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Research on marine ship production scheduling system based on Multi-Agent System

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ABSTRACT

Combined with the port distributed characteristics and role behavior model, the marine ship production scheduling system based on Multi-Agent System (MAS) is studied. The problems existing in the overall process of port scheduling are analyzed, such as longitudinal multi-level scheduling, low information sharing, local rationality, overall conflict, poor operation of scheduling plan, etc. The planning and scheduling model based on MAS and the cooperative framework of port dispatching system based on MAS are proposed.

Keywords: Port distributed characteristics; MAS; Longitudinal multi-level scheduling

1. Introduction

With the rapid development of global trade, maritime transportation, and port operations are increasingly busy. In the production of marine ships, port operations account for a large part. With the acceleration of economic globalization, ports as an important strategic resource have been more and more widely valued. The development of port economy has become an important force affecting and radiating the rapid development of regional economy [1,2]. It is the driving force of the development of national economy. Ports gather the storage, packaging, and transportation of goods, which is an important part of China's export economy. According to statistics, more than 90% of China's foreign trade volume is completed through ports. Ports are the important gateway of China's foreign trade and the guarantee of stable development of national economy.

As a key link in modern port ship production and operation system, ship scheduling plays a very important role in promoting the overall allocation of port production resources and the optimization of production objectives. In order to improve the real-time and correctness of port scheduling plan, organization, coordination, command and decision-making, speed up information feedback, and quickly adapt to market requirements, it is necessary to fully develop and utilize these resources to maximize port benefits. Many scholars at home and abroad have done a lot of research on port scheduling problem [3].

The concept of "distributed agent" can be traced back to the 20th century. It is responsive, autonomous, and initiative to the environment. An agent can perform tasks autonomously without interaction with the environment or commands from the environment. The agent must respond appropriately to the influence and information from the environment. In addition, agents can interact with people or other agents through some agent communication language. In addition, according to the application situation, there are other characteristics. In recent years, with the continuous research of agent technology, multi-agent system is composed of multi-agent loosely coupled. It is more and more important for each agent to interact with each other in the complex network environment. By cooperating with each other, multiple agents can solve problems beyond the capability of a single agent. In this paper, combined with the port distributed characteristics and role behavior model, the marine ship production scheduling system

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based on Multi-Agent System (MAS) is studied, and the scheduling role behavior model is analyzed. The planning and scheduling model based on MAS and the cooperation framework of port scheduling system based on MAS are proposed, in order to optimize the production scheduling of marine ships in port and improve the efficiency of the port.

1.1. Literature review

Goo et al. [4] proposed a hierarchical discrete event system specification modeling method for ship production scheduling system, which provided the concept of hierarchy for the mixed hierarchy of information. Its purpose includes integrating all production information. Each layer presents a layer of available details. In addition, it is designed to facilitate cross-linking information between different layers. Therefore, the mathematical form is defined as the extended form of the discrete event system specification and is applied to the production scheduling model. The model reflects the characteristics of ship production, which is simple and easy to implement [4]. Knight et al. [5] established a simple composite model of a planar vehicle, determining the Pareto leading edge of the optimal solution to minimize two targets: drag and vertical acceleration at the center of gravity. The weight of the spacecraft is modeled as a normally distributed random variable, and the sampling method is used to quantify the uncertainty of the estimated drag at points along the Pareto frontier. Preliminary results show that the uncertainty of resistance is not constant at the Pareto front, which provides useful tradeoff information for designers and decision makers [5]. In order to select the optimal welding sequence and minimize the residual stress of the welded joint, Huang et al. [6] used the comprehensive computational material engineering method to evaluate the influence of welding sequence on the distribution of residual stress. By studying the welding sequence of various deck materials (including ABS grade DH36 and HS-100 alloy steel), an optimized welding sequence was determined to reduce the radial residual stress distribution and thus the final deck plate distortion [6].

