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Production Management Modelling of Ship Repair Process Based on MAS

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Abstract: The current situation of ship-repair enterprises was described in this paper. Aiming at the current production management and process of ship-repair enterprises, the modelling based on Multi-Agent System (MAS) was built. It can transmit the information instantly via Order Agent (OA), Manager Agent (MA), Production Agent (PA), Quotation Agent (QA) and Inspection Agent (IA) and realize information sharing. It can realize the integration of data stream, business flow and fund flow.

Key words: Ship repair, multi-agent system, modelling, integration of data

INTRODUCTION

The ship-repair enterprises belong to a special industry which concentrates management, production, technology and service. The process of ship-repair has highly complexity because of the constantly changed task and different ship type and the short repair period. In general, the ship-repair belongs to individual production and includes numerous projects. It is difficult to plan for ship-repair enterprises (Taiyi *et al*., 2003).

In recent 30 years, particularly the last 10 years, the ship maintenance industry in the China has been developed rapidly and the capability of ship maintenance also has been greatly increased. But there are still greatly difference between the developed countries and China (Chen and Ye, 2009).

In this paper, the Multi-Agent System (MAS) has been adopted. The production management modelling of ship-repair based on MAS has been built. It can realize the integration of data stream, business flow and fund flow.

MULTI-AGENT SYSTEM STRUCTURE

Agent is a new computing model in the artificial intelligence field and can continually perceive the change outside and itself and also can give a corresponding action by itself. Agent can be looked as a black box and can perceive the environment via sensors and act on the environment via effectors. A complex system maybe includes one or more interactional agent systems. This system is named Multi-Agent System (MAS). MAS denotes that one complex problem can be solved via cooperation, harmonization and negotiation of two or more agents together. MAS is considered as the key technique to lower production cost, realize decentralized production and self-adaptation and resolve complicated process. And it is also a new methodology, which runs through each modern advanced manufacturing field, from the dynamic alliance, distributed intelligent manufacture system, enterprises integration, Enterprise Resource Planning (ERP) to field control (Zhang *et al*., 2009).

MODELLING BASED ON MAS

Function and structure of each agent: The production management modeling of ship-repair included Order Agent (OA), Manager Agent (MA), Production Agent (PA), Quotation Agent (QA) and Inspection Agent (IA) and the Production Agent was built also based on MAS, which includes Task Agent (TA), Out-worker Agent (WA) and Resource Agent (RA). Each agent defines its own rule according to its own task and characteristic and then put it in rule database which was packaged in agents.

Manager agent (MA): MA, which is core of the whole system, is built to manage, harmonize and control the whole system. It can get the information from other agents and resolve the conflict among agents. MA must record the registration information, identity (ID), address and function of each agent. When add a new agent or delete an old one, MA will update the system in accordance with the information. In addition, MA can apperceive other agents at all times. MA has the ability of judgment, decision making and get the optimal compound mode. The structure of MA includes information management, shipowner management, order management, production management and feedback information.

Order agent (OA): OA receives the repair orders and saves the information to the system. The structure of OA

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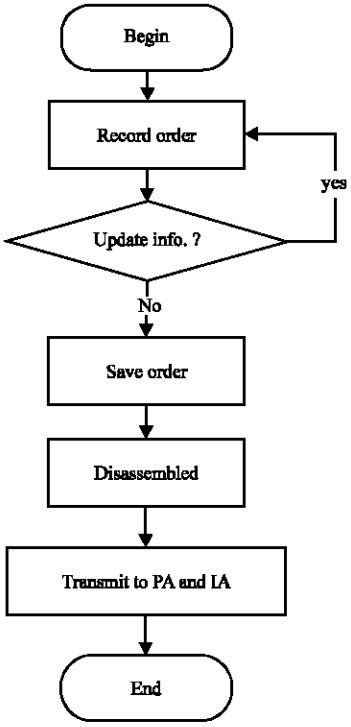

Fig. 1: Flow chart of OA

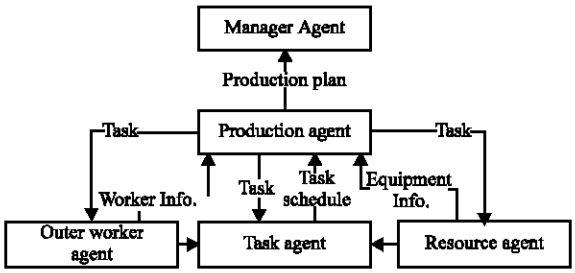

Fig. 2: The modelling of PA based on MAS

includes the order number, type, shipowner name, repairing item, contract amount, repairing period, etc. The flow chart of OA (Fig. 1).

