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Construction and Cooperation Mechanism of Logistics Vehicle Scheduling System Based on Ontology and Multi-Agent

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Abstract. The development of market economy has put forward new demands to the logistics. However, the traditional artificial decision has been unable to meet the demand of the market. Under the rapid development of Internet of things and information technology, the application of new technology in logistics vehicle scheduling makes it more reasonable, also, reduce the logistics cost. On the basis of traditional logistics vehicle scheduling process, the paper designs a framework of logistics distribution system from ontology view, combined with the application of ontology and agent in the logistics vehicle scheduling and material scheduling. Then, it sets up the vehicle scheduling system model based on the multi-Agent, to analyse the process of mutual cooperation between agents if they complete the task together. Meanwhile, the paper also establishes a communication mechanism based on the blackboard system, to further analyse the cooperation mechanism between Agents.

Introduction

In recent years, Logistics has been a hot topic for all business. Moreover, the competition between each enterprise also would lead to the fast development of Logistics in following years. Currently, the Logistics industry in China still falls behind some developed countries. The most significant problem is the high logistics cost and out-dated operation management processes. The distribution cost, as the most important performance in operation management, takes a high percentage in all logistics operation costs. That's because, most logistics companies still use artificial experience to design distribution processes, such as vehicle schedules and distribution routes design. However, at the end of 1980s, in Europe, US, Japan and other developed counties, it appeared some special software for logistics schedules. Instead of the artificial experience management method, the intelligent and automatic technologies have been well used on vehicle schedule design. And, the agent technology arises people's especially concern during the improvement processes.

Since the early 1990s, the ontology theory has been used to describe and share knowledge. And, it's also widely used to support the informatisation in various fields. Especially for the research of the artificial intelligence and knowledge projects, they need AI and KE to develop a field to share the knowledge. In AI, it calls the ontology as the domain model or concept model. And, the ontology has been a hot research in the field of KE, natural language process, cooperative information systems, intelligent information integration and intelligent information collection on the internet. Because the ontology is a standard, explicit and formalized description for shared conceptual model, the service between logistics enterprises can be integrated by applying semantic express, shared knowledge described by ontology and automatic inference mechanism in logistics system.

The Agent is an intelligent entity which is autonomy, initiative, persistence, interactivity and adaptability. It can independently react to the environment changes by their own sensors, without the absence of external direct manipulation. The Multi-Agent System (MAS) is composed of multiple function body in advantages of agile, flexible and real-time. Each Agent uses

independently architecture and has a certain function. And, the relationship between each Agent is dynamic adjustable. All different functional Agents tightly consists the coupled transport scheduling management system. This system is structure adaptive, self-organizing and in good coordination performance, which can complete complex operations through coordination methods [1]. Therefore, the multi-agent technology is very suitable for solving vehicle scheduling problem in logistics distribution. In recent years, researches on Agents about the problem of complex system modeling are popular. Many scholars developed the theory of fault diagnosis system and model study based on MAS theory, and proposed a basic framework [2, 3]. In some further research, scholars designed a set of judgment models based on the contract net mechanism and the mixed multiple Agent system architecture, then, applied it to the production scheduling [4] and related fields. In 1998, Tamagawa applied the multi-agent system to cities commercial transportation simulation. Tamagawa built three models - the learning model, the model of vehicle route planning with time windows and transportation scheduling model. In addition, some other scholars also applied the Multi-Agent technology to solve the dynamic scheduling of airport emergency resources and vehicles scheduling military goods [5]. The Agent can implement the intelligent search in ontology knowledge base and semantic net, to improve the intelligent of logistics distribution system [6, 7].

In China, due to the rapid development of modern logistics, the modern logistics industry has been much more domestic than before, and meet international standards better. At the same time, enterprises introduce information management into their operation process, to achieve more profits in business. In the field of logistics distribution process, the intelligent, informatisation and visual management would be a new development trend in following years [8]. In reality, the logistics distribution process is in complexity. For example, if emergent tasks occur or distribution lines are impeded, it needs to re-calculate all the original set of algorithms. Thus, it would disrupt the plan and increase the workload with additional labour. It also will fail to make decisions independently. Thus, it arises some researches about the agent distribution system studies. In this paper, it introduces the ontology theory and agent method on the study of the schedule optimisation of complex logistics distribution system based on its adaption.