2. Analysis and optimization of port business

2.1. Port business analysis

The infrastructure of modern bulk cargo terminal is mainly divided into two categories: production facilities and auxiliary facilities. Production facilities include berth, wharf front, warehouse yard, waterway, and various mechanical equipment. Auxiliary equipment includes port information integrated management platform and computer network and other hardware facilities.

Port ship scheduling is the core of port production management. The quality of production scheduling directly affects the economic benefits of the port. Therefore, how to do a good job in port ship scheduling has become the key to the success of port production and operation [7–10]. The content of port ship scheduling is concentrated on production planning and scheduling command. The content of production plan includes the prediction of loading and unloading task demand and the corresponding demand of various production factors such as labor force and production equipment. Port production is seasonal and unbalanced, port products cannot be stored. Therefore, the arrangement of port production plan should be balanced to avoid large fluctuations. The formulation of production plan needs full experience. Dispatching command is a series of command, inspection, supervision, coordination, and balance work to ensure the realization of production plan. According to the operation plan, the dispatching department should make sure that all departments in the production process can achieve the production plan. All links are organically linked to carry out rhythmic production. The problems to be solved are as follows: with the supply of goods, transport vehicles, ships, loading and unloading machines, and labor force, what kind of operation method to adopt, what type of machinery to choose, how to allocate manpower, how to arrange ship operation sequence, and how to determine the berthing berth and the starting and ending time of operation.

At present, the main problems of port production scheduling are: longitudinal multi-level scheduling, low information sharing degree; asymmetric information and unbalanced operation; disjointed with other auxiliary operation company scheduling plan; three shift plan is mainly based on personal experience; partial rationality, overall conflict, poor practicability of scheduling plan, etc.

2.2. Port business optimization

Through the analysis of the existing business process and the actual problems, the business process is optimized as follows: (1) ensure the connection between plans and avoid information transmission errors; (2) improve the data sharing degree; (3) improve the real-time scheduling. The specific optimization process is shown in Fig. 1.

2.3. Analysis of scheduling role behavior model

By analyzing the organization and business process of bulk cargo port, it can be determined that the posts directly related to port production scheduling include: planner of port company, tugboat company, group planner, three shift dispatcher, warehouse keeper, field dispatcher, mechanical captain, and mechanical driver.

The responsibilities and dependencies of each role in the model are described as follows:

Planner of port company: confirm the accurate information of the incoming ship and arrange the time, location, and loading/unloading sequence of the ship according to the port situation [11,12].

Tugboat company: assist in berthing and unberthing.

Group planner: manage the forecast information input by the shipping agent and shipowner in a unified way, change the company's day and night plan submitted by the company according to the tugboat plan and channel usage of the tugboat company, and form the group day and night plan.

According to the type of work, 1 h of work schedule, 1 h for each shift of the company.

Responsible for yard and yard management, make cargo plan according to warehouse location.

On site scheduling: the ship enters the port for operation, directs the berthing and unberthing, loading and unloading

