiple costs and additional capacity constraints. (Modesti et al.2009). Use an ad hoc utility function to weigh cost and time, and choose the best path to minimize the total cost, time, and customer inconvenience. (Sun et al. 2010) used Pareto optimality to select the optimal route of multimodal transportation to achieve the optimal total transportation cost and time, and then considered the commodity flow path, the specific timetable of railway services, carbon dioxide emissions, etc. The total cost of is the best. Although there are many considerations, it is transformed into a single objective function to solve. (Kangpol et al.2016) to reduce costs, lead time, risk and dioxide for carbon emissions, the objective function is determined through analytic hierarchy process and data envelopment analysis, and finally the optimal path is calculated through 0-1 planning. (He Zhuqing et al 2013) considered time and capacity constraints, and prioritized the time-sensitive logistics to minimize the overall cost, and solved it with a 0-1 integer programming. (Chen Yifei et al 2011) Convert carbon emissions and time into corresponding costs, and build a single-objective model of the total cost of the container multimodal transportation process. (Li Gaobo,2014)] changed the capacity Single-objective model of standard function.(Fu Xiaofeng et al.,2015) established cost-based Time-integrated single-object multimodal transport route selection model. (Wang Zhengbin et al.2014) calculated operating income, transshipment costs, storage costs due to delays and Loss costs, time value, these factors are transformed into costs and expenses to construct a single-objective planning problem. Although many factors are considered in these multi-objective planning studies, the final study is to transform the considered factors into a single objective function. Because of the existence of dynamic uncertainty in the transportation process, some scholars believe that customer demand and transportation time can be regarded as dynamic uncertainty in the transportation process. (Wang et al.2014) set the target as Minimal cost, a new mixed integer model with time constraints is proposed. Using image transformation, the problem can be turned into a shortest path model with nodal operation constraints and random characteristics. (Wang Hui et al.2010) Excellent Considering that the transportation demand is fuzzy, the optimization model of multimodal transportation and box transportation with the main purpose of total cost optimization is established, and solved by improved particle ant colony algorithm. (Zhang Dezhi et al.2018) limitedly considered the transit time and transportation differences in multimodal transport. Certainty, time window limitations, and the possibility of transhipment, etc., established a time-sensitive multimodal transport collaborative optimization model. However, the uncertain factors added in these studies are relatively single, and they are all single-objective optimization models. In general, the current multimodal transport route selection model is basically a single-objective optimization model. Even if multiple factors are considered, multiple factors are converted into single-objective programming problems for processing and solving. A few articles are establishing dual-objective optimization models. However, the research on multimodal transportation with uncertain information is mostly based on a single uncertain factor and a single objective function. Regarding the development trend of multimodal transport, (SteadieSeifi et al.2017) pointed out Multi-objective traffic planning in multimodal transport deserves more research. It is necessary to consider the integration of replacement resources and the simultaneous planning of multiple resources. Dynamics and data randomness are also important challenges for research.(Matthisen et al.2016) Pointed out Some issues related to the environment, such as low-carbon and sustainable development, are getting more and more attention. Therefore, from the perspective of multimodal transport operators, this chapter fully considers multiple factors that affect the choice of container multimodal transport process paths and transportation methods. At the same time, due to various reasons such as mechanical failures of vehicles, road maintenance, weather factors, or sudden traffic accidents, it is easy to cause uncertainty in transportation time and carbon emissions Transfer and consolidation refers to a form of logistics operation in which goods are transferred, consolidated, and distributed many times during the transportation process, and finally reach the destination. Transshipment collection has the characteristics of intensive operation, specialization of labor division, and flexible operation. It is widely used in logistics operations such as express delivery, aviation, and container multimodal transportation. At present, there are not many related literatures on the optimization of the operation of the transfer and consolidation, which is not compatible with the development of the current new transportation mode. Based on previous studies, this chapter puts forward a study on the optimization of transfer and consolidation operations in multimodal transportation. (Quan Jiaxiang et al. 2018). conducted a study on how to consolidate goods in 1998, and pointed out that in the process of reconsolidation, in order to minimize the empty load rate of the container, while unpacking and unloading, it is possible to consolidate an appropriate amount of goods. Using containers, this mode of transportation is later also called transit consolidation. Transit consolidation business. Specifically, it refers to the goods are transported to the consolidation point, where the secondary sorting and packaging are carried out at this node, and according to different destinations or different customers, they are repacked together with the local source of goods. A new type of logistics business for transportation. This business involves the simultaneous loading and unloading of goods with multiple ODs, the selection of goods to containers, and the coupling of container transportation routes and cargo transportation routes. There are the following studies for the simultaneous loading and unloading of multiple ODs. (Bu Lei et al.2013) studied the consolidation and assembly problems of a variety of goods, constructed a reasonable individual coding fitness function, and used genetic algorithms to optimize the consolidation and assembly problems of general spare parts. (Tasan et al. 2015) proposed a genetic algorithm on the basis of solving the VRP problem of simultaneous loading and unloading, and evaluated the method by solving multiple test problems, which proved the effectiveness of the algorithm. (Belgin et al.2016) considered the dual-echelon vehicle routing problem to pick up and deliver goods at the same time, using a hybrid heuristic algorithm based on variable neighborhood descent (VND) and local search (LS), and using single-level and two-level distribution systems Research on the simultaneous pickup and delivery system. There are certain similarities between the LCL problem and the LTL problem. (Salvador et al.2016) used the branch and cut method to solve the problem of cooperation between LTL cargo carriers under dynamic capacity, and weighed the cost of holding and the cost of congestion by waiting for packing and transshipment. (Cheung et al.2015) provides a strategy to study the randomness and dynamics of the LTL service network route, find the dynamic shortest path and calculate the travel time through the network with random arc cost. The difference is that the problem of transfer and consolidation can be combined with multimodal transport, not just as a means of delivery. However, the research on multimodal transportation is mostly focused on the study of FCL. (Literature et al.2017 a) studied the network design of hubs with capacity constraints, and analyzed the multimodal transportation network from two levels: the establishment of hubs and the operation of different vehicles efficiency. (Literature et al.2019) considers the optimization research of the entire network from each network node, uses greedy algorithm and intelligent search to solve the multimodal transportation problem, and compares the running time of the two algorithms to obtain the optimal operating time. (Xie Xuemei et al.2016) considered the multimodal transportation of the whole vehicle, which considered the transportation cost, replacement cost, risk cost and time penalty cost, and used the genetic algorithm of binary coding to solve the problem. These studies model and solve the multimodal transportation problem of the entire container under specific conditions, and do not consider the integration of operations in the transportation of multiple OD flows in the container, that is, the optimization of the transfer and consolidation of goods. For the transportation of small batches and multiple batches of goods, from the perspective of space utilization, starting from the concept of free rides, the optimization strategies of multimodal transport operations are also very different in the process of cargo shipment and container transshipment. Therefore, this chapter considers the overall perspective of LCL, fully and evenly utilizes the load and volume of containers, reduces the empty load rate, and establishes a mixed-integer planning multimodal transport model. The objective function considers the minimization of operating costs, including transportation costs, Transshipment costs and node operating costs. Through the design of genetic algorithm and the verification of a certain scale of calculation examples, the selection of different container consolidation points and transfer points, transportation methods and transportation routes in the process of container transfer and consolidation can be effectively completed.

2.4. Technology for truck platooning

A summary, from local to the global level, of the technologies that allow truck plating, is shown in Figure 2. 3. Locally, technologies within a small range of trucks are effective, such as Cruise Control (CC) and Adaptive Cruise Control (ACC). The ACC theory is an example of the CC framework which has been seen to be a way of allowing truck platooning[75]. The cruise system is a mechanism that takes over the accelerator of the truck to keep a stable speed as set by a car owner. The throttle valve controls the strength and direction of the engine by reducing the volume of air intake and is controlled automatically instead of by pushing the button while the steering wheel system is turned on[76]. The Adaptive Cruise Control System is an extension of the CC system, which dynamically changes the speed of the truck to ensure a reasonable distance from the trucks ahead. ACC uses either radar or laser technology to monitor the distance and speed of the truck ahead. If the distance to the truck or object before it decreases, the system will receive a notification to the engine or brakes to pick up speed the truck and vice versa to increase the distance [29].

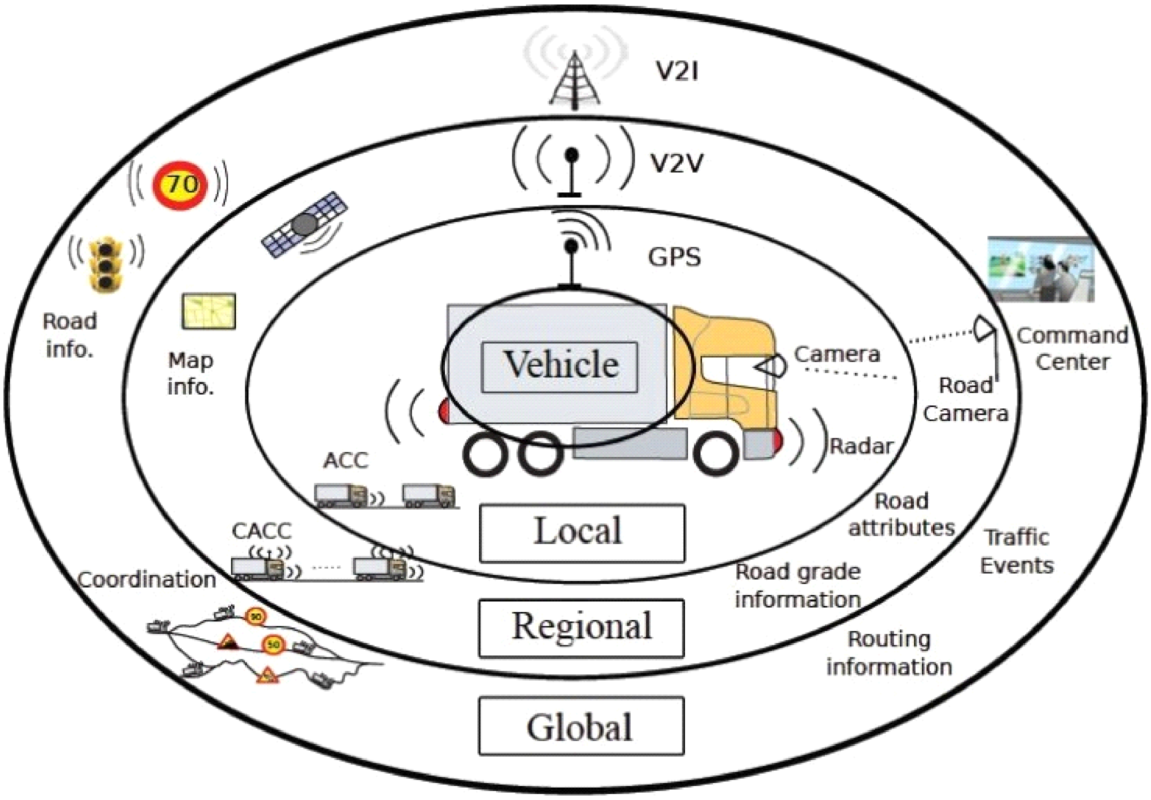

Figure 2.3: Technologies for truck platooning [77].

Extension of the ACC framework is the Cooperative ACC (CACC), which utilizes spatial self-matched truck regulation by adjusting for road detail, such as road elevation, and traffic incidents happening farther forward in the platoon, such as traffic congestion. This is achieved by short and gain exposure wireless communication relative to the truck, car to Truck (V2V) communication and Truck to Infrastructure (V2I) innovation, respectively [35][32]. Interaction between trucks is made possible through V2V communication and can, therefore, improve safety. Through integrating Global Positioning Systems (GPS) and V2V systems, calculations of the relative position of nearby trucks may be rendered at a high stage. As a consequence, better regulation can be accomplished by forecasting based on the knowledge obtained, allowing cooperative driving, and understanding autonomous truck platoons [30]. The application of routing and road knowledge is made possible at the global level by V2I technology. The control center or fleet manager may track trucks in real-time traffic via V2I, allow the capacity to adapt to road and traffic information and automate the transport task, and therefore the fuel usage of the truck. For eg, fuel usage may be reduced by Adjusting the speed of the truck in an attempt to establish a platoon. In reality, V2I will define an indirect path to ensure Deadline for the delivery of the transport project in Case states of congestion of traffic [33][18]. Technologies such as V2V and V2I are part of Intelligent Transport Networks and Facilities (ITS), where it applies to the convergence of Knowledge and Communication

Technology (ICT) with transport infrastructure, trucks and users [21]. Figure 2:2 shows ITS, where it covers both forms of truck and service communication (V2V communication) as well as service and infrastructure communication (V2I communication) [11]. With the help of these communication devices, a cooperative system is set up to support and replace human functions in various driving processes to improve operational performance, mobility, environmental benefits, and safety [21].

2.5. Truck platoon projects in the worldwide

Many platoon projects around in the world in different country is summary gives information about platooning in the world. Several leading team members have been investigating various facets of platooning in the past several decades. These structures specified platooning artifacts, platoon resources, and protocols according to their constructs.

A. **SARTRE** – In the European pedaling system SARTRE, an automobile is classified as a motorbike, a lead bike, another vehicle, a possible follow-up vehicle, a probable lead vehicle, a probable division driver, or a team leader vehicle [78][5]. Relevant platoon activities, such as the forming of a platoon, the entry of platoon, the maintenance of platoon, the release of the troop, and the Dismantling platoons are characterized as the use of platoon cases (Bergenhem et al., 2010; Robinson et al., 2010).

B. **PATH** – U.S.-based intercropping trailer project Guide extended to two types of platoon objects like lead car and prior driver and division assets such as inter-vehicle alignment, based on cross-platoon stance, clear team type action, number of platoon vehicles, length of the platoon, speed or rapid acceleration of the automobile, contact lag time as well as pause, and freeway. Operations such as holding the road, moving the path, entering, and dividing are being checked at this stage.

C. **SCANIA** – The Swedish carmaker SCANIA has launched two sedimentary ventures: SSDC and Intelligent real-time fleet control and management (iQFleet) (Bergenheim et al. 2012b). SCANIA has also developed two sedimentation schemes. In this context, Deng (2016) described the platoon class as a cluster of heavy-duty vehicles capable of platooning and three required characteristics: platoon ID, speed, and several pilots. Deng defined the action of the peloton as an advanced, basic operation. Simple operations involve acceleration, deceleration, and the necessary inter-vehicle space modification. Additionally, emerging structures are recognized for concentrating and party group sorting and dispersion.

The SCANIA projects defined the forming of platoons and created platoons separately, whilst the other projects did not address the creation of platoons or consider the forming of platoons as an informal collective operation. Besides, there is generally no justification or explanation for the categorization of processes. The requirement for standardization and operation of platooning objects is therefore necessary. [17]

D. **Others** – The Japanese platooning scheme Capacity ITS, Tsugawa et al. (2011) specified the track and lane monitoring control system. CHAUFFEUR3 has demonstrated a variety of methods – linking, referred to as 'boat pair,' decoupling, 'Inverted flange relation', and platings, such as lane changing, pace, and braking. Vehicles used in the COMPANION platooning project are not inherently linked to the same sender and receiver: choppers can be produced on the flu by combining vehicles and other platoons, driving together on the road. The Grand Collective Driving Championship was set up in 2009 and 2011 to support the growth, integration, and implementation of cooperative driving. So far as platoon duties are concerned, the main job was to check coordinated traffic flows as a platoon focused on approved machines and interoperable networking equipment and to monitor and perform joint operations. Move as a vehicle participant (Lidström et al., 2011; Bergenheim et al . , 2012b). In addition to the platooning measures related to above, Amoozadeh et al. (2015) submitted a platoon planning manual and coordinated three major platooning operations: split, break, and lane shift. Since then, three definitions of platooning have been clarified: leaving the leader, leaving the next, and touching the bottom. The Platoon API management considers the very first independent variables that every platoon-enabled car would have, namely automotive ID, platoon ID, platoon width, squadron size, and platoon-leaders. Although several research studies and study articles discussed some of the Platoon Manoeuvres and Platoon Properties, none of them defined these operations directly. The different programs defined platooning and platooning in inconsistent ways. For illustration, SARTRE 's joint role is the same as the integrated process in SCANIA projects and CHAUFFEUR's linking system. Not only do meanings vary, but the meaning of aim and process often varies. SARTRE used eight separate platooning methods to handle multiple platooning tasks, while others used three components: team chief, platoon partner. and platoon., occasionally also additionally free car.

2.6. Solution Techniques

The transportation problem as a major problem, to solve the transportation problem in this method table a summary of different methods solution. Table 2.2: below gives information about the world's solution techniques. methods table a summary of different methods of solution.

Table 2.1: Summarize of different solution methodologies implementing in previous Studies.

Solution Techniques	References
Direct Solution (MILP, LP)	Aifadopoulou et al, 2007; Chang, 2008; Kim et al, 2009; Lu et al, 2010; Flórez et al, 2011; Ayar et al, 2012; Bierwirth et al, 2012; Bhattacharya et al, 2014; Sun et al, 2015 Cea et al, 2003; Puettmann et al, 2010; Sergio et al, 2012;
Dynamic, Stochastic,Two-Stage	Cho et al, 2007; Agarwal et al, 2008; Bock, 2010; Cho et al, 2012; Ferrari, 2015; Hao et al, 2016 Kalinina et al, 2013;
Heuristics, Meta- Heuristics	Yamada et al, 2009; Caramia et al, 2009; Kengpol et al, 2014; Gkiotsalitis et al, 2015; Zhang et al, 2015 Vanovermeire et al, 2014;
Mode Choice, Predictive Analysis	Gelders et al, 2003; Frejinger et al, 2009; Macharis et al, 2011; Huang et al, 2011; Lu, 2013; Masiero et al, 2013; Arencibia et al, 2015; Bovy et al, 2015; Kucukaltan et al, 2016; Combes et al, 2016
Survey, Simulation	Shinghal et al, 2002; Luo et al, 2003; Kim et al, 2011 Simulation,Hanssen et al, 2012; Kelle et al, 2016.

2.7. Aerial cable way Technology (ART)

The ART technologies have served as mass transit modes in urbanized areas such as: Aerial Tramways, Bicable Detachable Gondolas (BDG), Dual-Haul Aerial Tramways Monocable, Detachable Gondolas (MDG), and Tricable Detachable Gondolas (TDG). One of major example using ART is Sochi Olympic park. In order to minimize the economic and environmental cost of building a road to link Olympic village to the event locations, a 3S gondola was developed for transporting athletes and event staff with their cars. There was integration of carrying platforms for Special car-Sochi Olympic Park’s 3S gondola along the line, with two support cables for adding strength and allows stability for carrying heavy objects. The cyclic motion of material ropeways which pass over terrain allows efficient hauling compared to trucks. Ropeways are also providing creative materials transport solutions. In addition, the ropeways are increasingly being applied to solve logistics problems.(P. Živanović, 2017) has introduced several aerials cars or aerial tramways system. Aerial tramway system is a transport technology that conveys people in motor-less and engine-less trucks which are propelled by a steel cable. Although there is well documentation of economic, technical and technological aspects of aerial tramway introduction, only small effort has been made to define the optimal market for this mode of transport. In (Balla, 2000), developing transport sector like other infrastructural sectors results to increase the productivity in different ways through the increase of accessibility and reduction of transport costs. (B. Alshalalfah, 2012) describes the origins of aerial transportation with advantages, characteristics, components, available technologies, and applications in the world. (S. Težak, 2016) have studied the merits and demerits of cable cars within urban areas in public transport. The merits of cable car transport were compared to other method of transport. Principally its operation is absolutely quiet with an electric drive, which is environmentally-acceptable secondly transporting passengers far above the ground made us able of providing more transport dimensions in urban center. Thus, cable cars possesses numerous disadvantages, mostly the cabin's capacities is small compared to other transportation mode in urban environment [79].