The Framework of Logistics Distribution System from Ontology View

In general, we use language in our daily communication. However, in computer science, the natural language is not understood. Its limits are from the vagueness and uncertainty of the natural languages.

The Framework of Logistics Distribution System. In the field of modern logistics distribution, each distribution center doesn't have an uniform standard for the knowledge representation on its own information resource. It always leads to information communication errors and distribution tasks delay. In recent years, the cooperative distribution mode can better optimise the allocation of resources. But, in many cases, this model has not yet been widely used. Because, the model doesn't have any effective knowledge sharing mechanism in it. So, the establishment of mutual understanding mutual cooperation is difficult to achieve.

OWL (Ontology Web Language) is a modeling tool used for the description of information system logical model on the semantic level, to clearly express the meaning of the vocabulary and the relationship between these terms. Logistics distribution business process is complex, including various business activities, and many semantic relationship between each activity. Since OWL owns rich relationship description, it can well express the relationship among the semantic information which the traditional keywords are hard to match. The construction of knowledge ontology needs to reanalyse the business process, including three stages - the concept extraction, OWL description, constraint axioms definination. Its basic framework is shown as Fig. 1.

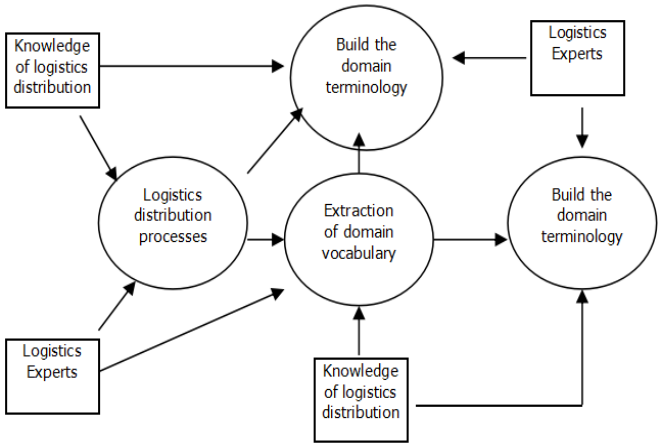

Fig. 1 The Framework of Logistics Distribution System.

The Operation Process of Logistics Distribution System. Logistics distribution business system is complex. And, it's time-consuming, laborious and error-prone, if artificial implement business decisions. But, if the logistics concept ontology and business regulations are used, it could significantly improve the efficiency and reduce its error rate.

In the logistics distribution process, it refers to lots of targets optimisation. The users will submit their business needs to the system. Then, the system will record all these orders data. The optimal distribution results will be automatically calculated out by the inference system. The flow chart of logistics distribution shown in Fig. 2 is based on ontology theory.

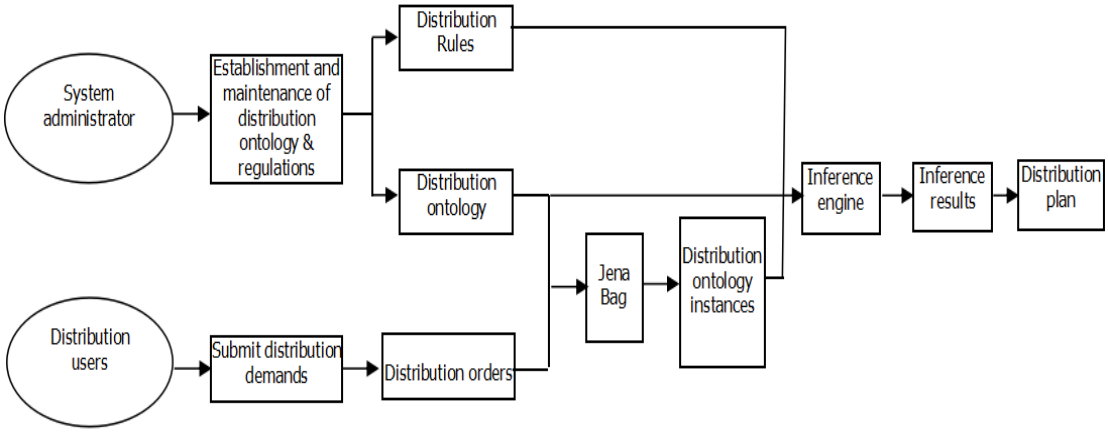

Fig. 2 The operation flow map of Logistics Distribution System.