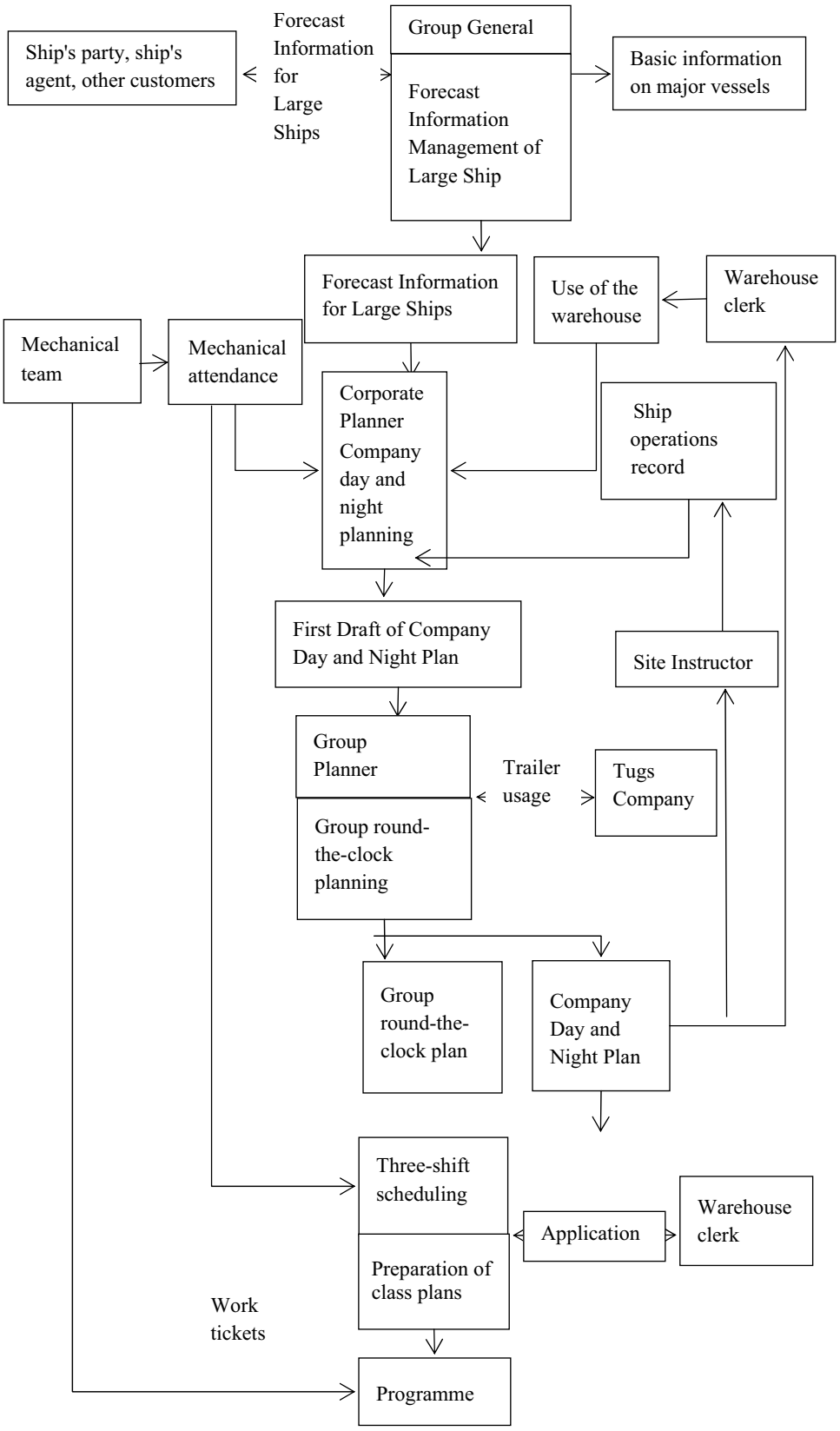

Fig. 1. Port dispatching flow chart.

sequence and space, and records the dynamic situation of the ship.

Mechanical team leader: manage mechanical attendance and assignment.

Mechanical driver: according to the task assigned by the mechanical team leader and the operation time and place, carry out the operation.

3. Framework design of scheduling system based on MAS

3.1. MAS based scheduling model

In this paper, we use the common modeling language amul. According to the behavior relationship and behavior similarity of scheduling role behavior model, agent classes are extracted. The classes extracted from port scheduling should include ship forecast agent, weather agent, berth agent, mechanical agent, tugboat, anchorage, and waterway. They are collectively called group public resource agent, warehouse agent, company day, and night plan agent and group day and night plan agent [13,14]. The agent class extracted from the company's three shift scheduling system includes work shift application agent. Therefore, the scheduling model based on MAS is constructed as shown in Fig. 2.