2.8. Comparison of different Type of ropeway technology

Table 1 summarizes main criteria that can be adopted to classify these cable car transportation systems, namely, the number of used cables, and the operating mode. However, other distinctive technical elements can be taken into account to better classify aerial ropeways, such as the type and size of cabins, or the type of connection to the cable and that may include the possibility of their detachment at the terminal stations[24], [8].

Table 1: Comparison of Type of ropeway technology [9].

Type	**Tramways**		**Gondolas**		
Rope type	Single-Haul Aerial Tramways	Dual-Haul Aerial Tramways	Mono-Cable Detachable Gondolas (MDGs)	Bi-Cable Detachable Gondolas (BDGs)	Tri-Cable Detachable Gondolas (TDGs)
	One or two tracks ropes and one haul rope	One or two tracks ropes and one haul rope	One rope for support and propulsion. (propelled and supported by the same cable	Two separates cables, one for support (track rope) and the other (haulage rope) for propulsion.	Two cables for support (track ropes), a third for propulsion (haulage rope).
Grips	Fixed grips	Fixed grips	Detachable grips	Detachable grips	Detachable grips
Operating speed	Up to 43.2 (km/h)	Up to 27 (km/h)	Up to 21.6 (km/h)	Up to 21.6 (km/h)	Up to 30.6 (km/h)
Maximum number of terminals	3 terminal stations	Multiple stations	Multiple stations	Multiple stations	Multiple stations
Maximum distance between towers	Less than 1000 m	Less than 1000 m	350 m	700 m	3000 m
Loop, Movement	One back and forth Loop	Two separated back and forth loops	Continuous circulating loop	Continuous circulating loop	Continuous circulating loop
	The loop shuttles back and forth between two end terminals (reversible system).		The cabin cars continuously move, circulate between the two terminals.		

Conclusion

This chapter discusses the salient features of multimodal transport that form the basis of the transport systems used in international transport operations. In terms of logistics and supply chain management, multimodal transport enables service providers to optimize their services and save costs for the company and the economy. A distinctive feature of multimodal transport compared to other existing transport systems is the need to integrate and regulations transport operations.

Chapter 3. The Optimal Path of Goods Multimodal Transport

3.1. Introduction

With the acceleration of the global economic integration process, the transportation network has become more and more complex, and container transportation has formed a multimodal transportation system that combines maritime trunk lines and inland container transportation networks. How to organize container multimodal transportation more reasonably and effectively People are paying more and more attention to reduce transportation costs and improve the competitiveness of products in the market[81]. Many scholars at home and abroad have done extensive and in-depth research on the organization and optimization of container multimodal transport. (Janicet al.2014) has established a system that includes the external costs and internal costs of multimodal transport. This model analyses the impact of policies on the multimodal transport network .(Zeng Yongchang et al. 2017) based on the multimodal transport model with time windows, established a multimodal transport model based on a satisfactory time path with the goal of minimizing the total cost.(Tang Jianqiao et al.2015) established a container multimodal transportation organization optimization model, and used simulated annealing algorithm to theoretically explore the solution of the model, so as to realize the problem of minimizing the generalized transportation cost (Chang et al.2013) established a method that includes transportation ,delivery time The mathematical model of multiple commodity flows with multiple objectives and multiple modes of transportation with time windows and transport economies of scale (Wang Wei et al. 2014) established a virtual transportation network to optimize the transportation route and transportation mode of container multimodal transportation. It is transformed into a shortest path problem with time constraints and capacity constraints to solve (Wei Zhong et al 2016). proposed the shortest time path-cost optimization model of multimodal transport, and proposed to solve the shortest path time through an iterative algorithm, and then according to the shortest time path calculates the transportation cost.[82] The current research on container multimodal transportation assumes that the time and cost of the transportation mode conversion operation at the node are a certain fixed value, and does not consider the impact of the change in the conversion time and cost on the choice of transportation routes and transportation methods.[83] In actual operations when the container is converted between different transportation methods, the time and cost of the conversion operation are often random due to waiting or other uncertain factors. Therefore, this chapter from the rational organization of container inland distribution transportation set out, in the Case state of node operation time with random characteristics, study the available transportation routes and transportation mode combinations in the container multimodal transportation process to help the container multimodal transportation group the weaver makes decisions.

3.2. The problem Description

In the container internal multimodal transport network, the starting point is *O* and the end point is *D*. There are several transfer stations for container containers that can be converted. There are different modes of transportation between the transfer stations. The transportation mode conversion operation of the transfer station requires a certain amount of time and operating cost. Because the transportation mode conversion operation is affected by the resources of the transfer station. Due to the influence of various factors such as configuration, weather conditions, workload, and operating level, the available transportation methods of different transfer stations are different. The total time of the conversion operation, especially the waiting time and equipment preparation time, has a certain randomness, so the conversion operation, the cost is not a fixed value. The problem that needs to be solved is under the premise of not exceeding the total transportation period from the starting point to the end, choosing a reasonable transportation path and the best combination of transportation methods to make the total transportation cost of the container Minimal. This problem can be abstracted as a multimodal transportation, which is described by a network diagram in Figure 4.22. Network Models Representation, the network model gives information as to transit costs and times at the interchange node through link cost functions opportunely specified and calibrated (Kiani et al , 2011). for a directed graph G = (V, A), V is the set of all network nodes, and A is all connected arcs (directed edges) For any arc (i, j), there are transportation mode to choose from, and each arc has time weight and cost weight. The conversion time on the node is inaccurate according to a certain distribution law. Constant value, the conversion cost changes with the change of the conversion time, requiring the lowest cost in the process of transporting goods from the starting point to the end point in the network diagram.

3.3. Network model assumptions and mathematical formulation

The transportation volume cannot be divided between a certain pair of transfer stations, that is, between each pair of container transfer stations, if there are routes of different modes of transportation, only one mode of transportation can be selected between the pair of transfer stations. The connection between various transportation methods can only occur at the node. At the node, only the transit time and transit cost are considered; The venues and facilities at the nodes meet the requirements for conversion between transportation modes; The transportation distance between any two nodes in the network is not different due to different transportation methods; The average speed of each mode of transport has nothing to do with arc.

$$minZ = \sum_{i\in 1} \sum_{i\in A_i} \sum_{k\in J} c_{ij}^k x_{ij}^k + \sum_{i\in I} \sum_{k\in J} \sum_{l\in J} c_i^{kl} r_i^k$$

Symbols Description

$x_{\mathrm{ij}}^k = \begin{cases} 1, & From\ node\ i\ to\ node\ j\ select\ the\ k\ transport\ mode \\ 0, & From\ node\ i\ to\ node\ j\ to\ select\ other\ transport\ mode \end{cases}$
$r_i^{\mathrm{kl}} = \begin{cases} 1, & \text{At node i, switch from the k transport mode to the l transport mode} \\ 0, & No\ change\ of\ transport\ mode\ occurs\ at\ node\ i. \end{cases}$
C_{ij}^k= The transport cost of choosing k_th transport made from node i to node j.
t_{ij}^k= Choose the transport time of the k transport mode from nodei to node j.

The conversion cost from the k transportation mode to the l transportation mode at node i

c_{ij}^k= The conversion cost from the k transport mode to the l transport mode at nodei;

t_{ij}^k= The transition time from k transport mode to l transport mode at node i,

A_i^-=The set of nodes pointed by the arc starting from node i connected to node i;

A_i^+= The set of node , sat the end of the arc that is connected to node i and points to node i

V = The collection of all nodes in the network.

O = The starting node of the network.

D = the termination node of the network

I = the collection of all intermediate node in the network

J = collection of all modes of transportation.

3.4. Mixed-integer model for path optimization

$$\text{Min z } = \sum_{i\in v}\sum_{j\in A_i^-}\sum_{K\in J} c_{ij}^k\, x_{ij}^k + \sum_{i\in v}\sum_{j\in A_i^-}\sum_{K\in J} c_i^{kL}\, r_i^{kL}$$

$$\sum_{j\in A_i^-}\sum_{k\in j} x_{ij}^k - \sum_{j\in A_i^-}\sum_{K\in J} x_{ji}^k = 1, i = 0 \tag{1}$$

$$\sum_{j\in A_i^-}\sum_{k\in j} x_{ij}^k - \sum_{j\in A_i^-}\sum_{K\in J} x_{ji}^k = 0, i \in I \tag{2}$$

$$\sum_{j\in A_i^-}\sum_{k\in j} x_{ij}^k - \sum_{j\in A_i^-}\sum_{K\in J} x_{ji}^k = 1, i = D \tag{3}$$

$$\sum_{j\in A_i^-}\sum_{k\in j} x_{ij}^k - \sum_{j\in A_i^-}\sum_{K\in J} x_{ji}^k = 1, i \in V - \{D\} \tag{4}$$

$$x_{ij}^k + x_{iP}^k \geq 2r_j^{kL}, j \in A_i^-, P \in A_i^-, K \in J, i \in J \tag{5}$$

$$\sum_{i\in v}\sum_{j\in A_i^-}\sum_{K\in J} \mathrm{t}_{ij}^k\, x_{ij}^k + \sum_{i\in I}\sum_{\mathrm{k}\in J}\sum_{i\in J} \mathrm{t}_i^{kL}\, r_i^{kL} \leq T\ , \mathrm{t}_i^{kL} \sim N(\mu, \sigma^2) \tag{6}$$

$$x_{ij}^k \in \{0,1\} \tag{7}$$

$$r_{ij}^k \in \{0,1\} \tag{8}$$

Objective function, the objective function takes the minimum sum of the transportation cost and the transformation cost of completing the cargo transportation as the target. Constraints (1), (2), (3) ensure that a path from the start point to the end point is obtained, which respectively represent the starting point Points, intermediate nodes, and termination nodes; constraint conditions (4) ensure that only one transportation mode can be selected from any node; constraint conditions (5) ensure the continuity of the transportation mode; about The binding condition (6) guarantees that the goods must be delivered within the specified time period; the binding conditions (7) and (8) indicate that the decision variables can only be integers the integer 0 or 1.

3.5. Model network transformation and data processing

In order to simplify the solution, the multimodal transport network is expanded and distorted, and the number of new nodes expanded by each node except the originating point is from the previous node in the original network graph to the node available for selection. The number of transmission modes is determined. If there are (J) transport modes to choose between each pair of nodes with connecting arcs, the latter node will expand into J new nodes, which are connected to the previous node, and each connecting arc represents a kind Transport mode, and there is no connecting arc between the new nodes expanded from the same node, so each node except the starting point is expanded. After the ending point is expanded, a virtual node is added as a new ending point, which is an expanded node with the original ending point There are arcs connected, the time weight and cost weight on the arcs are 0, and the transportation capacity is infinite. The network modification process is shown in Figure3.2 and Figure 3.3. In this way, the original problem is transformed into: Under the premise of not exceeding the transportation period, ask for the shortest path from the start node to the virtual end point.

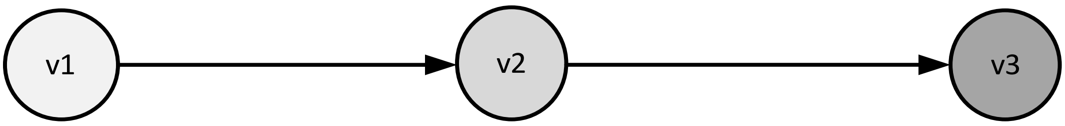

Figure 3.1: Arcs between 3 network nodes

V_1 is the starting node, and V_3 is the ending node. After node expansion, After the figure3.1, the new network diagram is shown in Figure3.2:

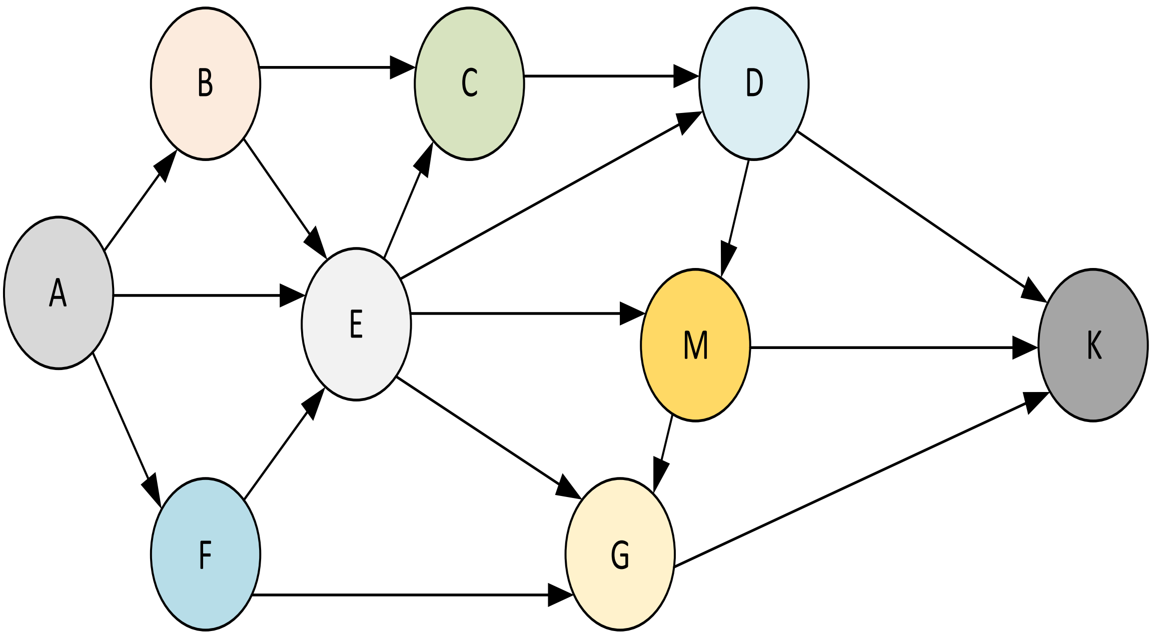

Figure 3.2: Network model under study

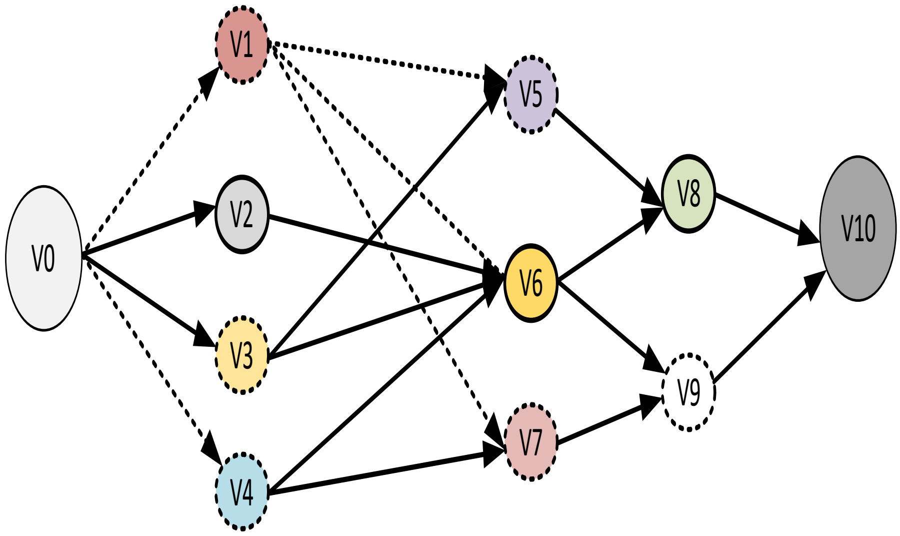

Figure 3.3: Example of new node virtual

In Figure 3.3, (V_0-V_{10}) V ij represents the j-th new node expanded from the i-th node, and the subscript j represents the J-th transportation mode from its previous node to node i. Arc (V_{3J}, V_6) represents the j-th Species set When the packing transportation method reaches the end point, the time and cost weights on this arc are both 0, and there is no transportation mode conversion at node V_3, and V_4 is the virtual end point. After the network diagram is deformed, the conversion time and conversion cost at the node are merged into the corresponding arc, so that the time weight and cost weight in the network diagram only exist on the arc. In the network diagram, each intermediate node where the conversion time and cost of the point are merged into the arc connected to the node from the node. If the first transportation mode is selected from V_1 to V_2, then the starting from V_{21} to V_{32}, V_{33}, V_{3J} arcs the transportation cost and time are respectively added to the conversion cost and time from the first transportation mode to the second, third. j-th transportation mode at node V_2; and the arc (V_{21}, V_{31}) indicates If no transportation mode conversion occurs at node v_2, no transfer will occur. Replacement cost, the node with the original destination extension does not undergo any conversion of the transportation mode, and its conversion cost and conversion time are 0, and the time and cost weights on the arc connected to the virtual node are all 0. After the change, the model symbols are defined as follows:

V’	the collection of all nodes in the network after deformation;
V	the collection of all arcs in the network after deformation;
O_st	the starting node of the network after deformation;
D_ed	the terminal node of the network after deformation;

T_time	transport period (known);
$x_{ij}^{k} =$	$\begin{cases} 1, & There\ is\ a\ transportation\ task\ from\ node\ i\ to\ node\ j \\ 0, & otherwise \end{cases}$
c_{ij}	the cost weight from node i to node j;
t_{ij}	The weight of time from node i to node j.

The shortest path model after network deformation:

$$\text{Min } z' = \sum_{i\in v'}\sum_{j\in v'} c_{ij}\, x_{ij}$$

$$\sum_{i\in v'} x_{ij} - \sum_{i\in v'} x_{ji} = 1 \qquad i = 0' \tag{9}$$

$$\sum_{i\in v'} x_{ij} - \sum_{i\in v'} x_{ji} = -1 \qquad i = D' \tag{10}$$

$$\sum_{i\in v'} x_{ij} - \sum_{i\in v'} x_{ji} = 1 \qquad i \in V' - \{0'\} - \{D'\} \tag{11}$$

$$\sum_{i\in v'} x_{ij} \le 1 \qquad \forall_i = 0', i \in V' \tag{12}$$

$$\sum_{i\in v'}\sum_{j\in v'} \mathrm{t}_{ij}\, x_{ij} \le T \tag{13}$$

$$x_{ij} \in \{0,1\} \qquad \forall (i, j) \in A' \tag{14}$$

The objective function is to minimize the total cost of completing the transportation task from the start node to the end node. Constraints (9), (10), (11) ensure that a path from the start point to the end point is obtained; constraint conditions (12) Ensure that the transportation volume is indivisible when passing through any node; the constraint condition (13) guarantees that the goods must arrive within the specified time; the constraint condition (14) indicates that the decision variable takes the integer 0 or 1.