The operation process of logistics distribution based on the ontology theory can be divided into following three parts.

Logistics distribution ontology and regulations establishment. The knowledge base of logistics distribution domain knowledge includes logistics ontology (LO) and logistics rule (LR). In the logistics ontology, it includes some concepts about the storage process, such as vehicles, storage service, cargoes and related information. The distribution regulations records the principles that should be followed during the distribution process implement.

Users submit distribution demands. The distribution demands includes the start location, start time, the nature of goods, the user's special requirements and so on. After these demands submitted, all cargoes information will be recorded in the orders data base, waiting to be processed by the system of engine.

Generate distribution schedules according to the delivery engine. Read the user distribution requirements from the database system by the Jena development kit. Then, it will generate the logistics Ontology individual (the LOI) in the basis of Logistics Ontology, which will be input as inference machine data in following steps. And, the logistics ontology and the logistics regulations

will be input as the inference regulation. After calculated by inference machine, it generates the inference results and distribution solutions.

The Vehicles Scheduling System Model Design on basis of Multi-Agent

The Analysis of each Agent in the System Model. In the traditional e-commerce, the distribution refers to the process insist of the order fulfillment, order accept in DC (Distribution Center) and vehicles arrangement. Since it's always processed by manual operation, which would be inefficient. Meanwhile, the vehicle schedule is designed by the artificial experience which would has irrationality. In order to overcome those difficulties, the logistics vehicles schedule system separate all distribution processes into several modules. They are order processing, vehicle scheduling calculation and vehicle tasks implement. The Agent will instead each module, namely order processing Agent, vehicle scheduling calculation Agent and terminal Agent and vehicle Agent. And, it also needs warehouse management Agent, road net information Agent. In addition, it will set a coordination & control Agent to do the overall control. In this paper, it defines the Agent into following kinds, namely Management Agent, Tasks Agent, Calculation Agent and Resources Agent.

Tasks: order agent. Tasks Agent will choose the appropriate resources for itself to process. This process is dynamically generated. It needs a control management at the same time. In the actual distribution system, it refers to the Order Agent. The Order Agent response for the accept and process of customer orders. It includes manually input files, then, order analysis and form tasks. Meanwhile, it also will send a feedback to customers about the orders process conditions. Moreover, it will do a market analysis about the customer state according to the network data.

Management: coordination & control agent. In the Management Agent, it's used to coordinate and control the overall information, especially under an urgent or emergency state. It always refers to the Coordination & Control Agent in the agent vehicle schedule system. If an urgent order appears, the Coordination & Control Agent would define it a higher priority, according to the regulations in the database.

Calculation: vehicle schedule agent. Calculation Agent is the Agent that owns a detail algorithm and ability of judgment. In the agent vehicle schedule system, it refers to Vehicle Schedule Agent. It's the core part of the whole system, namely the algorithms library, such as the genetic algorithm, simulated annealing algorithm and neural network algorithm. It's used to identify its capacity on each order, and form a vehicle schedule based on some special target.

Resources: warehouse management agent, yard agent, vehicle agent and network information agent. Resource Agent is a part or several units of resource management system. It refers to equipment, transportation and operators in the physical distribution.

The Model Design. In this paper, it designs the vehicle scheduling system model by multiple Agent work together to complete distribution tasks.

During the task implement, the cooperation between each Agent is as follows (Fig. 3):

(1) Customers shall input the order information through the Internet. Then, the Order Agent will be in activation, which can collect the order information, such as the distribution place, types and volume of the goods and time requirements. Then, it forms a special delivery task. This task information will be transferred to the Vehicle Schedule Agent. After that, the Order Agent turn to be waiting state.

(2) After the Vehicle Schedule Agent find its tasks, it also will be in activation. It needs all other Agents coordination to complete the calculation. Thus, all other Agents also shall be in activation through the collection of goods information from the warehouse, vehicles information from yards and the road information.

