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Modeling and analyzing of railway container hub scheduling system based on multi-agent system

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Abstract: As a typical discrete element dynamic system (DEDS), railway container hub scheduling system has the characteristic of high randomness, low flexibility, uncertainty of operation time and high coordination demand of facilities. In this paper, according to the analysis of layout, establishment, facility and operation procedure of railway container hub, we choose Multi-agent systems (MAS) which have strengths for solving asynchronism, concurrency, distributive and parallel problems as the basis to build the railway container hub scheduling system model, analyze the function of each agent, and describe the schedule procedure analysis of agents.

Keywords: Railway Transportation, Scheduling System, Multi-Agent System, Railway Container Hub

1. Introduction

The railway industry plays a vital role in many countries. All railway companies try to achieve more regular and reliable services, in order to satisfy their customers. (Pedro & Carlos, 2011) One way to improve service quality of railway container hub is to optimize its scheduling system. Railway container hub scheduling system (RCHSS) is a complex discrete element dynamic system (DEDS) composed by transportation systems, dispatching systems and information systems. It is related to the modeling and optimizing of logistic, dispatch and information. The operations of system have features of parallel, coordination and competition. Because of the high randomness, low flexibility, uncertainty of operation time and high coordination demand of facilities in RCHSS, the system model description has features of concurrency, flexibility

and dynamic.

Multi-agent systems (MAS) have been demonstrated their potential for solving complex problems in various domains. A multi-agent system (MAS) is defined as a loosely coupled network of problem solvers that work together to solve problems that are beyond the individual capabilities or knowledge of each problem solver (Durfee & Lesser, 1989; Wu et al., 2011). The increasing interest in MAS research is due to significant advantages inherent in such systems, including their ability to solve problems that may be too large for a centralized single agent, provide enhanced speed and reliability and tolerate uncertain data and knowledge.

For the advantages of MAS, it is largely applied in operation and schedule of container. Many studies which focus on the management of port container terminal, schedule of the container yard, distribution of berth, etc. have got several achievements. Degano et al. (2002) applied the MAS to the chain of terminal operations and take Italy Voltri terminal for simulation. Gambardella et al. (1998) combined operational research and MAS to study the scheduling and loading-unloading process. Yu (2007) used MAS as the basis for an intelligent terminal schedule system and proposes its framework, communication mechanism and negotiation mechanism between agents. Li et al. (2007) presented a modeling framework of container terminal logistics system which based on multi-agent and the successful algorithms in the computer domain and use AnyLogic platform to simulate for Shanghai harbor. Zhang et al. (2007) used MAS as the basis to build a container rail-sea intermodal transportation model. Wei (2007) built a container backup yard simulation model and makes this agent system can self study and autonomy. B. Sun proposes the MAS based architecture model of the operational scheduling system of logistics in container terminal and builds a robust berth allocation model based on ant colony optimization.

According to the studies mentioned above, we can find the applications of MAS in container logistic system most focus on port container terminals. The study about the application of MAS in RCHSS is few. As an important hinge of inland container transportation, railway container hub is different from port container terminal in distribution, facility, operation procedure and dispatch. So the study about the application of MAS in RCHSS is necessary. In this paper, we will use MAS for the modeling and analysis of RCHSS.

The rest of paper is organized as follows. Section 2 introduces the layout and facility of railway container hub. Section 3 describes operation procedure of railway container hub. Section 4 is the modeling and analyzing of RCHSS.

Section 5concludes the paper and provides some directions for future work.

2. Layout of Railway Container Hub

Railway container hub can be divided into eight function areas which include operation area, main container yard, auxiliary container yard, security inspection area, intelligent door, control tower, parking area and container service area. The functions of area are described as follow:

(1) Operation area

Operation area is the core function area of railway container hub. The main loading and unloading processes of railway container hub are in this area.

(2) Main container yard

Main container yard is the warehouse of arrival containers (temporary storage), transit containers and departure containers. If the container turnover volume of railway container hub is low, all common containers will be stored in this area.