3.6. Short path Algorithmic (Dijkstra's algorithm)

After the above processing, the problem is transformed into the shortest path problem with hard time constraints on an arc affected by the random characteristics of the conversion time. The transit time includes loading and unloading operation time and waiting and equipment preparation time [84]. Since the model assumes that a batch of containers is converted at the same time, the loading and unloading operation time has a linear relationship with the number of operations, while the waiting time and equipment preparation time are random. Statistics and verify the probability distribution that it following. The transport time between nodes can be obtained according to the transport distance on the arc and the transport speed of the container in each transport mode; the cost of container multimodal transport, including the conversion cost and transportation of different transportation methods Cost. The cost of switching operations at the node includes two parts: fixed cost and variable cost. Fixed cost mainly refers to the storage cost during the waiting time and the fixed cost of equipment. Due to the randomness of the conversion waiting time, this part of the cost is also uncertain, and the conversion cost is linear with the number of containers in the operation.[85] In addition, the number of containers for each conversion operation at a specific node is not Determined, the probability distribution can be calculated according to historical data, and the average value is taken in the calculation.

According to the probability distribution of the transition time of different transportation modes of the node. The simulation generates a set of random numbers for the transition time of nodes. Under a certain transportation period, use MATLAB software ™ to program the path optimization mixed integer programming model to obtain the optimal transportation path. Repeat this several times, each time a new set of the random number of the transportation conversion time, each time a new result is obtained. Count the frequency of different optimal paths, obtain the frequency of the optimal transportation path and the combination of transportation modes under different time constraints, and perform statistical analysis on the results, choose the best combination of container multimodal transportation routes and transportation methods.

3.7. Description of the calculation example

A batch of containers are to be transported from point A to point F. A total of n of container example 4 transfer stations B, C, D, and E can be used for the conversion of transportation modes. Among them, except for the only one mode of transportation between C and E, there are railways between any other interconnected transfer stations and road transportation methods. The problem is not lost in generality. The number of containers in this batch is uncertain and has a certain degree of randomness. Its conversion operation time and cost are related to the batch. Assume that railway represents the first mode of transportation, and road represents the second the waterway represents the third transportation method, and the multimodal transportation network faced by the container cargo is shown in Figure 3.4 The virtual transportation network diagram obtained after node expansion and deformation of the multimodal transportation network is shown in Figure3.5. Nodes V_1 and V_2 are expanded from node B, denoted as B (V_1, V_2), and the nodes in the virtual transportation network diagram are The relationship between the nodes in the original network diagram is: C(v_3,v_4), D(v5,v6), E(v_7), F(v_8,v_9), node v_{10} is the virtual end point.

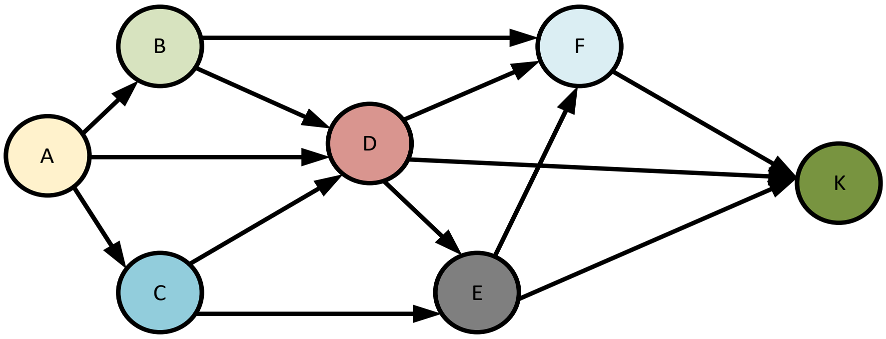

Figure 3.4: Network model.

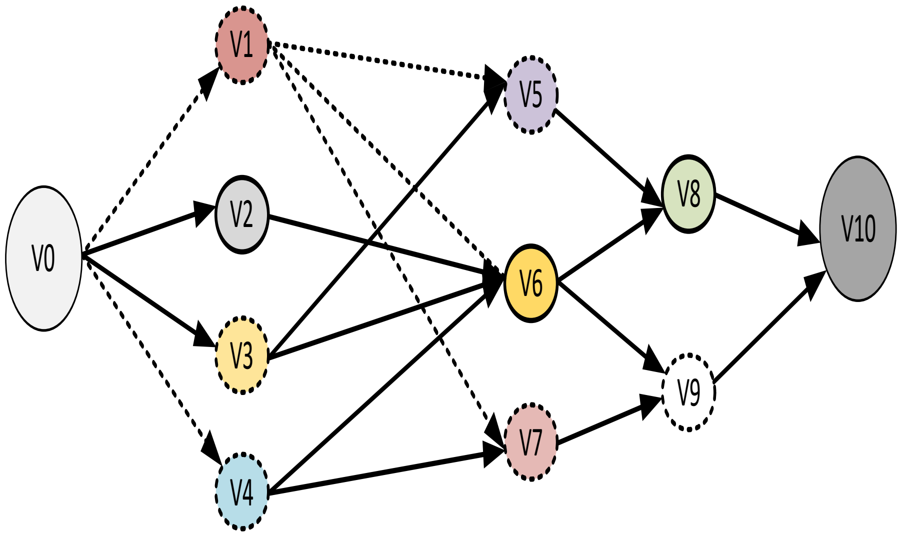

Figure 3.5: Virtual network model.

3.8. Model conversion time

According to the inspection, the conversion time of the transportation mode conversion of each transfer station objectives the normal distribution, as shown in Table 3:1.

Table 3.1: Transhipment time distribution of container City.

Transition node		Railway	Highway	Waterway
Node B	Railway	-	(12,32)	-
	Highway	(12,3)	-	-
Node C	Railway	-	-	(15,62)
	Highway	-	-	(16,42)
Node D	Railway	-	(13,52)	-
	Highway	(13,52)	-	-
Node E	Waterway	(14,42)	(15,52)	

3.9. Switching cost

The conversion cost of each container transfer station is mainly affected by the conversion time and transportation batch. The container conversion waiting time of each transfer station is obtained by subtracting the conversion operation time from the conversion time.

The container conversion operation time of the transfer station is shown in Table3: 2.

Let K be the container conversion cost of a transfer station and T be the conversion Waiting time, conversion cost K = a Q + b, conversion waiting time $T = t_1Q + t_2$, the relationship between change cost and transformation waiting time is a function with random variables, where t_1 is the conversion operation time required for a batch of goods, t_2 is a random variable, and batch Q submits a certain probability distribution, as shown in Table 3.2:

Table 3.2: Transhipment time between transportation modes(hour)

	Railway	Highway	waterway
Railway	0	1	2
Highway	1	0	1
waterway	2	1	0

Table 3.3 Probabilistic lot siz Q

Q	1	2	3	4	5
P	18	31	34	13	4

3.10. Container transportation time and transportation cost

According to the transportation distance between each container transfer station and each The container transportation speed of the transportation mode can be calculated The distance and transportation time between the packing transfer stations are shown in Table 3:4 and Table 3:5.

Table 3.4: Transportation time between container depots (hour)

		Node A	**Node B**	**Node C**	**Node D**	**Node E**	**Node F**
Node A	Railway	0	10.0	6	6.1	-	-
	Highway	0	8.8	5.3	5.4	-	-
Node B	Railway	10.0	0	10.0	1.8	-	9.0
	Highway	4.6	0	7.1	1.6	-	8.5
Node C	Railway	6.0	10.0	0	-	-	-
	Highway	5.3	8.8	0	-	-	-
	Waterway	-	-	0	-	4.5	-
Node D	Railway	6.1	1.8	-	0	-	10.7
	Highway	5.4	1.6	-	0	-	7.8
Node E	Railway	-	-	-	-	-	5.5
	Highway	-	-	-	-	-	4.9
	Waterway	-	-	4.5	-	0	-
Node F	Railway	-	9.0	-	8.7	5.5	0
	Highway	-	8.5	-	7.8	4.9	0

Shaking note: (-) the means that this mode of transportation does not exist between the two transfer stations.

According to the freight accounting method of each container transportation method The transportation cost between various transfer stations, railway transportation depends on different A certain amount of miscellaneous railway freight charges will be added to the situation. Various container transport parties the freight accounting and transportation cost between transfer stations are shown in Table 3:6 and Table 3:7.

Table 3-6 Transportation time between container depots (hour)

		A	B	C	D	E	F
Node A	Railway	0	2957	2656	2664	-	-
	Highway	0	3288	2856	2910	-	-
Node B	Railway	2957	0	-	1550	-	2928
	Highway	3288	0	-	876	-	4614
Node C	Railway	2656	-	0	-	-	-
	Highway	2856	8.8	0	-	-	-
	waterway	-	-	0	-	9.5	-
Node D	Railway	2664	1550	-	0	-	3526
	Highway	2910	876	-	0	-	4194
Node E	Railway	-	-	-	-	-	2626
	Highway	-	-	-	-	-	2658
	waterway	-	-	9.5	-	-	-
Node F	Railway	-	2928	-	3526	2626	0
	Highway	-	4614	-	4194	2658	0

Solution results and analysis Since the conversion time varies randomly, the combination of the optimal path and transportation mode of the container intermodal transportation obtained by the solution changes with the change of the conversion time. In order to analyzed the influence of the conversion time on the choice of container transportation path and transportation mode, statistics are different. Under the transportation period, the frequency of the combination of the optimal transportation route and transportation mode of the container. Under different transportation periods, the algorithm is executed 25 ;50;100 times in a loop, and the statistical results are as follows:

The statistical results are as follows:

- In Case State *When T = 25.*

There is only one route v_0, v_6, v_9, v_{10} that meets the time requirements. The transportation mode combination of this route is A to Highway D to Highway F, the average total time is 12.6 hours, and the average total cost of a single box is 6 120 €.

- In Case State When T = 50.

The first transportation path is (v_0 v10) (v_1 v10) (v_9 v_{10}), the optimal frequency is 32%, the transportation mode combination is A-rail B-road F, the average total time is 17.2 hours, and the average total cost of a single container is 5 728 €. The second transportation path is v_0 v_6 v_9 v_{10}, the optimal frequency is 68%, the transportation mode combination is A-k highway D-k Highway F, the average total time is 12.6 hours, and the average total cost is 6 120 .

When T = 30. The optimal combination when the transport period is T = 25 h is shown in Table3.5 When the transportation period T = 25 h, the path A to highway B to railway F has the greatest probability, accounting for 46% of all optimal paths, the total cost is the smallest, the total time is moderate, and the economy is the best, so this transportation path The combination of transportation and transportation mode is given priority when T=25. The probability that the second path combination and the third path combination are optimal is 27% and 14%, respectively, and the two probabilities are not much different, and the cost is almost the same. Therefore, the two path combinations have greater mutual substitution, but when the cargo owner pays more attention to the pursuit of time, the third path combination should be given priority. The fourth path and the fifth path are optimal the probabilities of are all very small, only 5% and 8% respectively, and in terms of time and cost expenditures, they are obviously not superior to the first three combinations, so these two path combinations are not considered. When T = 40 h. The optimal combination when the transport period T = 40 is shown in Table3.5 Table 3.6 The optimal combination when the transport period T = 25

Transportation route	Mode of transport out	The number of occurrences	Probability of occurrence	Average cost (€),	average time (h)
V_0-V_2-V_6	ABF	46	0.46	4936	23.4
V_0-V_2-V_6	ABF	27	0.27	5817	27.6
V_0-V_2-V_6-V_8	ABDF	14	0.14	5906	23.1
V_0-V_2-V_6-V_8	ABDF	5	0.05	5674	23.6
V_0-V_2-V_6-V_8	ABDF	8	0.08	6120	12.6

Table 3.5 The optimal combination when the transport period T = 40

Transportation route	Mode of transport out	The number of occurrences	Probability of occurrence	Average cost (€),	average time (h)
V_0-V_2-V_6-V_8	ABDF	3	0.03	3850	37.5
V_0-V_1-V_5-V_9	ABF	49	0.49	4936	23.4
V_0-V_3-V_6-V_9	ACEF	7	0.07	3745	38.3
V_0-V_4-V_6-V_9	ADF	41	0.41	5906	23.1

When the transportation period is 40 hours, and the conversion time of each transfer station is uncertain, the probability of the container transportation path combined with the optimal path of the container and the combination of transportation methods is different. At the same time, the second path has the highest probability of being optimal, at 49%, followed by the fourth path, at 41%, and the third path and the first path have a very small optimal probability and can be ignored. The probability that the path is optimal is the largest. The average time is 23. 4 hours, and the average cost is 4,936 €. The time and cost of the fourth path are This is relatively close, but the cost is 970 €, so the cargo owner should choose the second route first, and the fourth route can be used as a strong alternative route.

Conclusion

Through the analysis of the solution results, it can be seen that in the Case state of changes in the transportation period, there are a variety of optimal combinations of transportation paths and transportation methods for container multimodal transportation to choose from, but the probability of various combinations of paths and transportation methods is different. Multimodal transport operators or cargo owners can choose based on the total time and total cost of each combination and their optimal probability to assist in the selection decision of the optimal transportation route and transportation mode.

Chapter 4. Optimizing freight Transfers at Multimodal logistic platform transit and consolidation.

Operation optimization goods transit and consolidation under multimodal transport.
This chapter closely integrates the practice of optimal multimodal transport systematically introduces the basics. The chapter is divided into two parts, the first to the part chapter for the truck platooning part introduced. The basic overview of energy management and CO_2 emission. Also, it presents a review of platoon technology for truck and operates track platoon at short path and travels its trip in platooning with compared between them. To reducing CO_2 and decreasing fuel consumption where truck moving, the second part shows cable car, this part presented point view cable car form CO_2 and comparing others modals the result support main objective of green logistic transport.

4.1. Part one: Optimal of Multimodal Transport Base on platooning technology

The place of freight transportation cannot be underestimated or disregarded in the growth of the economy as it's fast-rising to a world market [86]. A large part of the inland freight transport is evident in its use on roads. It is dynamic and relative to change as it can be subjected to changes due to the un-ending innovations of man over the coming years, as cognizance needs to the recent trends of initiatives and innovations which have led to the improvement of our technological world. The application of truck platoon in freight transportation has occasioned an introduction of integrated goods freight transportation which has optimized logistics and real-time updates about our vehicular traffic communication joint trying to drive as well as independent trucks. In this research work, we gave an insight into the problems in making a reality, a better and adequate movement of goods by the road system to reduce environmental issues, and how we can proffer solutions with the aid of technology. We emphatically explained a medium which can increase the effectiveness of this movement scheme by truck platoon transports to fulfill the task on a prescribed road network.

4.1.1. Conceptual definition of truck platooning

Truck platooning applies to the autonomous running of trucks in small convoys, a limited distance apart, resulting in seamless traffic movement, improved road protection, fuel savings, and a decrease in CO_2 emissions [12]. Road shared mobility pure technical efficiency tracking of truck armored trucks on the highway. The pedestal truck can be in one of three Case states: leader mode, follower mode, and free mode; free mode is a free Case state where the truck does not join any pedestal. Manual control is the figurehead mode as well as the free mode, while the supporter mode is the pi controller. It's completely automatic. Every transformation between these types is one of the major platoon management activities. These activities are: the formation of a new platoon, the merger of two platoons, and the input/output procedures for the truck are from the platoon. The tracker is functioned by both regulate systems Longitudinal and spatial monitoring mechanisms. A different sensors array used to provide vehicular speed. acceleration and positioning of the truck, as well as inter-car space on the pedestal. [19]. The triple measuring instrument is used to determine the inter-truck width signal: an inter-sensor chosen to represent the laser range-finder, an integrated camera, and an observer, based on the dynamic equations of the system. This redundancy makes it possible to detect and identify faults in the sensors. Besides, it can be used to improve the efficiency of the follower control mode by adding a global PS framework that involves a data fusion level and a decision-making method. Free mode is the Case state in which a truck does not relate to a platoon.

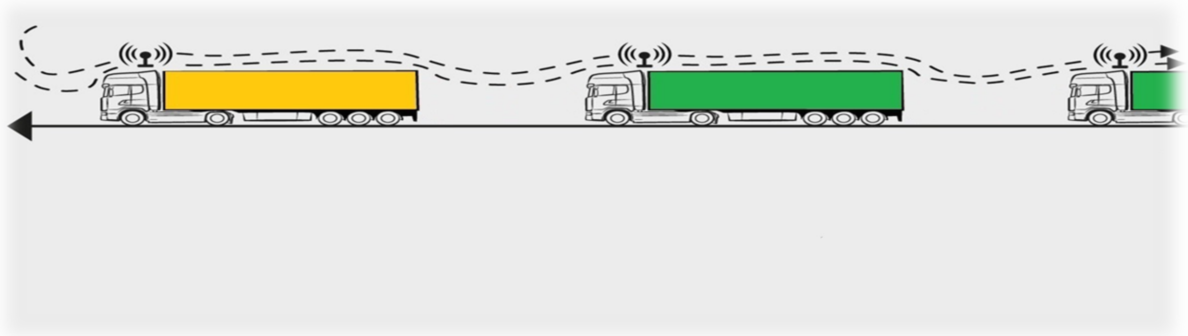

Figure 4.1: Truck platooning.

4.1.2. Truck Platoon System overview

Truck Platoon System, definition Truck platoon is the process of coupling two or more trucks together while they are travelling. Truck platooning refers to automatic driving of trucks in small convoys, a short distance apart, sharing of information that are pertinent to transportation via V2V/V2I connectivity together while they are traveling on a highway. Truck platoon increases the productivity of road transportation sector and truck industries, reduction of road freight operational costs as a result of fuel saving, and significant reduction of its environmental hazard due to the accumulation of greenhouse gas (Carbon dioxide) from road freight transportation over long distance. Congestion of route traffic is a major problem that affects daily life, causing delays and traffic disruptions with its negative impacts on economics. At the same time, the development of trucks platoon system and communication in transport systems opens up wide prospects for the development of new approaches to intelligent traffic management and transport system. Indeed, connected trucks, thanks to their communication interface, have the possibility to interact with a control system (aggregator) and each other by suggesting a route to them depending on various situations detected on the road.

4.1.3. Environment concerns

Transportation is the world's main cause of carbon emissions. Pollution caused by trucks and cars is responsible for instant and long-term environmental impacts, exhaust fumes emit a significant portion of gasses and solids responsible for acid rain, global warming, and environmental/human health hazards. Fuel spills and the noise generated by the engine also cause pollution. Cars, trucks, and other means of travel are the biggest contributors to air harmful emissions in the United States, and though car owners could even reduce the environmental impact of their trucks [9].

Figure 4.2: The impact of Road freight transport emissions on the Environment [10]

According to research, road freight transport accounts for 57% of global carbon dioxide CO_2 pollution, although other pollutants come from warehousing and storage. In 1995, 22 % of CO_2 pollution comes from coal usage (fossil fuels) in the transport sector [37]. Road freight increased rapidly during the second half of the century's a transport network, the goods, in a particular food, also low-cost, short-term and timely in several places. trucks are known to be transportable more quickly than trains, but more quickly. Polluting. (Jaroszweski, 2012). Transport, as well as increasing demand for electricity, has seen an effect on the international increase in sales for electric energy.