As shown in the Fig. 2, in the port scheduling system, the planner interactive agent is responsible for receiving the planner's instructions and preparing the completed day and night plan. When the day and night plan preparation starts, the group scheduling agent will dynamically establish the day and night plan agent of the port company according to the situation of the port company that needs to work in the group. Firstly, the berth agent, ship forecast agent, and yard agent transfer the data of each agent into the knowledge reasoning agent to obtain the operation priority of the ship and the combination of the ship and the berth, and pass the results to the company's day and night planning agent. At the same time, the weather agent obtains the weather and meteorological information during the operation through the real-time network and submits it to the company's day and night planning agent, The ship agent can encapsulate the day and night operation plan to the port agent, and then transfer the plan to the port agent. Only when all the created day and night planning agents of port companies are successfully submitted, the group day and night plan agent will combine the plans of each company and send them to the public resource agent. By detecting the overall use of the group's public resources, and adjusting the ships with conflict in the use of public resources in the ship operation plan of each company. The adjusted plan is returned to the group day and night plan agent. The group day and night plan agent sends the coordinated overall ship operation plan of the group to the interactive agent of the day and night plan to display the final results. At the beginning of work shift planning, the company's day and night planning agent, mechanical management agent, and work shift application agent send their own operation lines and machinery free and idle conditions to the work shift planning agent. The agent reasonably arranges the operation line and allocates port machinery according to the principle of efficiency maximization through its own knowledge reasoning. It encapsulates and dispatches the task to each agent, and sends the task to each agent.

3.2. Assistance framework of port coordination system based on MAS

Due to the complexity of port scheduling business, in order to better describe the process of agent cooperation in the process of scheduling, this paper uses a simplified agent

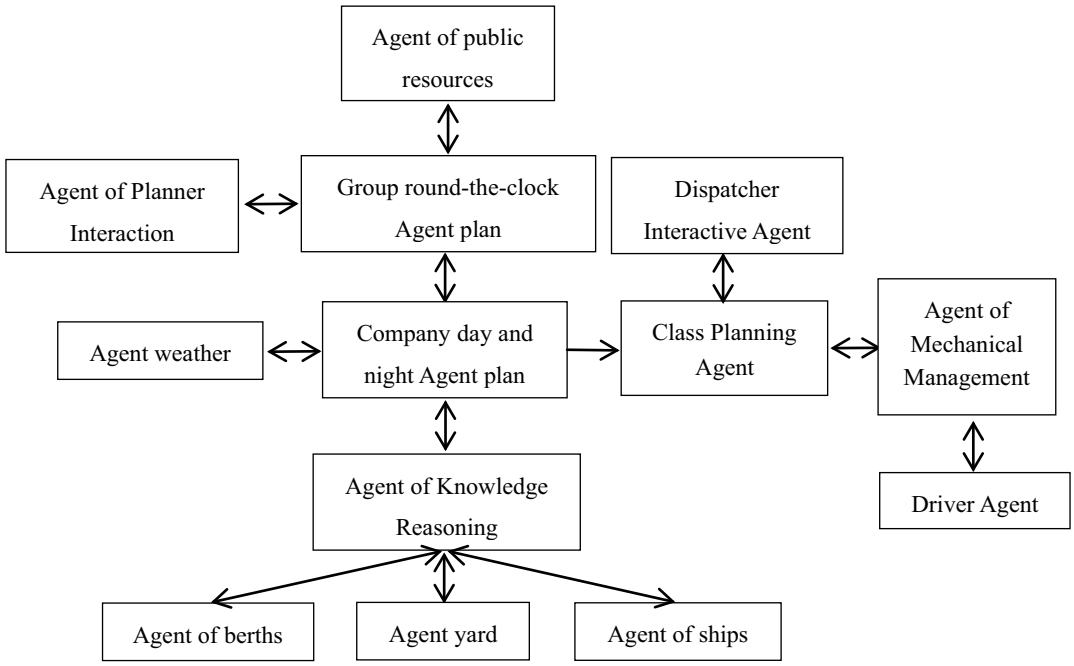

Fig. 2. Port scheduling model based on MAS.

collaboration framework model to describe the interaction and process between agents in port scheduling system.