(3) Auxiliary container yard

Auxiliary container yard is the auxiliary of main container yard. The special containers, refrigerated containers and empty containers are storaged in this area. When storage content of main container yard cannot meet the demand of container storage, railway container hub need transfer the demurrage arrival containers, transit containers and departure containers from the main container yard to the auxiliary container yard by container trucks.

(4) Security inspection area

Security inspection area is responsible for security checking of containers which are carried in railway container hub by container trucks.

(5) Intelligent door

Intelligent door can automatically recognize the number of container and container truck, and match truck and container information with electronic data to decide which trucks are allowed entrance or exit.

(6) Control tower

Control tower is responsible for supervising and managing the real-time status of containers and facility, giving task instructions for loading-unloading facilities.

(7) Parking area

Parking area is a parking lot of internal container trucks and reaches stackers.

(8) Container service area

Container service area is responsible for cleaning and maintaining of containers. The containers which need service are transported by internal

container trucks from main container yard and carried by reach stackers from auxiliary container yard.

Layout of railway container hub is shown in the following figure:

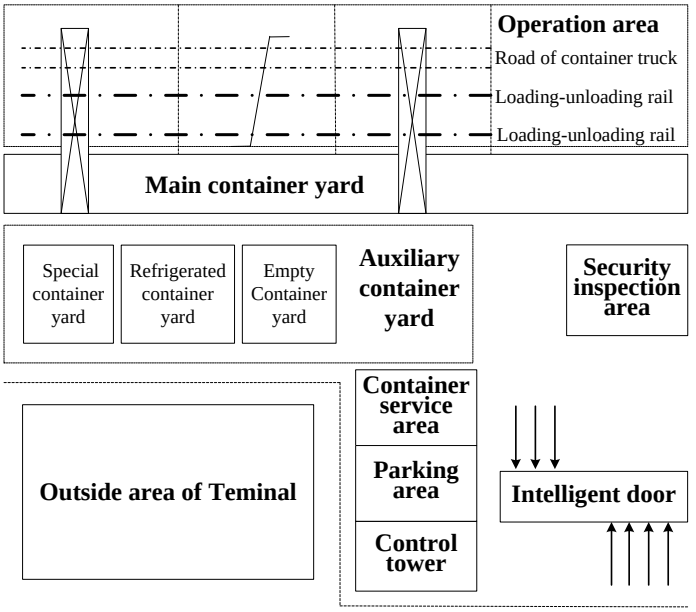

Fig. 1: Layout of railway container hub.

3. Operation procedure of railway container hub

Operation procedure of railway container hub can be divided into two parts. First is the operation procedure of container export which is shown in the right of Fig.2. This part operation mainly focuses on the empty containers, heavy containers, special containers and transit containers loading. Another part is the operation procedure of container import which is shown in the left of Fig.2. This part operation mainly focuses on the arrival container train unloading. The whole operation procedure of railway container hub is shown in the following figure:

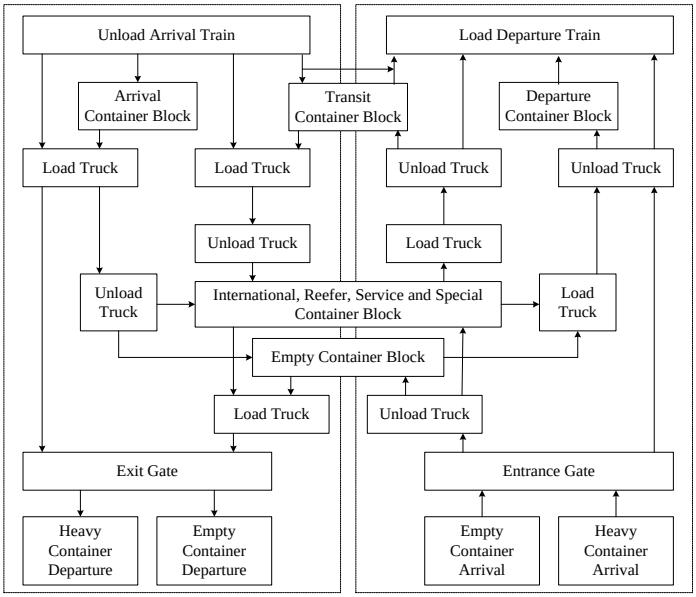

Fig. 2: Operation procedure of railway container hub.