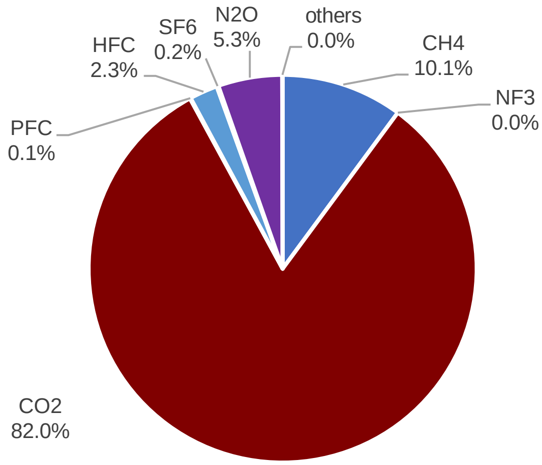

Figure 4.3: Total Greenhouse Gas Emissions (GHG) * (EU-28, 2017)

Local pollution of gas in OECD nations. In the last 30 years, greenhouse gases have been reported to rise by more or less 1.7% each year. Throughout Australia, for example, the combined usage of power and private trucks accounts for around 20% of carbon pollution, while 80 percent is related to public and commercial services or the stockpile of consumer products. Not only is greenhouse gas pollution a global transport issue. In 1996, the Regional The greenhouse gas stock executive committee announced the results of non- CO_2 emissions in the roads industry where it became evident that large amounts of harmful pollutants such as Cars carrying medium-heavy goods used for freight transport released CH4, N2O, NOx and CO_2 (Lenzen, Dey, Hamilton 2008). In shows, air pollution and their impacts (Table4.1).

Table4.1: Truck emissions: the constituents of air pollution and their impacts [11].

Constituents of air Pollution	Impacts
Particulate (PM) matter	This soot as well as metal particulates gives the pollution its mucky image. Fine particles (less than thing-tenth the thickness of human hair) present a more significant danger to human wellbeing as they may reach deep into the lungs. PM is an immediate (primary) and informal smog by hydrogen, nitrogen dioxide, and sulfur.
Hydrocarbons (HC)	Such contaminants combine with sulfur dioxide amid sunlight to create ground-level ozone, which is the main component in polluted air. While helpful in the interstellar medium, at street level.
Nitrogen (NOx) oxides	Such toxins cause lung inflammation and disrupt the body's aerobic protection mechanism. Illnesses such as bacterial meningitis and flu. These also add to the production of low-level natural background radiation.
Carbon (CO) monoxide	This odorless, colorless, and toxic chemical are triggered by the combustion of solid fuels, such as gasoline, and is transmitted mainly from automobiles. CO removes oxygen from the brain, skin, and other important organs while inhaling. Fetuses, baby boys, and individuals with diabetes diseases are highly vulnerable to the effects of CO_2 .
Sulfur dioxide (SO2)	Power stations or automobiles generate this carcinogen through processing sulfur-containing fuels, diesel. Sulfur dioxide may lead to the forming of small particles in the air. Health threats to small children and people with diabetes.
Hazardous air pollutants	These oxidizing agents are linked to chromosomal abnormalities, cancer, and some other serious diseases. The Environmental Protection Agency estimates that air pollutants generated from automobiles, including benzene, acetaldehyde, and oxides of nitrogen (NOx, cover half of all forms of cancer sparked.
Greenhouse gases	Motorists also emit greenhouse gases, along with carbon dioxide, which contributes to climate change. Trucks and trucks account for more than one-fifth of the overall global warming pollution in the country; transport, including freight, trains, and civil aviation contributes to about thirty percent of all heat-stripping gas emissions.

Effective truck platooning

Platooning has been shown to contribute to energy savings in the following aspects:

The first is the huge decrease of aerodynamic drag, although the second is the provision of larger rooms leading to excessive road Strength in the road community. The first is an extension of microscopy and the second a macroscopy. The usage of fluid mechanics to research aerodynamic drag reduction is part of the microscopic engagement [12]. The CD rating for a front and final tractor-trailer is bottom by something like 20 percent, while the center truck document volume is away by something like 50 percent. That suggests, there are 3 trucks they move with a slight distance, then the aerodynamic drag reduces, which leads to energy savings. As a consequence of the high-speed journey of the wagons, the Russell number is higher than for the tire wear; the fuel efficiency of the squad should be reduced by around 15%.

4.1.4 Platoon truck Energy Consumption

According to the Energy ITS report (2016), although the trend in energy use in the manufacturing sector has remained almost continuous since 1990, this same trend throughout the city and transport sectors has enhanced. In the rail industry, it rose by 7% in 2010 relative to 1990. In 2010, the electricity use of trucks was 89% for freight storage and 90% for commercial transport. The percentage for air freight, whereas the length of travel (commuters-km or ton-km) by car is 65 hundred cents including passengers and 61 per half for freight transport. The fuel intake was measured during the test track in situations where the pace was steady and 80 km / h, the gap was 10 m and 4.7 m and the trucks were empty-loaded. The results are seen in Figure 4.3, Observations reveal 13 percent of electricity supply at a range of approximately m and 18 percent of consumption at a range of 4.7 m. If the trucks are normally filled and 80 km driven, / h, fuel savings would be 8 percent if the 10 m distance is 10 m, and 15 percent if the 4 m width is 4 m. [22]

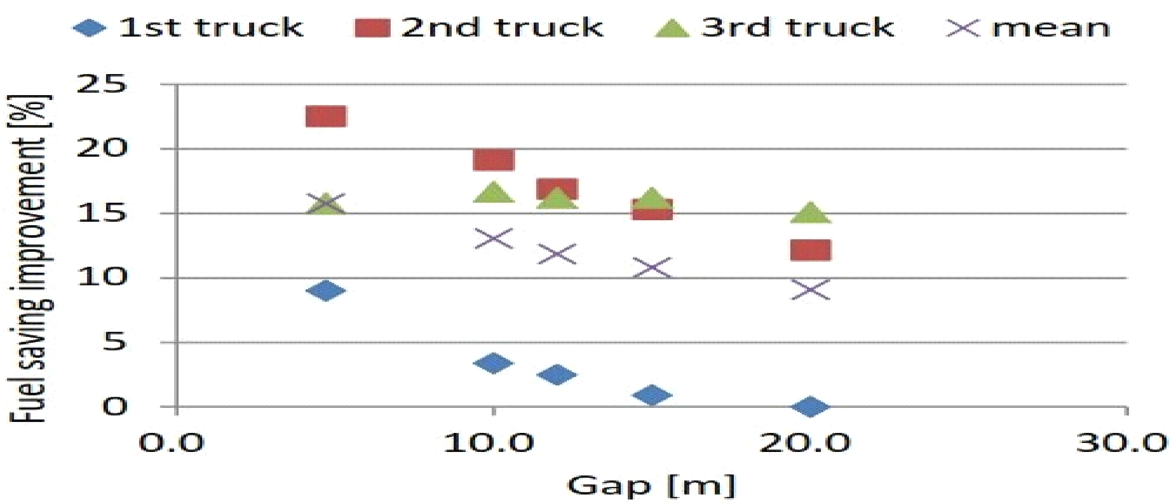

Figure 4.4: Relationship between fuel-saving improvement and the gap in the platoon [22].

4.1.4. Platoon truck Emission

The transport sector's CO_2 emissions (228 M ton in 2008) account for 19 percent of Japan 's overall pollution (1,214 M ton in 2008) and 90 percent of the transport sector's CO_2 emissions come from trucks. Cars are also the primary drivers of global change, and Considering the energy from existing trucks using electric motors is oil and gas the directly generates CO_2 following detonation, neutralizing climate science for cars and trucks (latest) is ecologically responsible. Truck Platooning may be one of the alternatives to environmental problems such as global warming. Closely running trucks in a group with high maximum air resistance and therefore fuel consumption. This was the result of the research on wind tunnels and field experiments [32, 18]. The findings of field studies show that fuel savings in truck platoons are closely related to the location of the truck in the platoon and the situational distance of the truck. A truck driving on the front and back of a truck can conserve up to 10% of the gasoline (3 to 6 meters of operational distance). The third and the leading car in the team achieve savings of 7 percent and 3-4 percent respectively. As a consequence, all trucks on the pedestal will gain. In table 4.1 presents of groups the characteristics of Possible areas in transport where are benefits of platooning in road network.

Table 4.1 Possible areas in transport where benefits of platooning can accrue

Traffic	➢ V2I Green waves: platoons may receive priority treatment in traffic management for trucks, with the possible effect of increasing capacity of crossings. ➢ Congestion: platoons might reduce congestion in specific circumstances. ➢ Safety: The equipment needed to run trucks in platoons increases visibility and introduces automation for early warning and incident response.
Transport	• Fuel economy: reduced costs through fuel savings because of lower aerodynamic resistance of the following trucks. • Daily range: the current driving time directive might be changed to account for lower task load of the drivers of the following trucks which may result in longer distance range. • Alternative driver tasks: the following drivers may be able to execute other tasks beside their driving task.
Transshipment	• Container terminal efficiency: if the order of truck arrivals at terminals is known well beforehand, yard planning can become more efficient. • Inter-terminal transport: multi-trailer systems become less effective on longer distances in extended terminal systems; this function could be fulfilled with platoons. • Automated docking: in a similar fashion as at container terminals, distribution centres.

4.1.5. Network model and Mathematical Model

A two node, single route path is depicted in Figure 4:2. Here i is the originate point whereas j signifies the destination point.

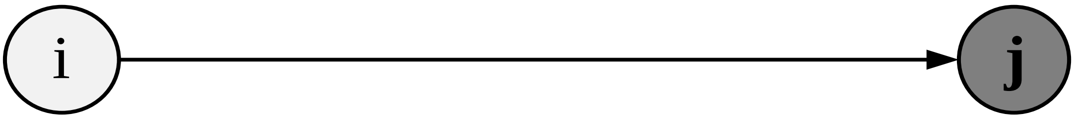

Figure 4.5: A simple 2 node route

To formulate the mathematical model describing is governed by (1-4).

$$minimize\ K_{total} = minimize\ (K_{fc} + K_{oc} + K_{pc}) \tag{1}$$

$$K_{oc} = c_{oc}(\theta^d - \theta^o\ ) \tag{2}$$

$$K_{fc}\ =\ c_{fc}\delta(i,j)(\alpha(\beta\ -\ 1) + 1) \tag{3}$$

$$K_{pc}\ =\ c_e max\{\theta^a\ -\ \theta^o, 0\} +\ c_l max\{\theta^d\ -\ \theta^b, 0\} \tag{4}$$

Here, K_{total} is the total schedule cost which is to be minimized. While, K_{fc}, K_{oc} and K_{pc} respectively denote the operational, fuel and penalty costs. θ^d, θ^o, θ^a and θ^b are the time window variables individually identifying destination, originate, arrival and departure points respectively [87],[88]. α is the follower indicator and 0< β<1 defines the fuel consumption for follower truck. c_{oc}, c_{fc}, c_e and c_l govern unit constants relevant to operation, fuel and penalty costs. Whereas, $\delta(i,j)$ is the edge being transversed by truck.

$$P_R = \frac{Dp}{Td} \times 100$$

Where:

(p_r), Platooning rate, (Dp) the distance platoon (Td) the total distance

$$\text{Total cost operation} = (K_{fc} + K_{oc} + K_{pc})*P_R \tag{5}$$

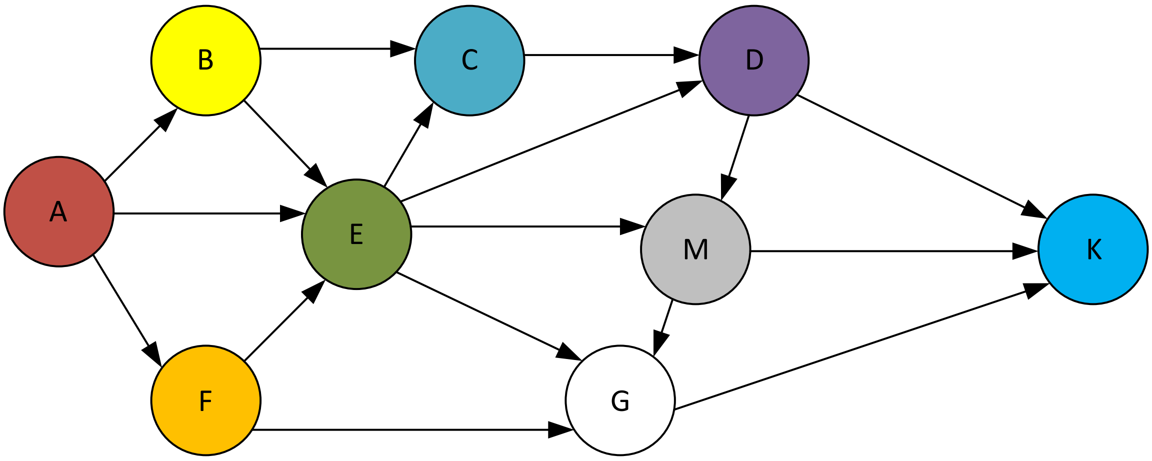

Figure 4.6: Network model

Representation network.

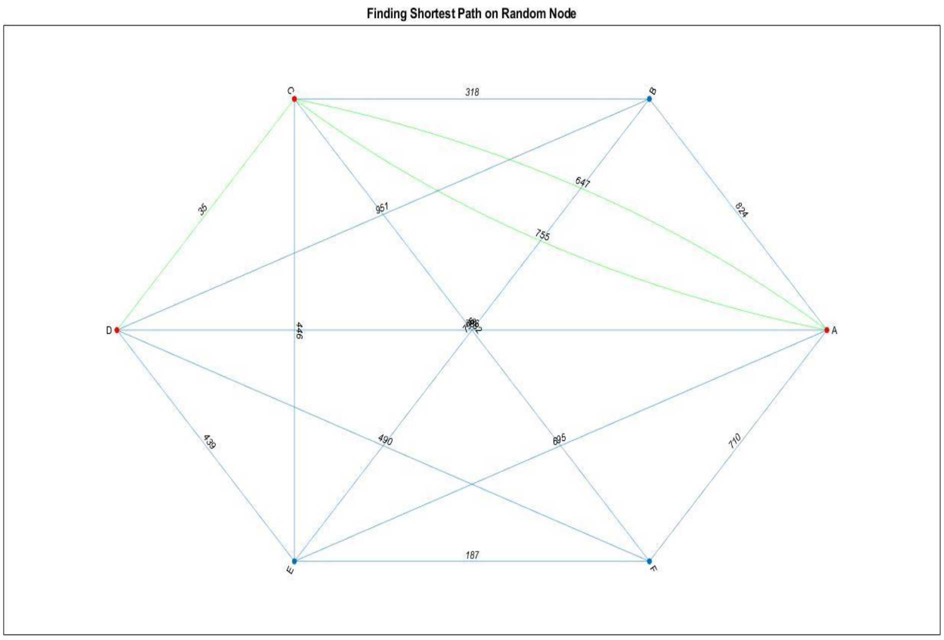

Figure 4.7: Short path on random nodes

The intermodal transport chain consists of a variety of transport networks supplied by different modes of transport linking the intermodal terminals to the transport channel. There may be a variety of links between two interfaces serving different facilities. Such services should be organized in such a way that container goods flow seamlessly from source to destination across the network within the timeframes defined by the customer. There are typically alternative network routes from the proposed source and the tank target, and the goal is to find a suitable route that satisfies the decision-making criteria (cost savings, time or emissions). The planned departure times are a characteristic of intermodal transport networks. It is especially true for train and waterway networks, while truck companies are typically more flexible because they do not have a network locked in time. As mentioned before that each arc corresponds to a certain link travel time, distance, the weights of the edges in the graph are denoted by the edge traversing time. The speed truck is 80- 90 km/h. As assuming the test network (in chapter 3). the following parameters will be used. The unit cost of fuel 1.23/euro , this is calculated based on the aforementioned assumption that the speed is 90 km/h, the fuel price 1.23/euro, /liter and the average truck fuel consumption, which is 0.3 liter/km

4.1.6. Platooning considering operation costs

The individual-driving problem and platoon. The former problem considers the situation where no platoon strategy is applied and all trucks traverse alone along their "short paths", which are also shortest paths in our formulation as Dijkstra's Algorithm. The latter problem is to minimize the fuel cost without considering operation costs and time windows, which is already investigated in (Zhang, et al 2017)

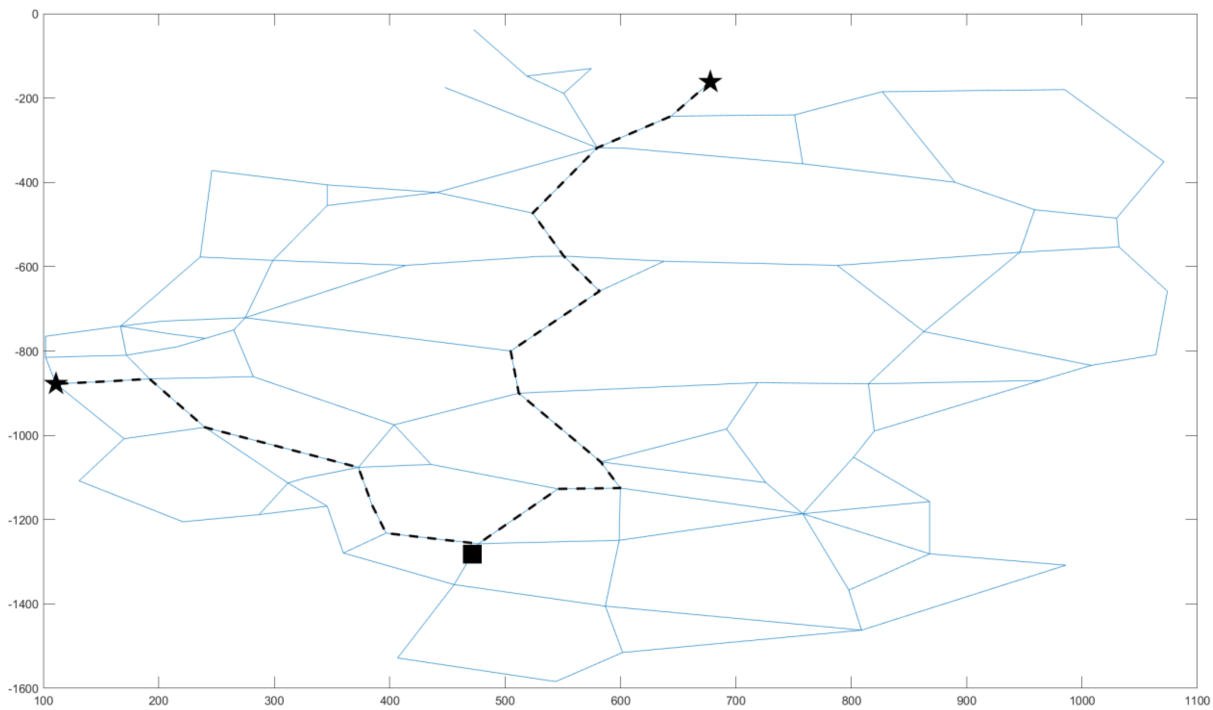

Figure 4.8: Truck travel in short path

Note that the operation cost is the same as in the individual driving Case state, but the fuel consumption is more than the fuel cost in the fuel-oriented platoon coordination Case state. This is because the fuel-oriented coordination enables very long waiting time,