(3) After the Yard Agent receives a schedule, it will activate each vehicle's Agent. And, it will allocate tasks to the appropriate vehicles.

(4) Distribution tasks implement. When each vehicle's Agent receives its tasks, they will implement its all tasks as the schedule.

In addition, Coordination & Control Agent is used to coordinate and control the overall information, such as tracing orders processing status. If an urgent order appears, the Coordination &

Control Agent would define it a higher priority, according to the regulations in the database. When the cooperation between each the Agent has communication problems, the Coordination & Control Agent will trace the problem link.

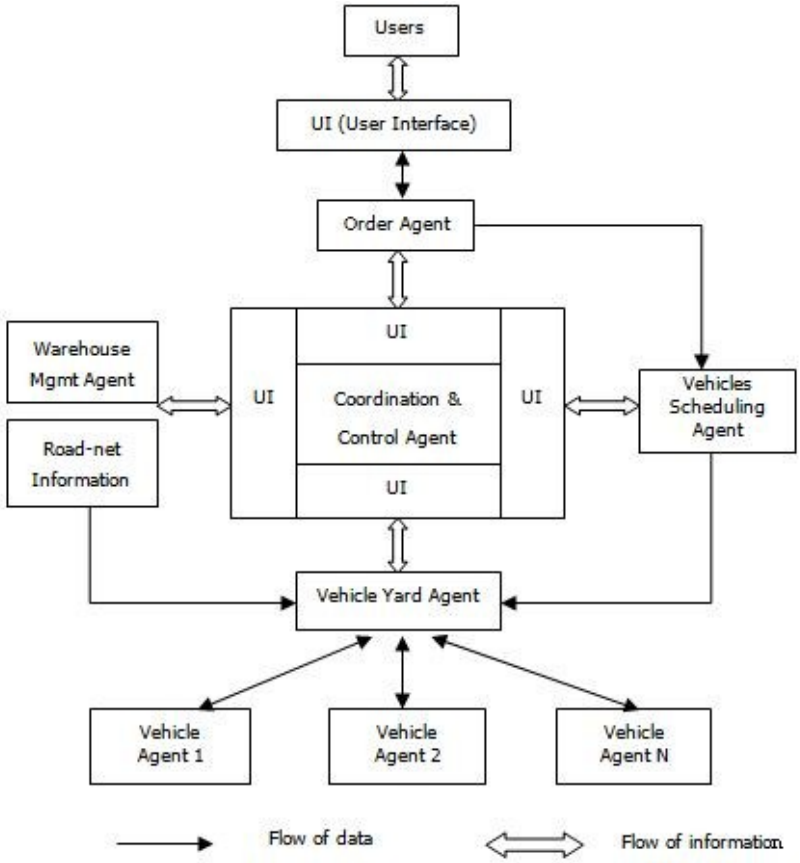

Fig. 3 The framework based on multi-Agent vehicle scheduling system.

The Communication & Coordination Mechanism between each Agent

The Physical Structure of the Agent. Agent is an intelligent entity, which independently respond to the external environment changes through their own sensors, in the absence of external direct manipulation. The application of a single agent can only solve some simple practical problems. It's a simple process (Fig. 4), including receive the external environment problems, calculation through the internal packaging algorithm or procedure and the response to external environment at last.

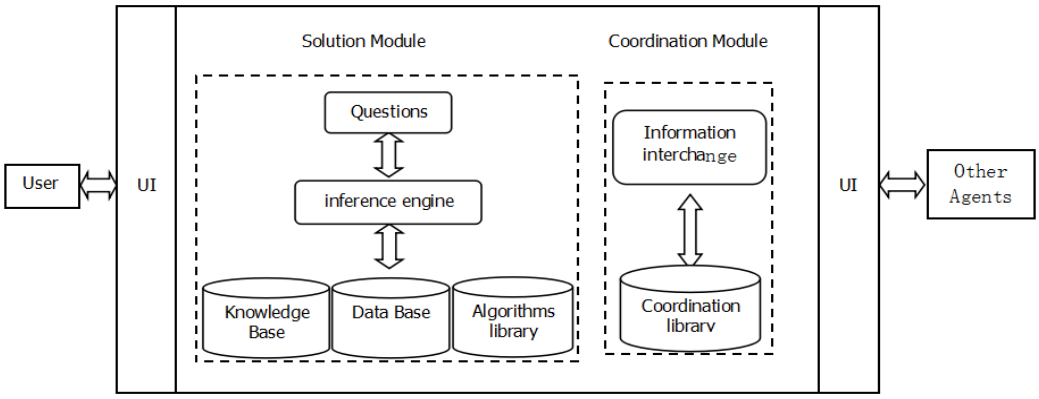

Fig. 4 Physical structure of Agent.