After the operation of the group port dispatching system, the planner first enters the personalized requirements, and the system creates the group planning agent, which sends the message of submitting the company plan application to the port company, waiting for the response of the company's planning agent. After the company's dispatching system is started, the company's day and night plan compilers begin to prepare the company's day and night plan. The system creates company planning agent and basic resource agent. The basic resource agent includes ship agent, berth agent, and storage agent. The company agent arranges the operation order according to the forecast time and priority of loading and unloading of large ships, and applies for resources to the basic resource agent. According to the constraints of ship forecast workload, customer demand, and optimal average efficiency, the system can be used as an example. After the company's planning agent submits the first draft of the company's day and night plan to the group planning agent, if the company's planning agent needs to make plan adjustment, it needs to apply to the group planning agent, and the group planning agent will conduct the change audit. The system creates tugboat planning agent

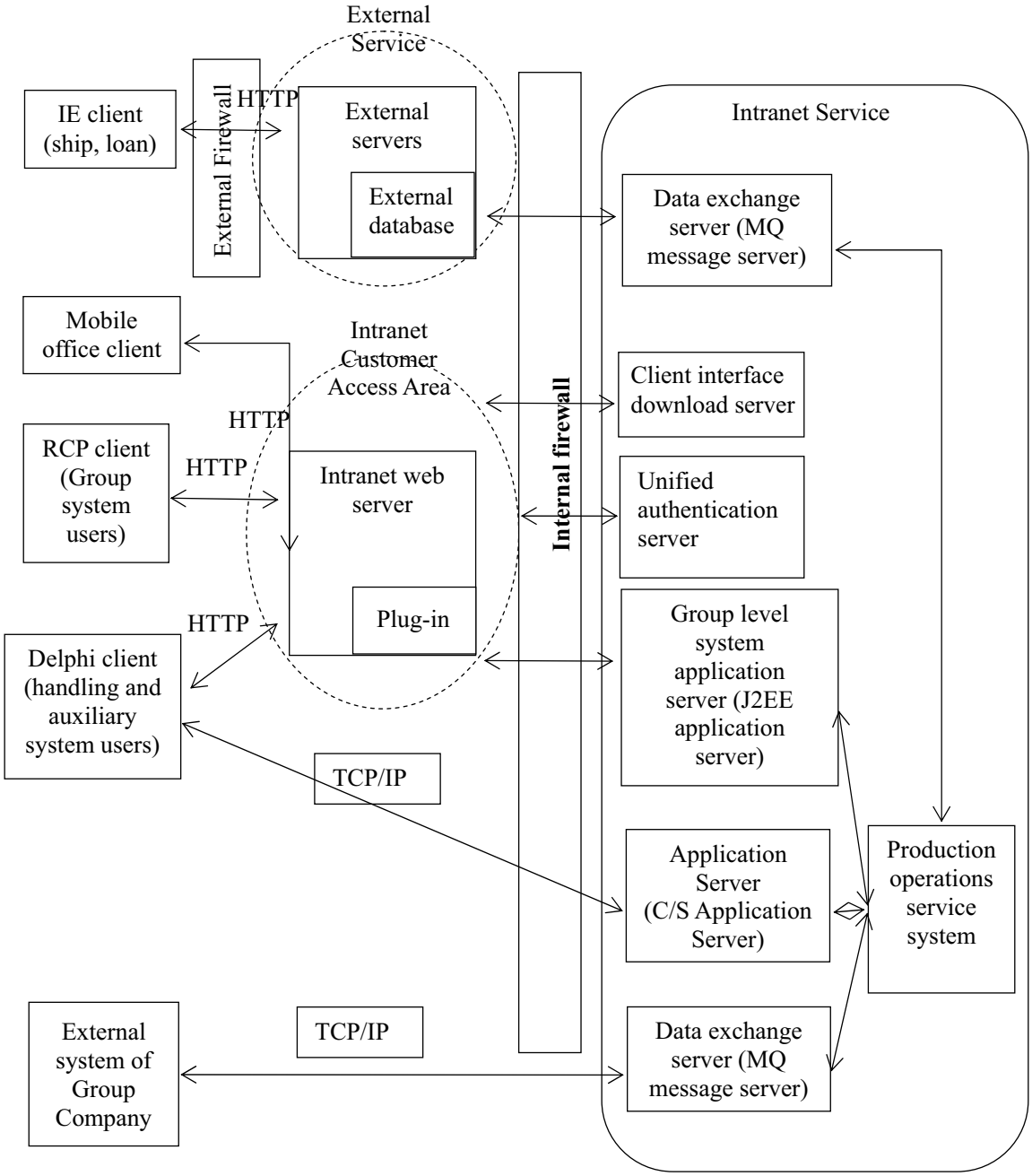

Fig. 3. System design scheme.

and channel planning agent (group resource agent in the figure). According to the goal of high utilization of port resources and large throughput, the system coordinates the allocation of group public resources, and transmits the company's day and night plan and group day and night plan to the company's dispatcher. The system creates the work shift planning agent, the work shift application agent, and the mechanical management agent. The work shift planning system automatically extracts the company's day and night plan provided by the company's plan agent. If the plan of the day is not completed, the system extracts the day and night plan of yesterday. According to the application time and the priority of loading and unloading the ship, the work shift planning agent sends out the work shift planning operation line. According to the operation line, the work shift planning agent sends the mechanical application instruction to the mechanical management agent, and the mechanical management agent requests or gives the adjustment strategy according to the machine free and busy period record. In the future, the agent will send the application information of the machine resource management agent to the terminal to complete the application of the machine resource management. The job content and completion status are returned to the mechanical management agent, and the mechanical management agent updates the mechanical status in real time.