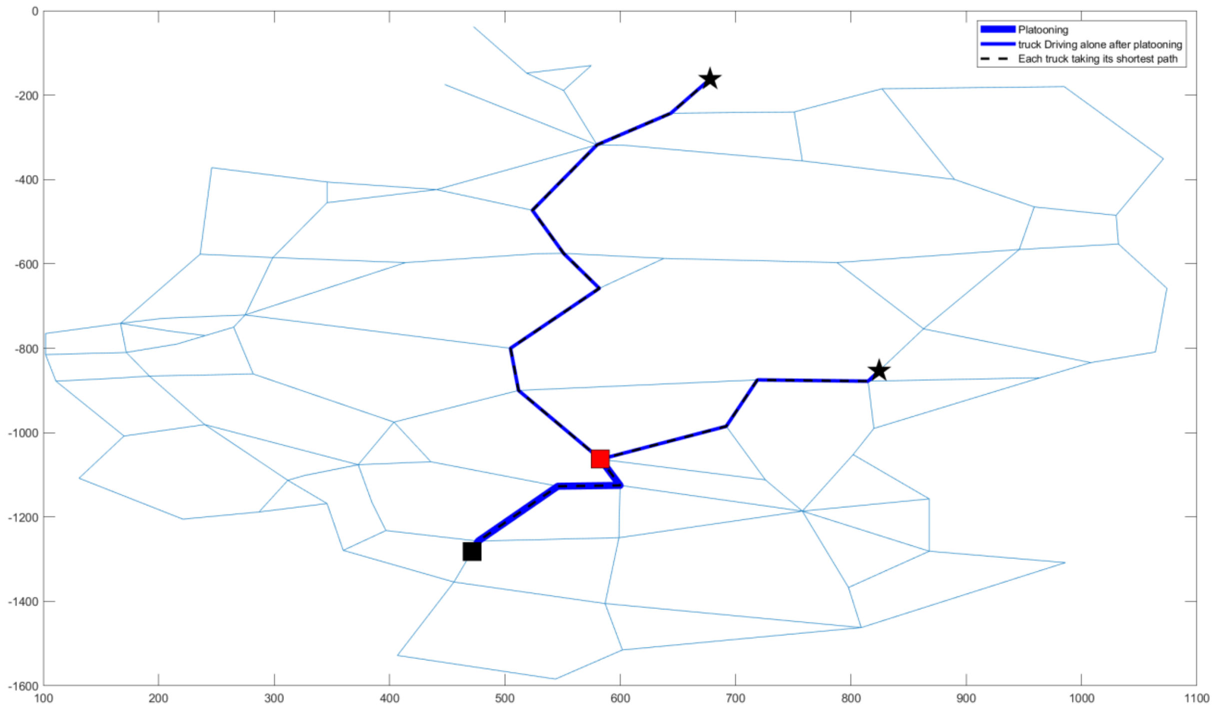

Figure 4.9: Combined truck in platoon and slept.

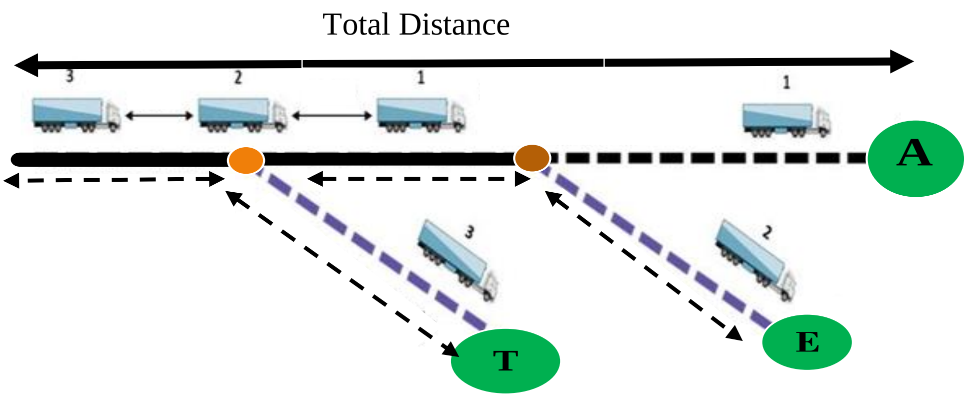

Figure 4.10: Model calculate truck platooning.

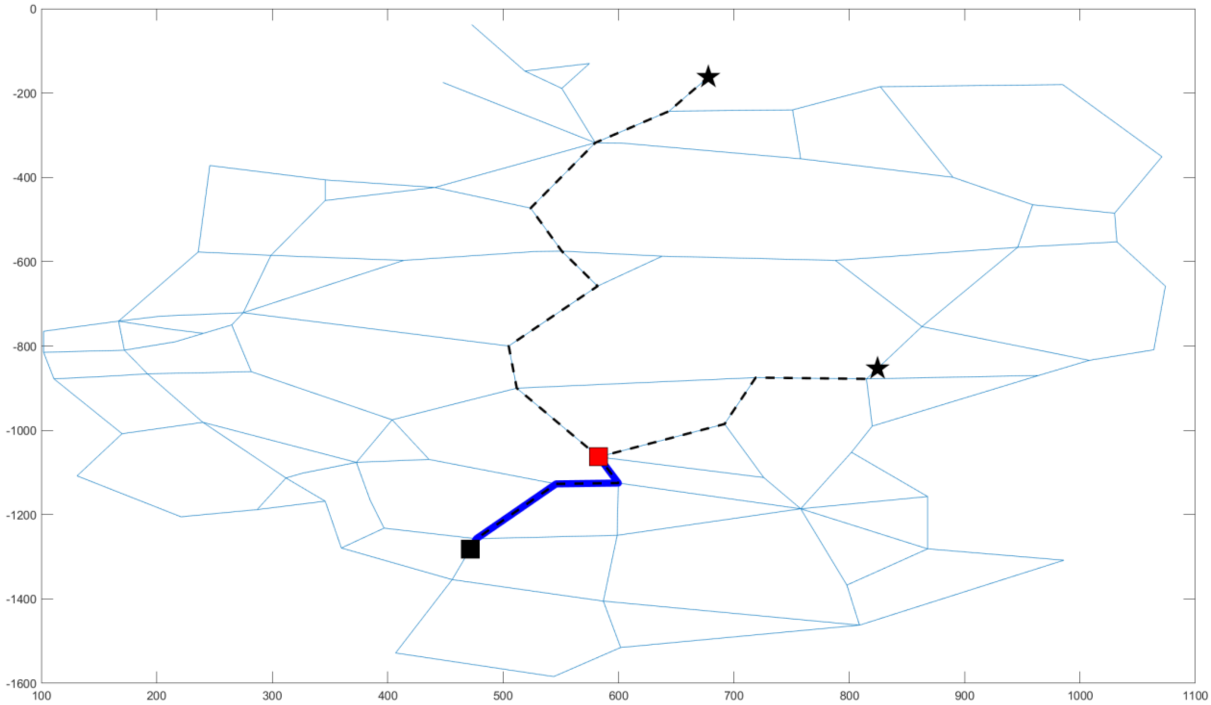

Figure 4.11: Truck platoon travel.

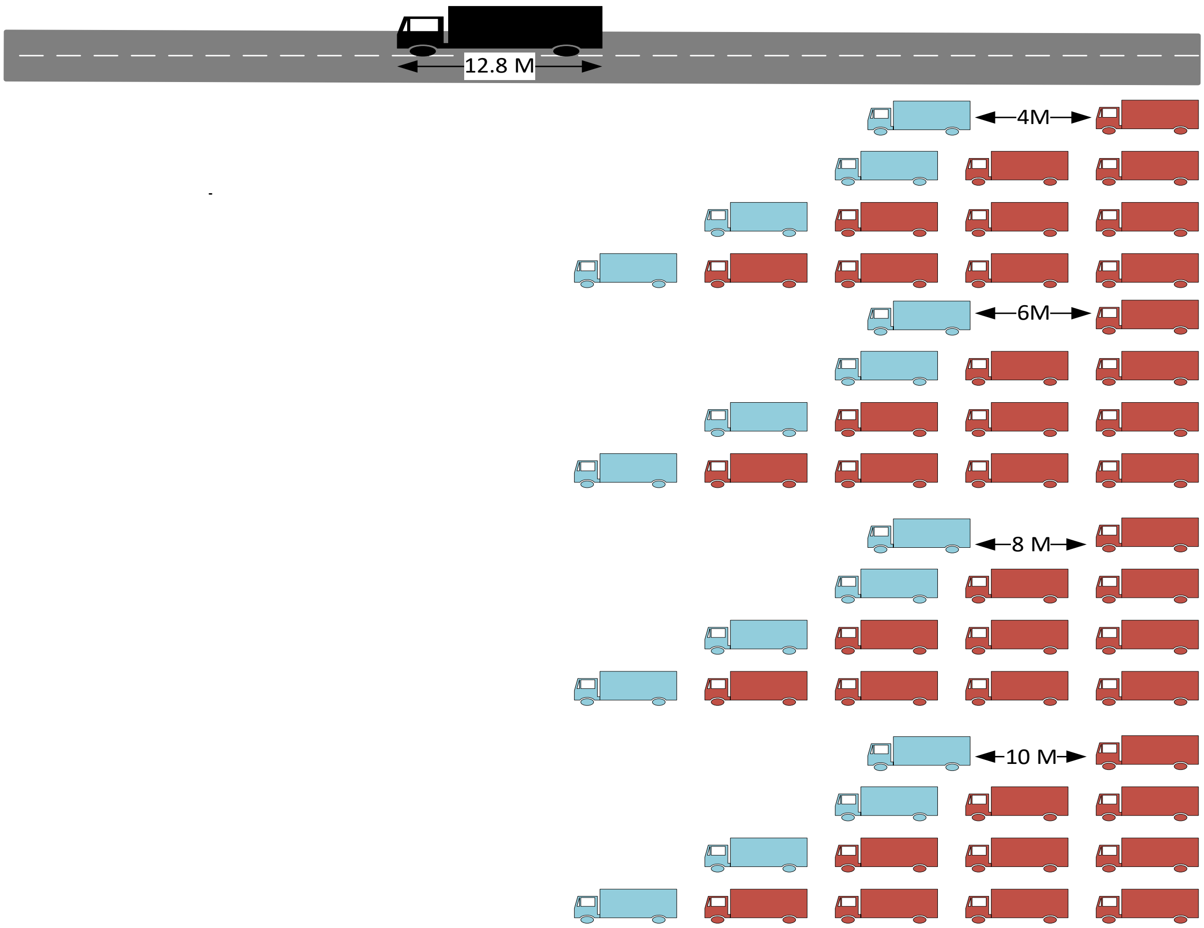

Figure 4.12: Capacity truck platooning in road network

4.1.7. Result Platooning

4.2 Platoon saving fuel

Fuel-oriented platoon			Cost 1.23€
Truck position id	Travel state	Distance	Ful saving
1	platoon	100	13.5821
2	platoon	50	7.4143
3	platoon	20	0.2736
4	platoon	35	0.67928
5	Induvial	0	0

The comparison results are shown in table4.3.

Table 4.3 Comparison of different scenarios

Scenario	Distance	Fuel	operation cost
Individual driving	100	100%	100%
Truck platoon	100	86.4197%	86.4197

Calculation of Percentage fuel cost savings=$\frac{\text{standard truck fuel cost} - \text{fuel cost truck platooning model}}{\text{standard truck fuel cost}}$

The first step has reviewed the technology of platoon trucks by conceptualizing potential trends in automated technology that have positive environmental impacts, reduce pollution and noise, and minimize unusual locations. To develop an innovation for the transport system, freight transport and logistics enable better use of transport infrastructure and contribute to the reduction of environmental issues (hazards), congestion, and distance traveled by trucks. The application of technologies is of high reliability and aims to be introduced shortly. A fuel consumption measurement on the path and expressway shows that when the gain is 10 meters, fuel can be saved by approximately 13 percent. The analysis reveals that the 10 m platooning device works with 40 percent incorporation of large trucks has declined by 2.1 percent. CO_2 on the expressway. Work is creating modern and creative approaches to boost the environmental protection and performance of the logistics chain. Significant improvements have been made by the optimization of freight transport networks, the effective combination of transport types, and the recognition of future results, the reduction of CO_2 emissions for logistics trucks. Nevertheless, it will also concentrate on the feasibility of low-carbon policy and the economy; businesses, governments, and financial organizations continue to grow technically, to enable industries to incorporate innovative technical approaches in the model of road haulage.

4.2. Part 2 Cable car– As an Alternate Transport Solution

This part of the chapter that solution having, should increase their capacity and reduce the social and environmental impacts of their operation, in this thesis, the main proposed to Interaction and integration of three models existing business to combined three parts Automated 'horizontal transferring' already existing in ports globally, Utilizing 'unused airspace' as in the road-traffic 'fly-over' solutions. Robotic lifting, shuttling and deliver as in modern autonomous warehouses. As using an aerial mode of transport and its application in the logistics transport system for a short distance, where the aerial transport mode can be realized as a part of multimodal transportation mode. The aerial ropeway transit (ART) has gained more attention regarding its energy-efficiency in goods transporting modes at transshipment areas and limited spaces which reflect positively on the environmental issues. Aerial ropeways are more economically and environmentally beneficial in short distance, especially in Case states when the terrain, high density of the housing and industrial development.

4.2.1. Overhead Conveyor

An overhead conveyor is a space-enclosed transport system that consists of hauling chains, carriages, carrying trolleys, overhead rails, slalom, and It is composed of driving device, tensioning device, safety device and electric control device. According to the driving mode of the traction trolley, there are four kinds: chain traction, spiral traction, and electric control. Rod-Driven, Self-Propelled, and Accumulation. Figure 4.13 shows the goods Pull Overhead Conveyor, Figure 4.13 shows a self-propelled Overhanging conveyor.

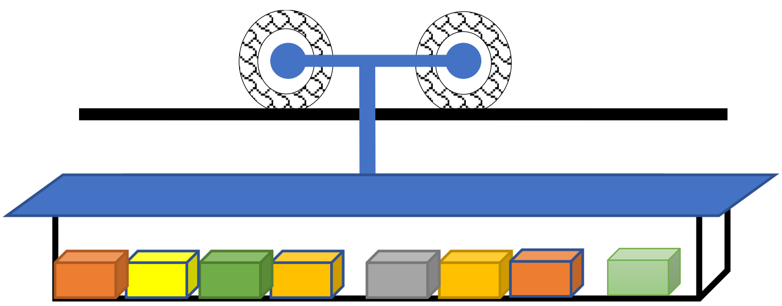

Figure 4.13: Overhead Conveyor of small pack goods

Overhead conveyor is suitable for transporting piece goods or cargo in factory workshop, warehouse and air transport of cargo and container unit. Transmission. The spatial arrangement of the overhead conveyor system has minimal impact on the operation of ground equipment and operations due to the spatial arrangement of the overhead conveyor system, and due to the transmission of the feeder itself is a "mobile warehouse", so it is possible to eliminate storage space between processes and thus increase production. Economic reasonableness of the working and storage area. The chain traction type load trolley is fixedly connected to the traction chain and is directly driven by the traction chain. The system is of simple construction. However, it is difficult to automate the loading and unloading process. The screw-driven carriage hooks are fitted to the screw by means of a nut, and the screw rotates to push the carriage forward. Go. [90]This is a particularly simple overhead conveyor. It has the disadvantage that the trolley runs at a low speed, and when the load is high, the increased wear of the screw. The track of the self-propelled conveyor can be straight, curved or forked, and its running line can be flexibly arranged according to the operational requirements. For accumulation conveyors, the traction trolley and the load trolley run on their own tracks. Push to run by actuators, stopping the trolley at any position on the line as required by the stopper; controlled by the control[91]. The actuator can be disconnected from the trolley by means of a turnout device to transfer the trolley from one conveyor line to another. On; can form a complete conveying system with separate loops at different speeds through turnouts or linear transfer. When choosing the type of overhead conveyor, full consideration should be given to the operating conditions, the type of material, operating productivity and so on. The different models function as efficiently as possible due to a variety of factors.

4.2.2. The Novel in the Proposed Model

This new logistics system makes the transportation of small shipments more flexible, efficient and competitive. The novelty of the proposed method is in layered transportation called cable car of goods. In the traditional or present system, there is truck used for the entire transport of the counterair, and small batches of goods. Whereas, in the proposed system, there are two different methods used depending on traffic density and location. Using cable car in dense traffic and truck in light traffic conditions minimizes total time.

4.2.3. Transport Conditions

In order to define the role of ART in multimodal platform, it is essential to understand the existing transport conditions in platform, and how ART can help solve some of the challenges and problems that exist within this platform system. Accordingly, a thorough review of the transport system conditions was conducted in the early stages of the thesis. The findings and observations of this review are discussed in the next few paragraphs for Challenges

1- It high truck density traffic use and limited space, for the conditional road network.

2- Changeable activity transshipment and travel demand by time non-fitting with the capacity of the platform.

3- Insufficient transport supply and poor service and safety; substantial future growth the insufficient capacity at a desirable level of service.

4- The centrally design of the multimodal platform.

In terms of freight transportation, it is essential to pick the most convenient mode(s) of transport as mentioned in chapter 3. To get a more flexible system, one can assume that the number of transport options at each hub should be maximized. Therefore, it is investigated how a new hub concept comprising four models, a so-called "overhead modal freight platform", can be implemented in the existing transport system from a traffic planning, technological and organizational point of view. As mentioned in Chapter 3, the road link is the only existing connection between search terminals of mode. To assess the impact of additional truck traffic on the road network, the effect on the travel time was investigated for the section concerned on the road network for each direction.

4.2.4. Aerial cableways

At present, aerial cableways are considered as a promising mode of transport that solving transport and logistics problems in various sectors of economy and urban environment Freight cable ways have long been used to transport various piece and bulk loads in mining, coal, chemical, metallurgical, energy and agricultural industries. In terms of economy and environment, cable transport is often more profitable than land transport (road, conveyor and rail) Cable transport is particularly effective when terrain relief (mountain, low-density, difficult-to-travel, remote regions), high density of residential or industrial development and various natural and urban planning restrictions prevent the development of land traffic For remote high-mountain areas, cable transport can be almost a non-alternative mode of transport for freight and passenger transport [92]. While container ships have increased in size to reduce transportation cost per container, ports have become congested increasing the amount of time required to transfer containers between larger and smaller ships, also between large ships and overland transportation. In the future, even larger container ships will require ports to develop faster methods for transferring containers off and on the super-size ships, using less waterfront port terminal area. Of the technologies being considered to facilitate faster transfer of containers at ports, the new conceptual of transport offers an overhead rail-based container transfer concept based on proven technology.