In a system composed of multiple Agents, all Agents shall share and collaborate between each other to complete the task together. A general Agent always has three parts. They are the user interface, communication interface and the modeling. The user interface is used to interact with the

outside environment, namely reception problems or feedback results. The modeling is the core part of this system. And, it's responsible for solving the problem. Generally, the modeling includes calculation module and cooperation module. In the calculation module, it has a database, the knowledge base and the encapsulate algorithms library. The reasoning machine is responsible for problem decomposition and using existing knowledge reasoning to solve. In the cooperation module, it has a collaboration base, used for the data interchange between each Agent to complete the task together.

Communication Mechanism between the Agents. There are three main kinds of Agent communication language between the Agents. The first one is Knowledge Query and Manipulation Language (KQML). It defines the message format and transmission system. And, it also offers a general framework for the communication and coordination between the Agents, especially for the agreement of identify, data link and information interchange. The second one is Knowledge Interact Format (KIF). It's used to describe the nature of the set field, and the common language between entities in the set field, strictly based on the logic calculus. The last one is the ACL language defined by FIPA, used to state the behavior nature. Generally, its message represents a communication effect [10].

There are two main communication types between the Agent. One is the synchronous information transmission, namely the blackboard system. The news on the blackboard can be widely accessed. Each Agent can send the message to boards. They also can read messages from the blackboard. The other one is asynchronous message delivery, namely point to point mode. One Agent can send message to several Agents. This communication mode needs Agents learn more about each other. It requires the sender of the message understand the receiver's information in advance.

The communication methods of intelligent vehicle scheduling system designed in this paper is blackboard system. The communication language is KQML language defines coordination rules. KQML includes following elements: performative, roles, language, discourse, content, etc. The example of KQML is shown as below [11]:

```
(tell
        : sender Agent1
        : receiver Agent2
        : language: SQL or XML or KIF
        : ontology:
        : content:
```

Each state of the Agent is defined by the coordination rules. For example, to obtain the state transition of coordination rules from the beginning of the order status are defined as follows:

```
(define—Conver—rule' rule1
:current—state' begin
:accepted'(propose: sender(customer Customer)
        :content(customer-order
                :has-line-item? A))
        :next-state' order-accepted
        :transmit'(tell: send? agent
                :receiver customer
                :content'(working on it)
                :conversation? conver)
        :do'(update-variable? con,? order? message))
```

The Coordination Mechanism of Vehicle Scheduling System. In this paper, the blackboard system includes two blackboards. One is for the calculation of vehicle scheduling solution by Vehicle Schedule Agent. Another one is for the management of vehicle yard. The information of the whole system are as follows:

The user will input the order information through the communication interface. The Order Agent will collect the order information and input it into the blackboard system.

After The Yard Agent, Warehouse Management Agent and road-net information Agent find the order information, it will input relevant vehicle information, cargoes information and road-net information into Blackboard 1. And, it also needs Blackboard 2's cooperation. Each vehicle's Agent will input this vehicle information into Blackboard 2. The Yard Agent will collect all vehicle's information for Blackboard 1.

After the Vehicle Schedule Agent read the information in blackboards, the internal encapsulate algorithms library will be activated. Then, scheduling solution will form in the blackboard.

After the Yard Agent read the vehicle scheduling solution, the scheduling solution will be in Blackboard 2. Then, it will select appropriate vehicles and complete all tasks.