4. Modeling and analyzing of RCHSS based on MAS

4.1. Modeling of RCHSS based on MAS

According to the layout and operation procedure of railway container hub mentioned above and the characteristics of RCHSS, we use the methodology of MAS-commonKADS, comprehensively consider the operation type, operation organization, communication mode and consultation mechanism, adopt the mixed distribution pattern, build the model of RCHSS.

The model is composed by ten agents include rail designation agent, container yard distribution agent, gantry crane dispatch agent, reach stacker dispatch agent, container truck dispatch agent, rail agent, container yard management agent, gantry crane agent, reach stacker agent and container truck agent.

In the ten agents, rail designation agent and container yard distribution agent belong to the establishment control agent class. Gantry crane dispatch agent, reach stacker dispatch agent and container truck dispatch agent belong to the facility control agent class. Gantry crane agent, reach stacker agent and container truck agent belong to facility implement agent class. Container yard management agent is responsible for the management of main and auxiliary container yards. The model of RCHSS based on MAS is shown in the following figure:

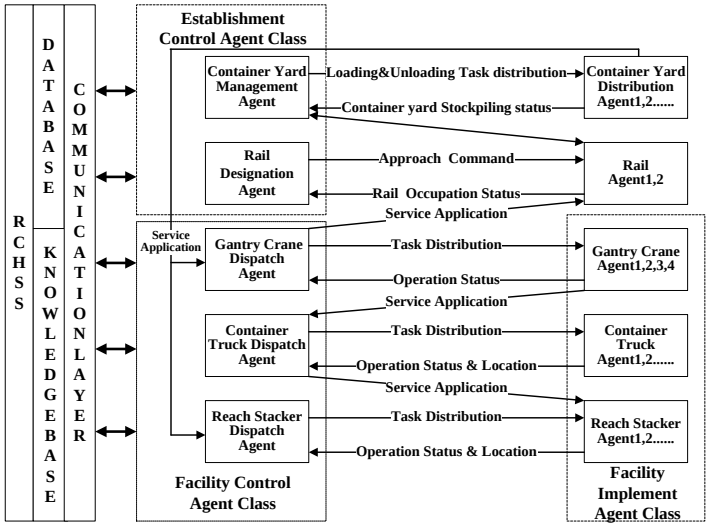

Fig. 3: Model of RCHSS based on MAS.

In the model, we divide the schedule problem of railway container hub into several sub-problems, and each sub-problem is solved by specific agent. These agents are relatively independent between each other. There are consultation mechanism and communication mode among agents.

4.2. Function analyzing of Agents

Functions of ten agents are analyzed as follow:

(1) Rail designation agent

This agent is responsible for the distribution of loading-unloading rail, planning the service time and coordinating the utilization of rail.

(2) Rail agent

This agent is responsible for the arrival and departure of container trains and sending service application for gantry crane dispatch agent.

(3) Gantry crane dispatch agent

According to the service application from rail agent, this agent is responsible for ensuring the loading-unloading order of containers in main container yard and dispatching gantry crane to accomplish loading-unloading.

(4) Gantry crane agent

This agent is responsible for generating loading-unloading sequence on the basis of gantry crane dispatch agent order and container attribute, sending service application to container truck agent.

(5) Reach stacker dispatch agent

This agent is responsible for the loading-unloading operation of container in

auxiliary container yard and dispatching reach stacker to accomplish loading-unloading.

(6) Reach stacker agent

This agent is responsible for generating loading-unloading sequence on the basis of reach stacker dispatch agent order and container attribute, sending service application for container truck agent.

(7) Container truck dispatch agent

According to the service application from gantry crane agent and reach stacker agent, this agent is responsible for generate loading-unloading sequence and routes, and cooperating with gantry crane and stacker to accomplish loading-unloading.