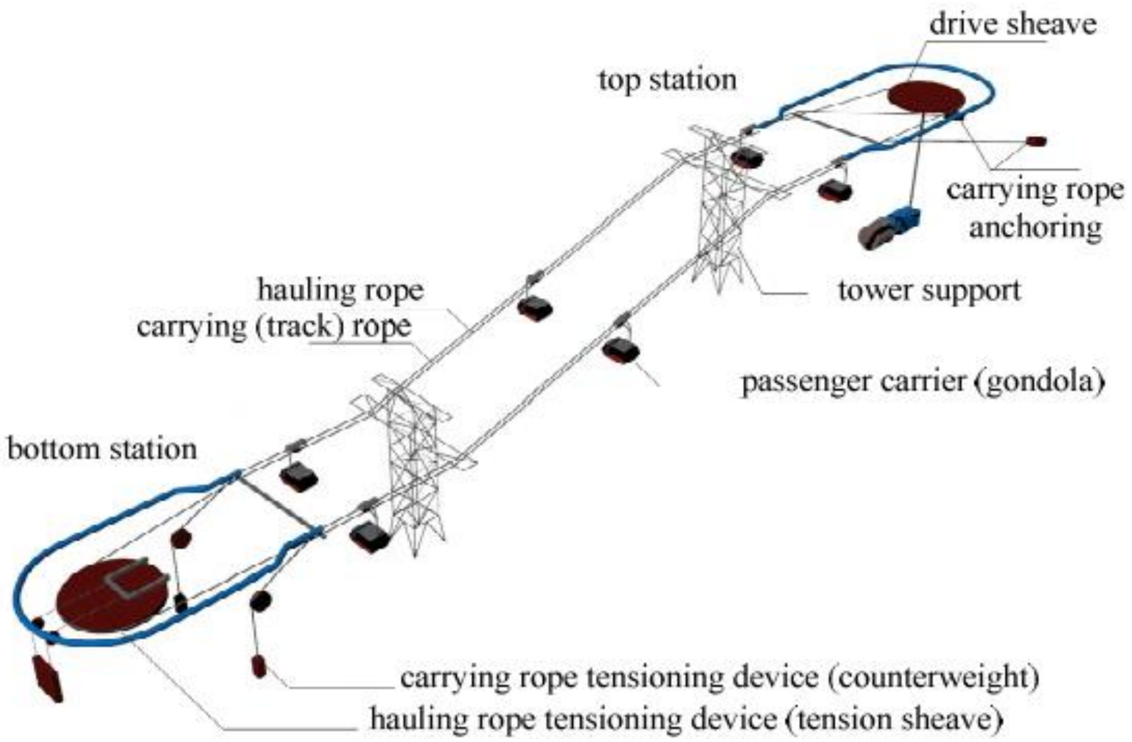

Figure 4.14: Cable car system[25]

4.2.5. Benefit Aerial Cable System

The cable car is well suited to be a first and/or last mile solution for journeys made by train or ship transport. The cable car is introduced to improve the transport system of goods in urban and interurban areas. From point of view of time saving and environmental issues, considering ropeway technology as an environmentally-friendly mode. It shows different characteristics when it is compared with traditional transport modes, like, no waiting time, unaffected by road congestion [9]. In these advantages, we can add also the minimization of costs, the maximization of service level and the fact that this system can connect easily all types of transportation. Then the operating costs and the transshipment delay could be minimized.

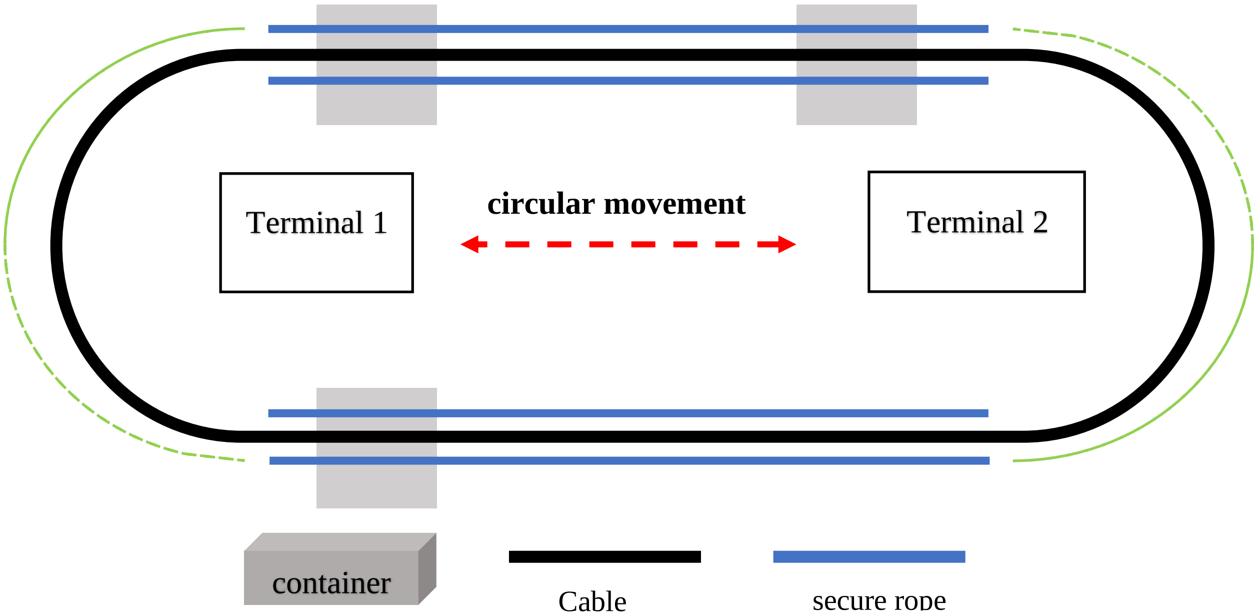

Figure 4.15: Tri-Cable Detachable Gondolas (TDGs).

The purpose of this study is to analysis the developments implement of cableways in new technology intended to more efficiently and more quickly transfer containers at platform would need to be based on long-proven technology. The cable car system has similarities to a system at the City of Wuppertal in Germany where passenger transit trucks travel around the city along a network of overhead rails [10]. The structural support system that carries the overhead rails involves minimal ground space. For example, The Wuppertal system forms the basis of parcel transfer logistics technology. A freight version of the overhead railway system would move full-size containers over short distances of up to more than 10 kilometers. To properly serve the logistics sector, the technology would need to quickly move massive numbers, far exceeding the port transfer capacity of fleets of road trucks and traditional dockside railway container trains [33]. Advantage freight Aerial Ropeways the possibility of applying this type of transport goods as a suitable and effective logistics transportation tool, aerial ropeway is widely used in industrial and mining enterprises, scenic spots and transportation due to its strong adaptability to terrain, large climbing ability, low energy consumption and small footprint.

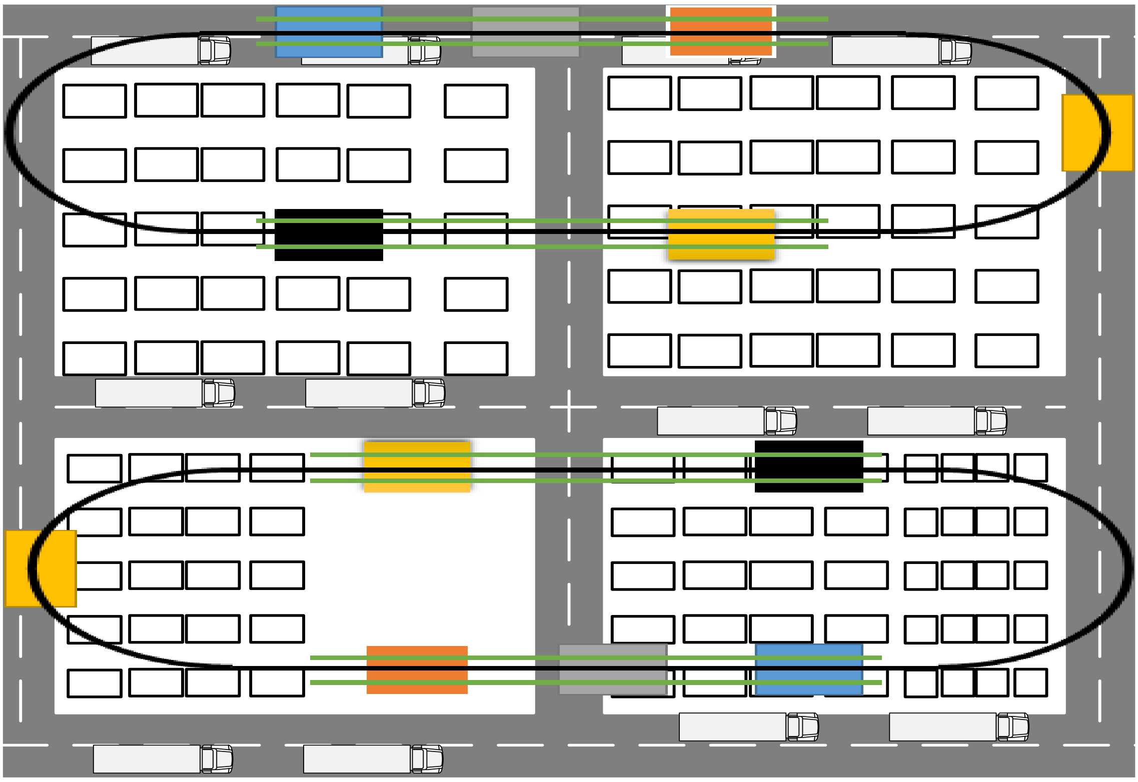

Figure 4.16: Platform system with overhead transport.

4.2.6. Cable car Time window

A time-window can be defined as the interval of time that a specific cabin must arrive at a node, generally characterized by both early arrival time and late arrival time. In this work, the delay of the proposed transportation system (cable car system) will be estimated by verifying the time window constraints. The timing and sequencing relationships of transport system events during movement can be used to determine whether or not deliveries are made on time, these constraints are essential in estimation of the delay time [93][80].

4.2.7. Time window constraints concept:

Assuming that there is a cable-car system, the time window constraints is proposed, to verify time of cabin departure between the starting point p_i and the delivery point at terminal p_j. The monitoring system provides time-stamps (occurrence of events p_k) during the crossover of defined tracking locations. The time-stamps can be used to determine how long it has been since the start. Therefore, the remaining duration is the temporal relationship between the event p_k, which called an intermediate event, and the delivery event $_j$. The relationship between events p_i and j and the remaining duration allows estimation of the occurrence of new j. This mechanism improves the early detection of the violation of the time constraint [94]. In fact, instead of checking the constraint when k occurs, information such measured duration and in advance known remaining duration are given by the occurrence of intermediate points to detect if there is a violation of the time constraint.

4.2.8. Calculate time window constraints of cable Cabin

Based on study [61]. We use the timing window between the event occurrences to characterize the behavior of the system movement and scheduling an arrival event for the cabin. In addition, the time of the arrival event is based upon the departure time; that is, the arrival event is scheduled for the time of the departure event plus the interval time of the object [95] . To determine the time window of the cable car, we consider that the C_{ji} constraint is connecting points $_j$ and $_i$ and an intermediate event indicating the passage of a cabin to a predefined tracking point. The remaining time (Δ) is the value of remaining between $_k$ and $_j$. The time measured is between i and k, which is indicated by (Φ), $\Phi = (_k - _i)$. to check the C_{ji} constraint by considering the remaining duration Δ, $\Delta = j - k$

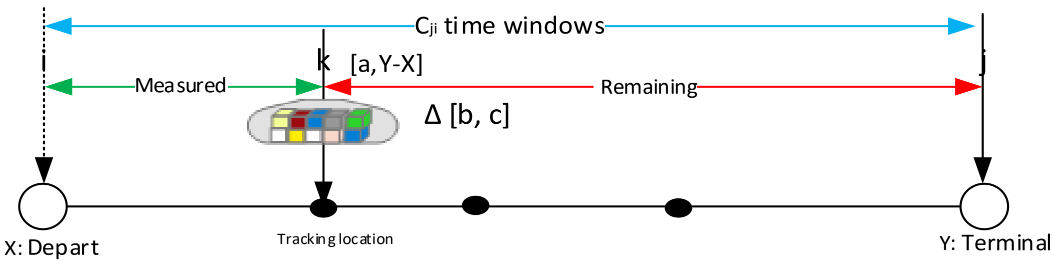

Figure 4.17: Scheme of cable car time window

Where:

- C_{ji}: constraint time windows
- [a, Y-X] travel time
- i, node depart
- j node arrives
- k timestamps (occurrence of events)
- O: occurrence event
- Δ: bounded remaining duration of travel time
- Φ: Measured duration
- Q+: the set of positive rational numbers

4.2.9. Time windows model

the time measured is calculate as $\Phi = (_{k} - _{i})$,

The remaining duration Δ, $\Delta = _{j} - _{k}$.

We can calculate

$$p_j - p_i = (p_j - p_k) + (p_k - p_i) = \Delta + \Phi \text{ and } \quad \text{as } b \leq \Delta \leq c_{ji},\ b, c \in Q+ \quad (1)$$

$$\Phi + b \leq C_{ji} \leq \Phi + c,\ \Phi \in [-\infty, +\infty] \quad (2)$$

the constraint C_{ji} is $a \leq C_{ji} \leq Y - X$ (3)

the time window constraint C_{ji} durations $C_{ji} = p_j - p_i$

$a \leq C_{ji} \leq Y - X$

$\Phi + b \leq C_{ji} \leq \Phi + c$

Mentor position of container based on time windows

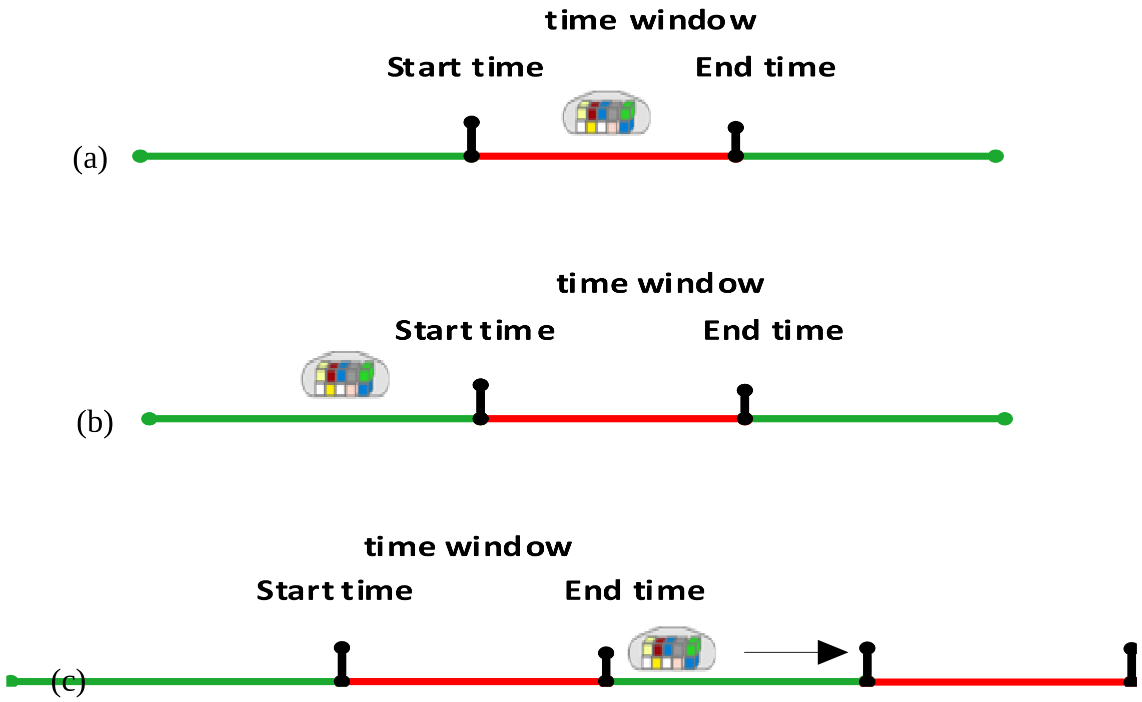

Figure 4.18: Cabin position based on time windows (a, b, c)

4.2.10. Operation of overhead Conveyor

Integrate multi model transport system, to Installing automated electric overhead rail container transfer would enable ports (terminal) to achieve greater efficiency and throughput with minimal negative impact of terminal congestion. [96]. The system could lower carbon emissions by an estimated 60 % percent by reducing road traffic and related road congestion. The transport mode would robotically lift and shuttle containers from overhead, replacing short-haul trucks that would otherwise contribute to traffic congestion while emitting carbon dioxide. The automated container transfer system could operate 24 hours each day with minimal noise while the overhead structural support system could carry solar PV panels.

4.2.11. Traditional multimodal transport network description

Based on the traditional multimodal transport network, this part considers the transportation of small batches of goods and the transfer and consolidation of containers. There are three modes of transportation by one freight forwarder, multiple shippers in different countries or regions, and road, railway and waterway. Formed a combined transport network. The object of the study is multiple batches of goods assembled into containers. The overall study is the operation process of a container from full container to empty container through transfer, and then to empty container. Choose appropriate consolidation points and transfer points to minimize the total cost. In this chapter, the transportation network G is defined as a network diagram composed of truck F, train R, ship B, node N, and container C to meet the needs of different cargo owners. The network is a directed graph formed by connecting nodes, which is similar to a broken line graph formed between adjacent nodes. M and E represent consolidation points and transfer points, respectively. In the figure, s represents the supplier, c represents the demander, the same demander can have multiple suppliers, and the same supplier can also provide services to multiple customers, o and d represent the starting and ending points of a single batch of goods, m or o represents the unloadable point of the port, t represents the unloadable point of the railway, which forms the optimal transportation route under specific circumstances.

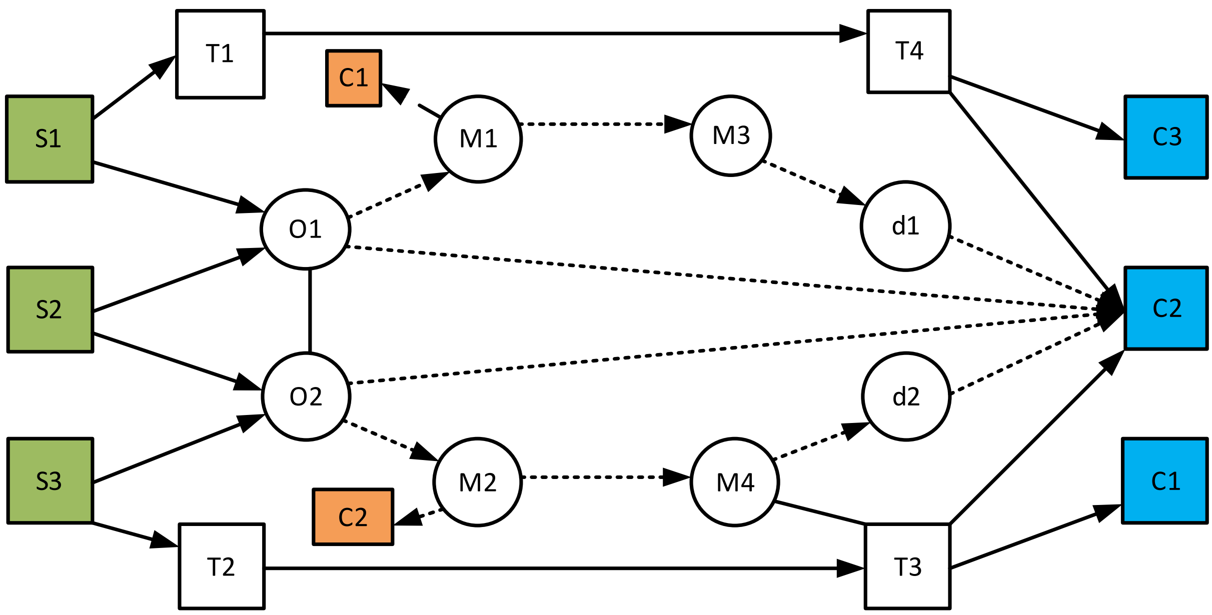

Figure 4.19: Diagram platform network with cable car.