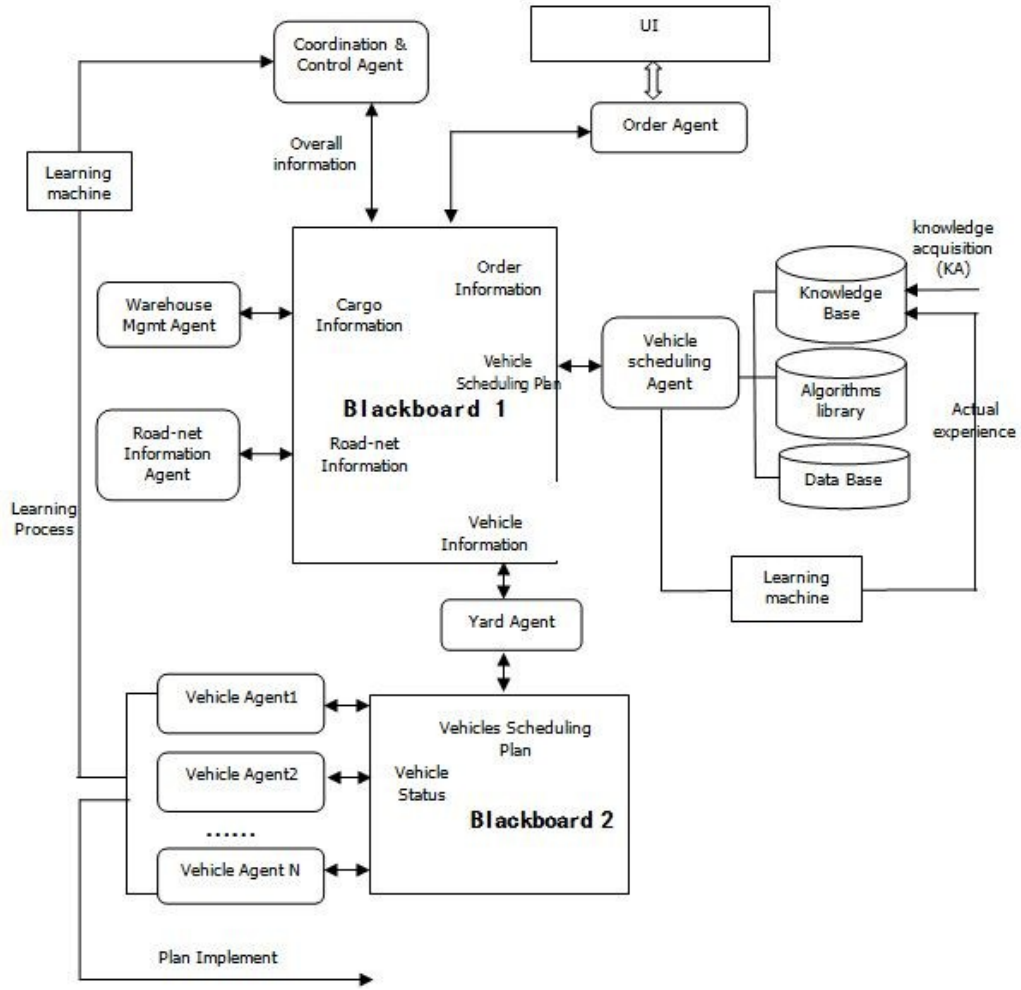

Fig. 5 Cooperation Mechanism among Multi-Agent.

In addition, as a control node, the Coordination & Control Agent can read all information during the whole schedule process in the blackboard system, such as order processing, warehouse information and road net information. If any emergent problems occurs, the Coordination & Control Agent input the coordination method into Blackboard 1. Then, other related Agent will find the information on Blackboard 1, and implement their tasks.

The system model will put the Agent of learning mechanism into consideration, namely group learning mechanism. After each scheduling solution forms, learning machine will analyse and integrate all information from those solutions, then selective amnesia and memory.

Conclusion

This paper designed an intelligent scheduling system model in basis of multi-Agent vehicles that make use of the agile, flexible, and the advantages of real-time, according to the current research results on the Agent technology. The paper also analysed the internal coordination process and communication mechanism to achieve the intelligent and rationalization on the vehicles scheduling. To meet the requirements of information and network of logistics distribution, it set the information ontology knowledge base of distribution enterprises through the instantiation of domain ontology information. And, the computer can understand the ontology, namely Intelligent Agent. In future study, logistics and distribution will have a further development on intelligent. And, the Agent technology will be more valuable for the study of distribution decision-making and vehicles intelligent scheduling, and has a widely application.

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