Inspection agent (IA): The inspection of ship-repair includes three-level inspection, self-inspection, workshop-inspection and shipowner-inspection. IA creates inspection report and transmits the inspection report to MA after finishing the inspection. The report includes the information about order number, engineering name, quality requirement, index, results and remarks and so on.

Quotation agent (QA): When the shipowner or its representative sends the inquiry list to the sales department of the ship-repair enterprise, the sales department must form a quotation according to the repairing items of the inquiry list and send it to the shipowner as soon as possible. QA is responsible for forming the detailed quotation. The structure of QA includes quotation number, inquiry list number, inquiry list content, detailed price, total price, delivery date, requirement, index and remarks. When QA completes the quotation, it saves the quotation and transmits the quotation to MA.

Production agent (PA): PA can get the tasks and available resources according to the engineering order. PA disassembles the engineering task received by contract into work order and then transmits it to TA. At the same time, PA records the information to the task table. The system inquires the unoccupied equipments via RA and the assign the task to suitable equipment. The structure of PA includes information management, task management, resource management, outer worker management.

PA was built also based on MAS. Each agent also defines its own rule according to respective tasks and characteristics and keeps it in the rule database packaged in agents. PA implements general scheduling and harmonizes the conflict between RA, WA and TA (Fig. 2).

Resource agent (RA): It is built on client. After registration, RA begins to wait for inviting public bidding. When RA receives inviting public bidding document, it will evaluate the task according to production state and ability. Then computes a feasible bidding value and fills in the bidding document and sends it to PA (Fig. 3).

When RA receives the winning bidding message, the task will be scheduled on corresponding machine. After finished the task, RA will waiting for the next bidding. Also RA monitors and controls the machining process real time. If the normal state are changed, for example, there are something wrong with certain machine or add new machines, RA immediately reports it to PA and PA will reschedule. The dynamic scheduling is finished. The structure of RA includes equipment name, equipment information and equipment condition.

When the new equipment is purchased, the corresponding information will be added to RA. When the new task arrives, RA will pass the unoccupied resources information to TA and PA.

Task agent (TA): TA answers for executing the whole production plan. It creates automatically and will be vanished automatically after finished one task. It can finish the distribution and execution of the plan via

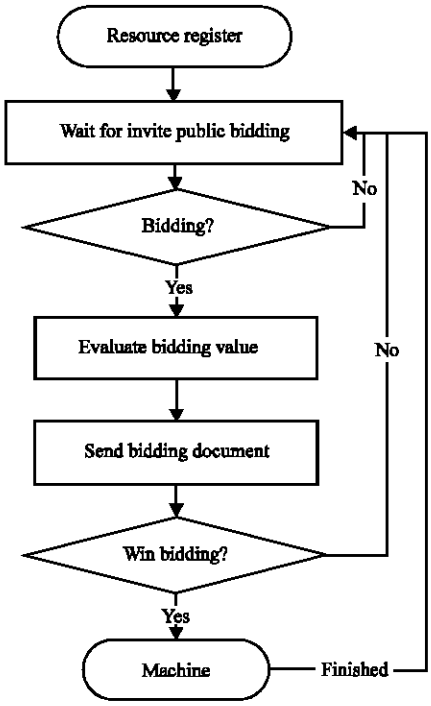

Fig. 3: Flow chart of RA

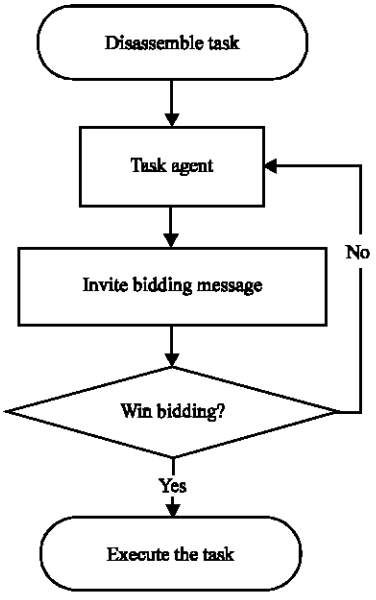

Fig. 4: Flow chart of TA

negotiation of each client and server. An incepting buffer and a sending buffer are packaged in each agent for communicating to other agents. The working flow is shown in Fig. 4. The structure of TA includes task information, contract content, and delivery date.

When the new task arrives, TA will receive the unoccupied equipments and outworkers information from RA and WA and scheduling these tasks and transmit the scheduling to PA.