Figure4.18 shows the whole process of completing the order task from the start point to the end point. The goods go from the supply point S to the demand point C. The goods first arrive at the starting point o or t. At this time, the goods are in the same area, such as the same country, and you can choose to transport there are railway and waterway transportation. In order to reduce the complexity of the transfer, it is assumed that there is no transportation connection between the starting points in the same area. Different containers choose different transportation routes and different transfer and assembly routes according to the destination of the cargo loaded into the container and the remaining capacity of the container. During the transportation process, they will continue to reach the destination of the cargo for unloading, and then combine the same purpose. Goods at the destination or passing through the destination[97]. When the quantity of goods is allowed, it can also directly assemble a destination goods, from o directly to d. While consolidating containers, there will be a certain cost advantage if the transportation mode is changed. You can choose railway transportation or direct door-to-door transportation, so that the container is continuously converted from empty to heavy and then to empty, completing the small batch of goods Transportation. Mathematical model establishment his part proposes a method based on mixed integer linear programming,

4.2.12. Cable car Operation for small batches of goods Container Logistics

Based on the concept of green logistics and the goal of reducing environmental pollution, the route and mode of multimodal transport in the logistic platforms and ports are studied. Adopting a thinking that is different from only considering cost and time factors, establishes a packing logistics network path and transportation mode selection model with minimum CO_2 emissions, and demonstrates the advantages of this model compared with only considering cost and time. Finally, a model for rationally arranging transportation routes and choosing the best transportation mode under the constraints of CO_2 emissions is established, and the total transportation cost is minimized [21]. The result is conducive to a better balance between time, costs, and transport corridor requirements for transport corporate CO2 emissions restrictions. Considering Greenhouse Gas Emission in Operation Strategies of Container Logistics. Global warming and energy consumption have become global issues. Transportation, as an important carrier of logistics and passenger flow for socio-economic activities, is not only a key industry for oil consumption, but also an important source of greenhouse gas and air pollution emissions. In transportation, road transport accounts for the major part of the CO_2 emissions at 86.32%, followed by waterway, air and railway [98]. With the global transport "containerization", container logistics has become an important part of the modern logistics industry, the study in the energy consumption, low-carbon constraints of the container multimodal logistics network model have important practical significance. Container logistics network is to achieve the organic system of container cargo transport, consisting of network nodes and network lines. Container logistics network research mainly concentrates on two aspects, one is the container logistics network transport system and external demand coordination, through the design, optimization of the container transport system to meet the system outside the cost, time, efficiency and other requirements. Costs. The external costs include the social and environmental impact costs of the container transportation network [99][79]. The second is the coordination and optimization of the internal links of the container logistics network, including nodes, transport channels and modes of transport, and even by the node group. Francesco Parole analyzes the optimization of multimodal network systems in ports, especially in the port-centric port container logistics network. In this chapter, we will develop a simulation model of logistics activities, consider the distribution of land transport modes, and finally evaluate the possible future growth of container flows [4]. (Wei) The multitude of pairs of multimodal transport networks considering the minimization of node time, node transition time and possible delay time as the goal to solve the path and phase in order to improve the efficiency of container operation, (Le Meilong et al. 2015) optimized both berth and shore bridge resources [88]. With the global concern for the environment, the study of low-carbon logistics has gradually become the focus. Low-carbon research gradually from warehousing, transportation, packaging to the entire supply chain. (Oevermann. R, et al.2017) proposed the concept of green transportation, through the rational layout and regulation of freight transportation network and distribution center settings. To achieve the goal of energy saving and emission reduction. (Turan Paksoy et al. 2014) has developed a closed-loop supply chain plan to shorten the route and reduce the idling rate [7]. Subsequently, (Turan Paksoy et al.2013) considers the closed-loop supply chain under CO_2 emissions. Network optimization, encourage enterprises to adopt products and transport modes that produce low emissions [8]. The study of intermodal container transport under low-carbon conditions has only been conducted in recent years. Several years have appeared in the literature, (James J. Wine brake et al.,2012) using the example of transportation on the East Coast of the United States, which integrates energy consumption, environmental impact and cost factors. (Joanna Bauer et al.,2018) proposed to apply the CO_2 emission constraint to multimodal transport networks under the assumptions of the GIS network analysis [9]. In addition to the design of intermodal transport, it is also used in the design of railway networks [10].in this part study the container logistics network model with minimal CO_2 emissions but also the relationship between CO_2 emissions and cost and time targets is analyzed to provide better decision making for managers and finally, in this part , we establish the transport route and transport mode of the container based on the CO_2 emission constraint with new path is cable car .

4.2.13. Problem assumptions

The container logistics network consists of nodes and lines, as shown in Figure (4 18), including sources of goods, transit points, ports, railways, highways, waterways and other transportation methods. In the process of container transportation, energy consumption and CO_2 emission are required both at nodes and on-line. Because the energy consumption, cost and time of various transportation modes are different at each node, the transport mode can be changed at each node to achieve the optimal transportation path and transport mode combination. Suppose a batch of goods departs from a source point, and is transported to the port through various nodes and transportation methods. In the transport process, the transportation method can only be Road, Railway and Waterway, cable car transportation, the container transfer link at each node is very good, and the specific loading, unloading, handling and other processes are not detailed; the transportation volume of goods is indivisible, at the node , At this point, the goods cannot be transported in multiple batches, only one mode of transportation can be selected between the two nodes; the unit cargo transportation price of various modes of transportation, unit cargo transportation time, unit cargo energy consumption, transportation capacity of the transportation mode, The distances between nodes are in appendix.

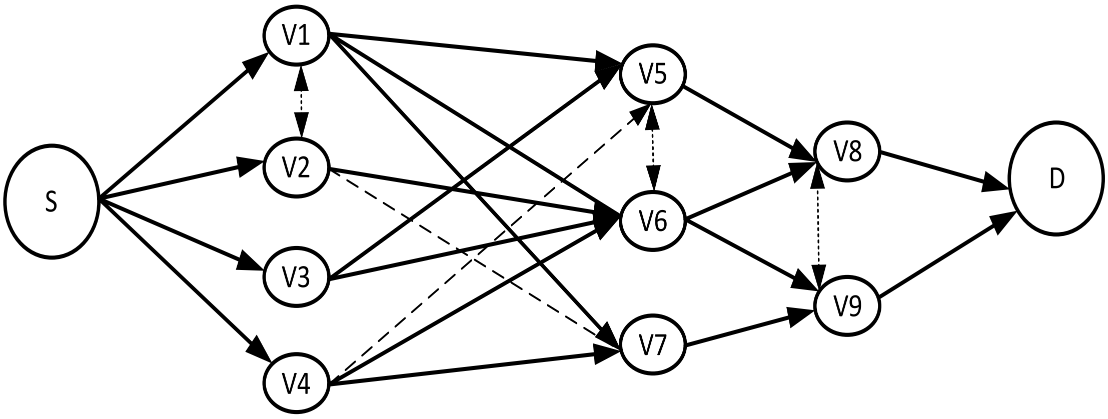

Figure 4.20: Network model of transport with cable car

4.2.14. Modelling setting Parameter description and Decision variables:

V	Represents the city node, V = (v_1, v_2..., v_n)
S	starting point,
D	endpoint
M	the mode of transportation
M	(m_1, m_2, m_3, m_4), respectively representing roads, railways, cable car, and waterways;
Q	the freight volume during transportation, and no cargo damage occurs during transportation;
d_{ijm}	represents the transportation distance between node v_i and node v_j using transportation mode m;
cap_{ijm}	represents the transportation capacity when the transportation mode m is used between node v_i and node v_j;
c_{ijm}	represents the transportation price per unit of transportation distance between node v_i and node v_j using transportation mode m;
t_{ijm}	represents the time required for the unit transportation distance between node v_i and node v_j using transportation mode m;
$ch_{tim}l$	conversion occurs, that is m = l, ch_{timl} =0, no conversion time occurs;
ch_{ciml}	Represents the conversion fee for switching from transportation mode m to transportation mode l at node v_i. If no conversion occurs, that is, m = l, then chciml =0, no conversion fee will be incurred;
β_{ijm}	represents the use of transportation mode m between node vi and node vj, and the amount of CO_2 emissions per unit of transportation distance per unit of cargo;
ch_{oiml}	represents the CO_2 emissions from the transition from transportation mode m to transportation mode l at node vi;
T_{COEmax}	Represents the constraint of total CO_2 emissions;Among them, q, d_{ijm}, $capi_{jm}$, c_{ijm}, t_{ijm}, ch_{timl}, chc_{iml}, β_{ijm}, cho_{iml}, T_{COEmax} are all known.

x_{ijm}	indicates whether there is a path from vi to vj with m as the transportation mode, that is, there is a path between nodes and the transportation mode m is 1, otherwise Then 0;
y_{iml}	indicates whether to switch from transport mode m to l at node vi, if yes, it is 1, otherwise it is 0;
Z	represents the total transportation cost during the entire transportation process;
T_{CO2}	Indicates total CO_2 emissions

4.2.15. Model establishment

In this chapter, the research of container logistics network mainly focuses on three aspects,

- ❖ The choice of transportation methods, such as the choice of road, railway and water, cable car transport. This requires comprehensive consideration of factors such as transportation time, cost, environment, and transportation capacity limitations of various transportation methods.
- ❖ Reasonable for container multimodal transportation the path selection, such as the path selection under the conditions of cost, time, and CO_2 emissions.
- ❖ From the perspective of platform operator, that is to say in the CO_2 emission Under a certain amount of circumstances, the transportation route and transportation method of the container should be selected reasonably to minimize the total transportation cost.
- ❖ The model is as follows

$\min Z=\sum_{i\in V}\sum_{j\in V}\sum_{m\in M} c_{ijm}\times d_{ij}\times x_{ijm}\times q+\sum_{i\in V}\sum_{j\in V}\sum_{m\in M} chc_{iml}\times y_{iml}\times q$	1
$\min T=\sum_{i\in Y}\sum_{i\in V}\sum_{m\in M} t_{ijm}\times x_{ijm}\times d_{ij}+\sum_{i\in V}\sum_{m\in M}\sum_{l\in M} c\,ht_{iml}\times y_{iml}\times q$	2
$\min T_{CO_2}=\sum_{i\in V}\sum_{j\in V}\sum_{m\in M} \beta_{ijm}\times d_{ijm}\times x_{ijm}\times q+\sum_{i\in V}\sum_{m\in M}\sum_{l\in M} ch\,o_{iml}\times y_{iml}\times q$	3
$\sum_{m\in M} x_{ijm}=1 \quad i,j=1,2,L,n$	4
$\sum_{mIM}\sum_{M} y_{iml}\leqslant 1 \quad i=1,2,L,n$	5
$x_{ijm}\times x_{jul}=y_{jml} \quad i,j=1,2,L,n \quad mIM$	6
$q\leqslant q_{ijm} \quad i,j=1,2,L,n, \quad mIM$	7
$x_{ijm}, y_{iml} I\{0,1\}$	8

Equations (1) and (2) represent the minimum transportation cost and minimum transportation time. The transportation cost includes the transportation cost between nodes and the conversion cost of the transportation mode at the nodes; the transportation time includes the transportation time between the nodes and the transportation mode conversion time at the nodes. Equation (3) represents the total CO_2 emissions, and its CO_2 emissions include the CO_2 emissions produced by transportation between nodes and the CO_2 emissions produced by the conversion between transportation modes at nodes. Equation (4) indicates that between two nodes, if there is a path, then only one of the transportation methods can be selected; Equation (5) indicates that at the node, if the conversion of different transportation methods is required, then there is and only There is a kind of conversion; formula (6) guarantees that the transportation mode used in the two adjacent transportation sections in the one-time transportation plan is continuous with the transportation mode conversion at the city nodes at both ends, that is to say , If in the process of transportation, it is transported to city j through arc i(j,m), and the conversion from transportation mode m to transportation mode l is performed at j, then it will be used in the next section transportation process Transport mode l is used to transport, otherwise it will cause discontinuity in the transportation process; formula (7) indicates that when goods are transported in a certain section, the freight volume cannot exceed the maximum transport capacity of the transport mode m. Equation (8) represents 0-1 variable. Among them, the combination of formula (1) and formula (4) ~ formula (8) represents the model (1), which is the route and transportation mode selection model of the container logistics network with the least cost. The combination of formula (2) and formula (4) ~ formula (8) represents the choice model of container logistics network route and transportation mode with the smallest time, namely model (2). The combination of formula (3) and formula (4) ~ formula (8) represents the path and transportation mode selection model of the container logistics network with the smallest CO_2 emissions, namely model (3). In the case of a certain amount of CO_2 emissions, a reasonable choice of container transportation routes and transportation methods to minimize the total transportation cost is model (4), as shown in equation (9).

$\min z=\sum_{ijV}\sum_{jiV}\sum_{mIM} c_{ijm}\times d_{ij}\times x_{ijm}\times q+\sum_{ijV}\sum_{jiV}\sum_{mIM} chc_{iml}\times y_{iml}\times q$	9
$\sum_{mIM} x_{ijm}=1 \quad ı,0=1,2,L,n$	10
$\sum_{mIM} y_{iml}\leqslant 1 \quad i=1,2,L,n$	11
$x_{ijm}\times x_{jul}=y_{jml} \quad i,j=1,2,L,n, \quad miM$	12
$q\leqslant q_{ijm} \quad i,j=1,2,L,n \quad mIM$	13
$x_{ijm},y_{jml}I\{0,1\} \quad i,j=1,2,L,n \quad mIM$	14

$\sum_{i \in V} \sum_{j \in V} \sum_{m \in M} \beta_{ijm} \cdot d_{ijm} \cdot x_{ijm} \cdot q + \sum_{i \in V} \sum_{m \in M} \sum_{l \in M} \text{cho}_{iml} y_{iml} \cdot q \leqslant COE_{\max}$	15

Equation (15) indicates that the total CO_2 emissions produced during transportation are under certain constraints. This value is generally given by government department managers Give the company the amount of CO_2 that can be emitted during production and transportation.

4.2.16. Logistics Network adapt

Since the above container logistics network path selection model increases the dimension of the transportation mode compared to the traditional logistics network path selection model, it is difficult to solve it with the help of traditional mathematical planning methods. It is necessary to reduce the three-dimensionality of the variables in the model to two. Dimensional variables can be converted to the traditional logistics network path selection model to obtain a feasible solution. Therefore, the method of multimodal transportation shortest path network deformation, so that each transportation mode corresponds to a new edge, and the nodes (except the start and end points) are deformed, and the start and end points of each transportation mode are separated., The starting point and ending point of each mode of transportation represent a new node. As shown in Figure 4.22, from the starting point S to the end point D passing through node 1, there can be three transportation modes: railway, highway and waterway. After being deformed, it can be transformed into following show in Figure 4 20.

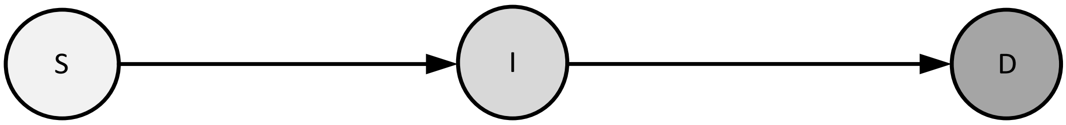

Figure 4.21: Simple intermodal Node

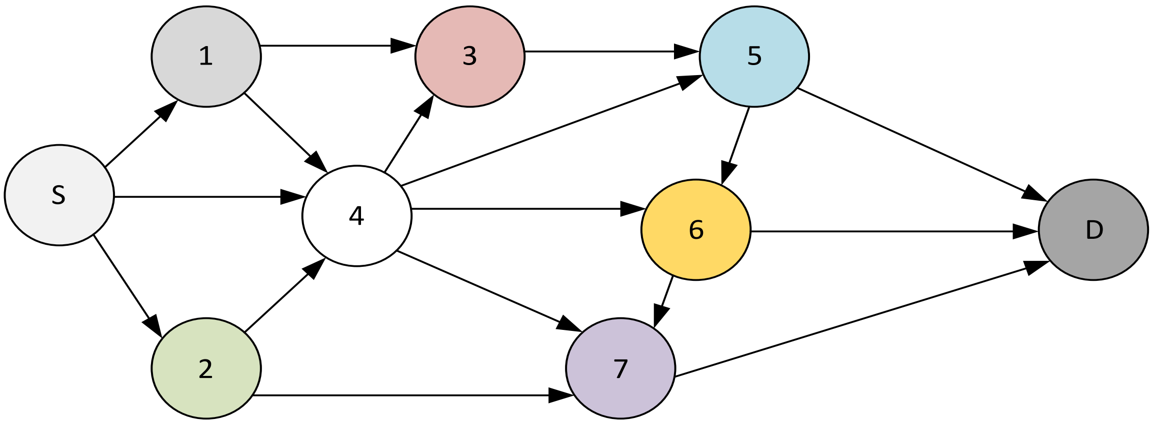

Figure 4.22: Diagram of short path using cable car

The graph on the right is divided into 6 nodes at node 1. The lines between the nodes can be expressed as the transportation mode, and the transportation mode is selected by selecting the edge. Among them, $V_{(1,7)}$, $V_{(1,5)}$, $V_{(1,6)}$ respectively represent railway, highway, waterway, and so on, you can get the conversion of various transportation modes at nodes. Note that on the terminal side of the transportation mode, that is, the attributes of the 4, 5, and 6 nodes entering edge should be consistent with the attributes of the exit edge. Through network deformation, the network diagram 4.21 can be transformed into the one shown in Figure 4.22, which is transformed into a general network path selection model.

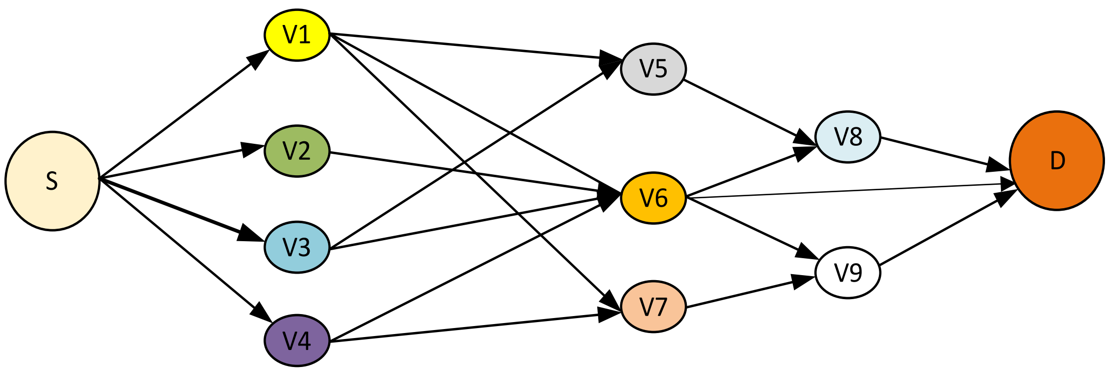

Figure 4.23: General network path selection model.