(8) Container truck agent

This agent is responsible for sending status and feedback information to container truck dispatch agent.

(9) Container yard distribution agent

This agent is responsible for ensuring distribution quantity and stack position of import containers in main and auxiliary container yard.

(10) Container yard management agent

This agent is responsible for ensuring the container stack plan, and the position of import and export container.

4.3. Schedule procedure analyzing of Agents

The RCHSS model is composed by several agents who have different knowledge are joined by communication network. The agents make decision by the message which is sent from other agents. Schedule procedure of agents is shown in the following figure:

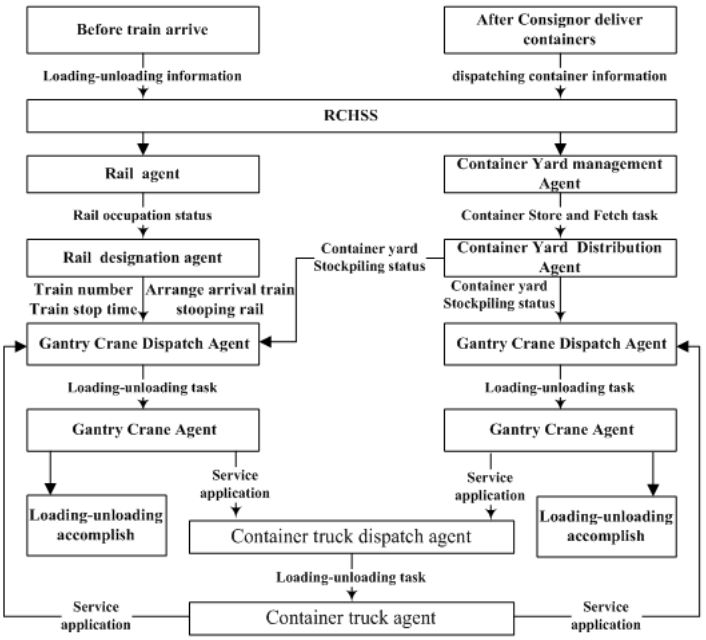

Fig. 4: Schedule procedure of agents.

5. Conclusion

In this paper, we introduce the layout, establishment, facilities, and operation procedure of railway container hub. According to the characteristics of railway container hub, we use MAS as the basis to build the railway container hub schedule system model, analyze the functions of each agent, and describe the schedule procedure analysis of agents. The study about communication mechanism and negotiation mechanism among RCHSS agents will be the future direction.

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References

Durfee, E.H., & Lesser, V. (1989). Negotiating task decomposition and allocation using partial global planning. *Distributed artificial intelligence*, 2, 224-229.

Degano, C., and Pellegrino, A. (2002). Multi-agent coordination and collaboration for control and optimization strategies in an intermodal container terminal. *IEEE International Engineering Management Conference*, 2, 590-595.

Gambardella, L.M., & Rizzoli, A.E. (1998). Simulation and planning of an intermodal container terminal. *Simulation*, 71, 107-116.

Li, B., & Li, W.F. (2007). Modeling of container terminal logistics system based on multi-agent. *Journal of Southeast University*, 23, 146-150.

Pedro, A.A., & Carlos, F.B. (2011). Railway traffic management: Meet and pass problem. *Journal of System and Management Sciences*, 1, 1-26.

Wei X.J. (2007). Research on container backup yard machine scheduling simulation system based on agent. Dalian Maritime University. Dalian, China.

Wu, J.J., Kang, N., Si, B.F.(2011).A new approach of supply chain cost modeling for integrated rail-post package distribution system in China. *Journal of System and Management Sciences*, 1(2), 11-24.

Yu, M. (2007). Research on container terminal scheduling system based on multi-agent. WUHAN University of technology. Wuhan, China.

Zhang, R., & Yan P.Y. (2007). Information system model of rail-sea intermodal transportation based on multi-agent. *Journal of TONGGI University*, 35, 72-76.