Out-worker agent (WA): There is a characteristic in the labour force management in almost all the ship-repair enterprises. Most workers are out workers. That is to say, they belong to certain engineering brigade. When the repairing task are so much or so urgent or some other condition that the existing hired workers can not be competent for the repairing work, the production management department will hire extra engineering brigade. WA is responsible for managing the engineering brigades and its workers. Instantaneously record the engineering brigade and its workers' information, contact number telephone number, the starting and ending time, amount of work, working hours, reward, punishment, specialties and its equipments and so on. The structure of WA includes register, brigade name, brigade number, worker number, telephone number, material, index and remarks.

When the new task arrives, WA will pass the available workers information to TA and PA.

The modeling based on MAS: This modeling, based on multi-agent and the negotiation of Contract Net Protocol (CNP), adopts Client/Server structure for communication. It realizes communication via the communication port of the numerical control system. RA and equipments are connected by Controller Area Network (CAN) bus (Ren *et al*., 2009) and transmits data two ways between numerical control equipments.

The working flow is the following: After OA received the repairing orders from shipowners, it begins to estimate if the enterprise has the capability to meet the requirements. For the unserviceable task, sales department gives the shipowners practicable suggestions. For the competent task, OA receives it and changes it into engineering order and transmits the order to MA; MA issues information to PA and IA. IA will give the inspection flow and requirement. PA starts up and transmits the task to TA, RA and WA. In this paper, TA, RA and WA ensure the distribution of each task on each resource according to the inviting public bidding-bidding mechanism of CNP (Smith, 1980). TA receives the information of unoccupied equipments and available workers from RA and WA after RA and WA evaluates throughput itself according by the task from PA. PA determines the equipment winning the bidding by the biding information and sends the winning bidding information to TA and RA and thus the whole inviting public bidding-bidding process can be completed (Fig. 5).

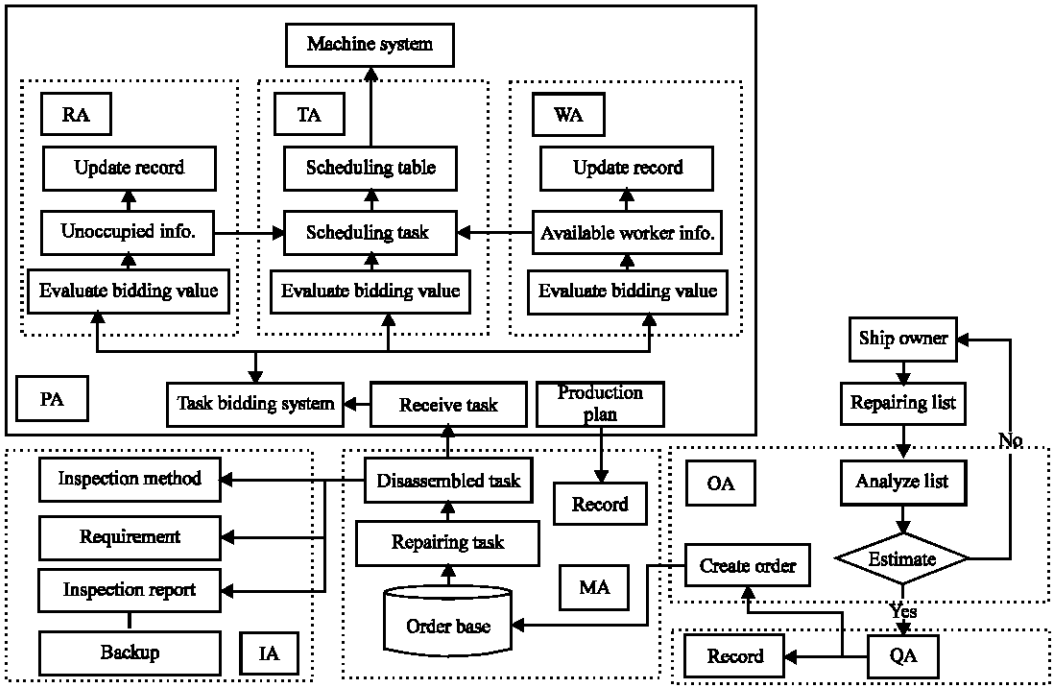

Fig. 5: The Modeling based on MAS

CONCLUSIONS

This new modeling realized the information transmits and shares instantly via MA, OA, PA, IA and QA. Each agent can work in parallel and communicate and collaborate with each other. So, shorten the time of delivery and improve the working flow and production efficiency. Each department shares the information and thus can reduce the misunderstanding. It has been found that it can improve the working flow and production efficiency and shorten the time of delivery.

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