3.3. System design scheme

Based on the consideration of security, easy maintenance, scalability, and operability, this paper proposes a system design scheme based on J2EE architecture, as shown in Fig. 5. This scheme needs to set up two firewalls, and divides the whole application system into three security areas: external service area, intranet service area, and intranet customer access area.

External server is mainly deployed in the external service area, which is responsible for providing information query, business data submission, and other information services for group customers, such as shipping agent entering forecast information and group leaders querying report data. Business customers of group companies use browser to access the server through external firewall. With the help of intranet firewall and security mechanism, group business customers can only reach the service area.

The intranet service area is deployed behind the intranet firewall of the group company, which mainly stores the core business logic and data resources of the group company.

- The application server is mainly responsible for encapsulating and running the group production business logic. Among them, the group level production business system is completely based on J2EE architecture. The production business system of job assistant company is based on Common Channel Signaling three-tier structure and uses the middle tier server.
- The unified identity authentication server is responsible for the identity authentication of all users in the whole group.
- The client interface download server is responsible for publishing the client program interface. When the system interface changes, the server automatically provides interface download service for Radio Control Protocol and Delphi clients to minimize the amount of manual maintenance.
- MQ message server is responsible for information exchange with other systems of group company, and external servers.
- Oracle server is responsible for storing the data resources of the group, operating company, and other companies in the group.

4. Summary

In this paper, combined with the port distributed characteristics and role behavior model, the marine ship production scheduling system based on MAS is studied. The problems existing in the overall process of port scheduling are analyzed, such as longitudinal multi-level scheduling, low information sharing, local rationality, overall conflict, poor operation of scheduling plan, etc. The planning and scheduling model based on MAS and the cooperative framework of port dispatching system based on MAS are proposed.

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