4.2.17. Solving each model

For model (1), it is the choice model of container logistics network path and transportation mode with the least cost. After reform through the network, the choice of network path and transportation mode is transformed into the shortest optimal classic choice model from node 1 to node 7 in Figure 4.21. That can pass. With lingo9.0 TMsoftware, the shortest path model can be established under the condition of increasing capacity constraints, and the shortest path solution can be solved. Similarly, the model (2) and model (3) of the container logistics network path and transportation mode selection model can be solved. The difference is that the objective function is different. In the case of a certain amount of CO_2 emissions, the transportation path and transportation method of the container should be reasonably selected to minimize the total transportation cost. The model is model (4), which is to explore the relationship between CO_2 emission environmental factors and costs.

To explore the relationship between them, the calculation steps are as follows steps. **Step1** Let n=1, and the cost z is a fixed value (determined by the decision maker); **Step2** Use model (3) to solve the minimum CO_2 emission CO_2 min

the corresponding cost z_0. If $z_0 \geq z$, execute

Step 3. Otherwise Line **Step5;**

Step3 $\mathrm{COE}_{\max} = n*tr + \mathrm{CO}_{\min}$ where tr is the amount of CO_2 emitted by conversion between various modes of transportation, in model

(1) the minimum cost on the basis of the shortest path model solution method, the TCOEmax constraint is added to solve the total transportation cost zn; **Step4** Compare zn and z, if zn ≥z, then n=n+1, execute Step3. Otherwise, execute **Step5.** Stop. Then discuss the relationship between cost and corresponding CO_2 emission constraints.

4.2.18. Computational Example

Taking a six-node transportation network as an example, suppose a batch of goods with a weight q of 900 t starts from the source node S and is transported to node D after passing through several nodes. Nodes represent cities, and there are multiple transportation routes and multiple transportation modes between cities, as shown in Figure4.23 shows the distance between nodes in the transportation network it is assumed that the distance between nodes will not change due to the mode of transportation, the transportation unit price of different transportation methods, the transportation time per unit distance and the simulation data of transportation capacity shows Table 4.3. the CO2 emissions per unit of various transportation methods, and shows the transfer costs, time and CO_2 emissions of various transportation methods at the nodes. The results of the calculation are as follows:

Table 4.4: Transport capacity

Nodes	Distances	Transport unit price-km				Transport time				Transport capacity/t			
		HW	RW	WW	CW	HW	RW	WW	CW	HW	RW	WW	CW
S-V1	300	0.32	-	-	-	20	-	-	-	1050	0	0	0
S-V2	310	0.32	0.25	-	-	20	25	-	-	950	1300	0	0
V1-V3	240	0.32	0.25	-	-	20	25	-	-	1000	100	0	0
V1-D	200	0.32	0.25	0.17	-	19	24	30	-	1100	1500	174000	0
V2-V3	240	0.32	0.25	-	0.8	21	26	-	-	900	950	1400	0
V2-V4	120	-	0.25	0.18	0.7	-	25	31	15	0	1100	1500	0
V3-V4	150	0.33	0.25	0.18	0.8	21	-	32	20	900	0	1600	1000
V3-D	180	0.33	0.25	0.17		-	-	31	10	950	0	1500	750
V4-D	400	-	0.25			-	25	30	9	0	950	0	550

HW= highway, RW= railways, WW= Waterways, CW= Cable car

The smallest cost container logistics network path and transportation method The running result is the path in Figure 4.22: (1-4-6) (1-3-5), and the reaction path in Figure 4.23 is: S-V_2-V_6-V_8-D. The transportation mode is S-V_2 for railway, V_2-V_4 for waterway, and V_4-D for waterway.

The smallest the cost is 136,255. The time is 21. 355h.The smallest time container logistics network path and transportation method the running result is the path in Figure 4.22: 1-6-8-11-13-20, which is reflected in the path in Figure 1 as S-V_2-V_3-D. The mode of transportation is S-V_2 for highway, V_2-V_3 for highway, and V_3-D for highway.

The time is 13.55h and the cost is 3) Container logistics network path and transportation method with minimum CO_2emissionsThe running result is the path in Figure 4.22: 1-4-6-9, which is reflected in the path in Figure 4.22 as S-V_2-V_6-D. The transportation method is S-V_2 is railway,

V $_2$-V_4 is railway, V_4-D is railway. The time at this time is 18.15h, the cost is 155,125 , and the CO_2 emissions are 17,374kg. Table 4.3 is Adopt the 2008 environmental report of Deutsche Bahn Statistics of CO_2 emissions.

Table 4.5: Emissions per unit of CO_2 by mode of transport (kg 100t. km)

Highway	Railways	Waterways	Cable car
79.6	2.8	4.9	2.7

Decision makers can choose according to Table 4.4Choose the optimal transportation route and transportation formula. The data in Table 4.4, consider starting from the minimum CO_2 emissions Path selection and transportation mode under, Compared to the least cost path Said that although the cost is a bit higher, but in Time and CO_2 emissions Both sides have advantages. And compared to the least. In terms of time, the cost and CO_2 Emissions also have advantages.

Table 4.6: Transit costs، transit time، and transit CO_2 emissions of various transport modes at the node

Switching by mode of transport	V_1	V_2	V_3	V_4	V_5	CO2 emission estimates
Roads - railways	9/1	8/0.9	8/0.9	8/0.9	-	1.56
Roads - Waterways	8/0.9	9/0.8	9/0.8	9/0.8	8/0.9	1.56
Waterways – Railways	10/1	9/0.9	10/0.9	10/1	-	1.56
Roads – cable car	5/0.9	9/0.9	10/0.9	10/1	-	0.76

Estimation of CO_2 emissions from V_1, V_2, V_3, V_4 ,V_5 conversion by transportation mode
Note: a/b, a represents the transfer cost per unit volume, unit: /t; b is the transfer time per unit volume, the unit is h/1000t, the unit of CO_2 , which is evaluated according to the calculation method of the unit energy consumption for cargo handling and production in the industry standard.

Table 4.7: Comparison of various transportation methods

Different objective functions	Cost (€)	time/h	CO2 emission/kg	transportation mode
minimal cost	136 255	21.355	24884.3	Waterway
Minimum time	182495	13.55	446556	Highway
Minimum CO2 emissions	155 125	18.15	17,374	Railway

It has become a trend to gradually develop towards the goals of high efficiency, low cost and environmental protection. Establish a container logistics network path based on the smallest CO_2 emissions and the choice of transportation mode is more realistic. Reasonably arrange transportation routes and choices under the constraints of CO_2 emissions The model to minimize the total transportation cost under the best transportation method In reality, corporate decision makers often need to consider government The measures proposed by the door to reduce CO_2 emissions. Reflected in the model Medium, it is an approximation of the total CO_2 emissions of the company during production and transportation. Bundle. By constantly changing the amount of T_{COEmax} to see the total transportation cost Variety. Among them,

$$T_{COEmax} = n \times 1329 + 17374$$

Where n is adjusted For the number of times, 17374 is the minimum CO_2 emission constraint, and 1329 is the amount of CO_2 emitted by the conversion of various transportation methods. The result is shown in Figure 4 22 Volume 34 Number in study 5 Shen (Zhijun, Yang Bin 2017) Research on Container Logistics Operation Strategy Considering Carbon Emissions It can be seen from Figure 4 22 that when the CO_2 emission limit is increased from 18703kg to 24019kg, the cost is always maintained at 141525 When the emission constraint increases to 25,348, the cost is 136,255 , which is the cost value of the least cost method. So decision makers are considering When considering cost and CO_2 emissions constraints, pay attention to cost and CO_2 emissions at the same time, you can choose CO_2 emissions as 18703kg and cost 141525 . The path at this time is 1-5-6-4-7-d , as shown in Figure 4 22. The transportation mode is S-V_2 for railway, V_2-V_3 for railway, and V_3-S for waterway. Through research, a container logistics network path and transportation mode selection model based on minimum CO_2 emissions has been established, and it is not considered the comparative analysis of this model and the time model demonstrates the advantages of the model compared with the model that only considers cost and time, and verifies it through a calculation example. Finally, from the perspective of the operator and enterprises, it has established reasonable arrangements for transportation routes and selection of the best transportation methods under the constraints of CO_2 emissions to make the total transportation cost Minimized model. Its purpose is to enable managers to better balance the cost of the enterprise CO2 emission limit requirements when making decisions. Made the ART system the most environmentally friendly in the world. The system. Table 4.6 shows the results of this study.

Table 4.8 Transport mode Carbon Emissions.

Transport mode	CO2 Emissions in g/pkm
Petrol-Powered motor vehicles	248
Diesel-Powered Busses	38.5
Electric Locomotive Trains	30
Cable Cars	27

General Conclusion and perspectives

Green transportation, the exchanges and development of economy and trade have promoted the development of transportation in a green and environmentally friendly direction. At the same time, it has also put forward new requirements for the sustainable development of transportation methods. Has increasingly received global attention to establishing for the modern transport modes, multimodal transportation is more environment-friendly.it has terms of both energy consumption and noise emissions. In modern society, the multimodal transport was generally regarded as an environmentally friendly transportation system. For attention to the distribution organization optimization for logistic platform with equipment and transshipping time constraints in platform, which may have an important impact on the high-volume and long-distance transportation organization. The arrival of the "platooning technology" and ubiquitous technology has opened up new opportunities to make the existing transportation industry far more efficient.

In particular, the development of multimodal transport with the participation of cable car mode and the improvement of the utilization rate of road network freight is of great significance to improving the status quo of low truck platooning container freight and improving the efficiency of multimodal transport.

In this thesis, we formulated this problem in view of the operation process and facilities as a mathematical model to applied for operation container transport platooning technology on based trucks. Then, computational are conducted to show the efficiency and practicality of our method. According to the proposed methods, the operation schemes are obtained and the results indicate that the multimodal transportation organization scheme.

Therefore, studies the transport system that freight intermodal transportation from a carrier perspective. In addition, the fundamental contribution of this thesis is the introduction of platooning technology concept into the freight intermodal transportation to be more precise, for operational level), the develop an innovation for the transport system, freight transport and logistics enable better use of transport infrastructure and contribute to the reduction of environmental issues (hazards), congestion, and distance travelled by trucks. The application of technologies is of high reliability and aims to be introduced shortly. A fuel consumption measurement on the path and expressway shows that when the gain is 10 meters, fuel can be saved by approximately 13%. The analysis reveals that the 10 m platooning device works with 40 % incorporation of large trucks has declined by 2.1 % CO_2 on the expressway. This Work is creating modern and creative approaches to boost the environmental protection and performance of the logistics chain. Significant improvements have been made by the optimization of freight transport networks, the effective combination of transport types, and the recognition of future results, the reduction of CO_2 emissions for logistics trucks. To enable industries to incorporate innovative technical approaches in the model of road haulage. Through the analysis of the solution results, it can be seen that in the Case state of changes in fuel consumption. Multimodal transport operators or cargo owners can choose based on the total time and total cost of each combination and their optimal probability to assist in the selection decision.

Benefits of implementing platoon system

Truck platoon has great potential both to make road transport safer, cleaner and more efficient in the future.

- Environment: Truck platooning reduces fuel consumption and CO_2 emissions. By enabling trucks to move closer together, air-drawn friction is considerably reduced.
- Safety: Truck platooning improves safety. There is automatic and immediate braking; the following trucks it only takes one-fifth of the reaction time of a human being for the lead truck to react.
- Efficiency: Platooning optimizes the transport by making more efficient use of roads, faster delivery of goods and reduction of transport costs. Traffic jams. Truck autonomy can also be extended in certain situations.

Benefits of implementing cable car

With the rapid development of the world economy, logistic platform, ports, and other multimodal transport are facing serious traffic congestion problems, the use of an overhead cable car logistics system will largely ease traffic congestion and improve the efficiency of goods transport. Through the analysis of the chapter of the operation process of the system logistic platform, function settings and its internal connection, improves the understanding of the cable car logistics system, and provides a method of system layout. On this basis, we can make further use and research on the actual project. in the world to the overhead logistics system research just started, the planning and construction of the underground logistics system is still in a relatively low level of understanding and practice. In order to early and international advanced level, promote the rapid development of this logistics system, should carry out relevant research work as soon as possible.

Perspectives

to the implemented cable car of the multimodal platform and container port, will give full play to the advantages of the transport in port, distribution network, and related industries, and accession to bring about sustained economic prosperity, reform the, develop multimodal transport, improve and logistics facilities, improve the logistics business development of each type of cargo, improve the logistics information network, consolidate and improve the existing container handling, unloading, warehousing , and improve the logistics network. On the basis of service functions such as storage and transportation, cable car is actively developing value-added logistics service functions and new laying into multimodal transport, distribution service, etc., forming an all-round, all-functional container logistics system with the port as the center and container transport development as the focus, Export-oriented logistics development model. The development model of export-oriented logistics starts from the objects involved in the port. Pay full attention to the vertical and horizontal connections in the development of port logistics. System, through the in-depth development of the external environment of port logistics.

This is especially so in light of the dearth on Multimodal Transport research.

- ❖ Choosing suitable cargo types with establish a self-operated logistics chain in platforms
- ❖ Establish a logistics chain with shipping, road, railway and other transportation companies (cooperative logistics);
- ❖ Joint development with bonded logistics parks to develop international transit, international procurement, international transit trade and international distribution functions (joint logistics);
- ❖ Coordinated development of port clusters, between hub ports and feeder ports;

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Appendixes[100]

Details of input parameters of test instance are shown as Appendixes A-E.

Appendix-A Detail of input parameters of instance-1 (n=10, m=4)

Table A1. Distance among city pairs (km)

City pair	1	2	3	4	5	6	7	8	9	10
Distance	1116	1161	1441	1001	1436	813	970	1131	935	881

Table A2. Transport capacity of different transport modes among city pairs (tons)

City pair	1	2	3	4	5	6	7	8	9	10
Airway	0	20	0	0	20	0	0	20	20	0
Highway	50	50	50	50	50	50	50	50	50	50
Railway	100	100	100	100	100	100	100	100	100	100
Waterway	0	200	0	200	0	0	0	200	200	200

The time window of arrival at the end destination is set to [90, 100].

The other input parameters are same as Tables 2-4.

Appendix-B Detail of input parameters of instance-2 (n=15, m=4)

Table B1. Distance among city pairs (km)

City pair	Distance
1	1465
2	1124
3	809
4	1105
5	1219
6	1330
7	1246
8	1379

9	998
10	1401
11	934
12	1062
13	818
14	1263
15	1194

Table B2. Transport capacity of different transport modes among city pairs (tons)

City pair	Airway	Highway	Railway	Waterway
1	0	50	100	0
2	20	50	100	200
3	0	50	100	0
4	0	50	100	200
5	20	50	100	0
6	0	50	100	0
7	0	50	100	0
8	20	50	100	200
9	20	50	100	200
10	0	50	100	200
11	20	50	100	0
12	0	50	100	0
13	20	50	100	200
14	20	50	100	0
15	0	50	100	200

The time window of arrival at the end destination is set to [140, 150].

The other input parameters are same as Tables 2-4.

Appendix-C Detail of input parameters of instance-3 (n=20, m=4)

Table C1. Distance among city pairs **(**km)

City pair	Distance	City pair	Distance
1	1087	11	1288
2	1015	12	1029
3	1077	13	1150
4	1463	14	1341
5	907	15	1305
6	1470	16	1400
7	892	17	1430
8	823	18	847
9	1114	19	1270
10	818	20	858

Table C2. Transport capacity of different transport modes among city pairs (tons)

City pair	Airway	Highway	Railway	Waterway
1	0	50	100	0
2	20	50	100	200
3	0	50	100	0
4	0	50	100	200
5	20	50	100	0
6	0	50	100	0
7	0	50	100	0
8	20	50	100	200
9	20	50	100	200
10	0	50	100	200
11	20	50	100	0
12	0	50	100	0
13	20	50	100	200
14	20	50	100	0
15	0	50	100	200
16	0	50	100	0
17	20	50	100	0
18	20	50	100	200
19	0	50	100	200
20	20	50	100	200

The time window of arrival at the end destination is set to [180, 190].

The other input parameters are same as Tables 2-4.

Appendix-D Detail of input parameters of instance-4 (n=25, m=4)

Table D1. Distance among city pairs (km)

City pair	Distance	City pair	Distance
1	1261	14	1373
2	911	15	1140
3	1178	16	1171
4	1186	17	1459
5	995	18	1289
6	839	19	1384
7	1009	20	1197
8	913	21	1152
9	1231	22	1396
10	1161	23	929
11	1053	24	1311
12	829	25	1294
13	1404		

Table D2. Transport capacity of different transport modes among city pairs (tons)

City pair	Airway	Highway	Railway	Waterway
1	0	50	100	0
2	20	50	100	200
3	0	50	100	0
4	0	50	100	200
5	20	50	100	0
6	0	50	100	0
7	0	50	100	0
8	20	50	100	200
9	20	50	100	200
10	0	50	100	200
11	20	50	100	0
12	0	50	100	0
13	20	50	100	200
14	20	50	100	0
15	0	50	100	200
16	0	50	100	0
17	20	50	100	0
18	20	50	100	200
19	0	50	100	200
20	20	50	100	200
21	0	50	100	200
22	0	50	100	0
23	20	50	100	0
24	20	50	100	200
25	20	50	100	200

The time window of arrival at the end destination is set to [210, 220].

The other input parameters are same as Tables 2-4.

appendix-E Detail of input parameters of instance-5 (n=30, m=4)

Table E1. Distance among city pairs (km)

City pair	Distance	City pair	Distance
1	1161	16	1318
2	1017	17	1202
3	981	18	962
4	1404	19	961

5	1269	20	1126
6	1452	21	1044
7	1415	22	1027
8	1407	23	1074
9	892	24	1425
10	1061	25	958
11	1124	26	1154
12	1125	27	872
13	1079	28	983
14	1239	29	918
15	969	30	1372

Table E2. Transport capacity of different transport modes among city pairs (tons)

City pair	Airway	Highway	Railway	Waterway
1	0	50	100	0
2	20	50	100	200
3	0	50	100	0
4	0	50	100	200
5	20	50	100	0
6	0	50	100	0
7	0	50	100	0
8	20	50	100	200
9	20	50	100	200
10	0	50	100	200
11	20	50	100	0
12	0	50	100	0
13	20	50	100	200
14	20	50	100	0
15	0	50	100	200
16	0	50	100	0
17	20	50	100	0
18	20	50	100	200
19	0	50	100	200
20	20	50	100	200
21	0	50	100	200
22	0	50	100	0
23	20	50	100	0
24	20	50	100	200
25	20	50	100	200
26	0	50	100	0
27	0	50	100	200
28	20	50	100	200
29	20	50	100	200
30	20	50	100	0

The time window of arrival at the end destination is set to [240, 250].

The other input parameters are same as Tables 2-4.