Multi Agent System in Job Shop Scheduling using Contract Net Protocol

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ABSTRACT
In this paper, Job shop scheduling problem is solved through multi agent system. An agent based scheduling model is introduced to solve the job shop scheduling problem. Dynamic rescheduling problem is also an important issue in modern manufacturing system with the feature of combinatorial computation complexity. This model improve the job shop scheduling problem and provide the better flexibility to the production system. According to contract net protocol (CNP), agents co-operate with each other through contract net and the process of inviting public bidding makes for computing the production order and dynamic scheduling. The CNP offers negotiation mechanism and agents communication for the decision making in the manufacturing system. This paper proposed model for job shop scheduling as well as problem associated with has been discussed.

Keywords- Agents, MAS, Job shop scheduling, Agent based dynamic scheduling model, Contract net protocol.

1. INTRODUCTION
In traditional manufacturing system, there are various stage of production planning, design, system construction as well as better scheduling. In earlier there were many approaches and different technique been used to improve and enhance the efficiency of production system [1].The traditional scheduling process always deals with a clear schedule and a fix processing time, while for the actual processing problem, there are many uncertain factor, for example, changes in processing time, product demand, delivery, equipment failure, resources and production variations. The dynamic changes of these factors causes that the original dynamic scheduling cannot be implemented successfully. Therefore dynamic scheduling model and its solution method are of significance importance for dynamic scheduling problem [2].To schedule the job shop, a set of job is given to a set of machine. Each machine can process at most one job at a given time and each job has a specified processing order through machines. It is not only a NP-Hard problems, it also has a combinational problem in manufacturing systems.

2. JOB SHOP SCHEDULING PROBLEM
Job shop scheduling is regarded as a NP-hard problem and the actual problem and the characteristics of, dynamic, randomicity, multi-objective and so on [3][4]. The research methods about job shop scheduling include Optimization method, Simulation, Huristics methods, local search method and so on. In recent years, many optimization methods , for example , Artificial Neural network(ANNs), simulation Annealing Algorithm(SAA), Genetic Algorithm, Multi Agent system(MAS) have been brought forward and become a research hotspot because of their parallel processing, robustness, flexible and maintainability.

The job shop scheduling system needs to be achieved: (1) the production schedule has been ahead of schedule as far as impossible, rather than tardiness. (2)The average time of the job is short in the production flow. (3)The average load machine Tool has been wanted to keep balance [5]. (4)When there is an emergency, such as equipment failure or a new equipment and add an emergency mission to insert when as little as possible the impact on the ongoing work of flow and achieve production plan [6].

The job shop scheduling system must to satisfy the follower assumption: (1) getting the same batch of task s, the possible existence of any sub-task. (2) All the tasks have been possible for same processing time at zero time. (3) The same piece of equipment can achieve different types of sub task. (4) each of equipment can only be processed a task or a sub task at any time. (5) Starting processing after the mission should not interrupt in the agreed equipment, and other tasks should not start the early in the previous time to finish the task.

3. JOB SHOP SCHEDULING MODEL DESCRIPTION
Job shop scheduling management includes task management, static scheduling, dynamic scheduling and resource management. The task management takes over the contract information and distribute the task according machine process and resource: static scheduling can distribute tasks and resources during normal production process and try to improve equipments 'utilization ratio'. When something wrong happen during production process, it is dynamic scheduling that adjust production plan and rescheduling in time; resource management manages equipments and storage basics data and inspect equipments machining state real time.

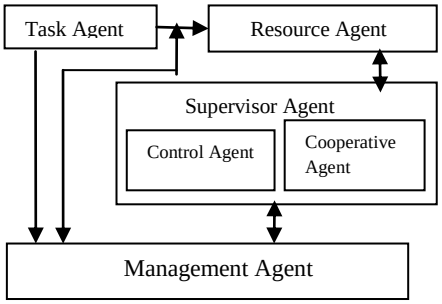

Fig: 1 job shop scheduling model

4. AGENT BASED DYNAMIC SCHEDULING
In an agent-based dynamic scheduling problem, agents are used to represent each resource and job. The job agent associated with a job will announce its requirements for the next operation to those resource agents that have the potential to perform that operation. The resource agents who receive the announcement

message will respond with a bid message to the job agent. All the bids submitted for the job's next operation will be evaluated by the job agent based on a set of heuristics.

Once bid evaluation is finished, one resource will be selected and awarded a contract for performing the operation. The above bidding procedure is the core of the contract-net protocol. Bidding schemes based on the contract-net protocol may differ in such aspects as the timing of message exchanges involving announcements and bid collection, information reported within the bid, and the rules used in bid evaluation.

4.1 Functional design of Agent

According to the requirement of achieving job-shop functions and the different shop resources, the multi-agent-based shop scheduling system should be as follows: Management Agent, Control Agent, Resource Agent, Task Agent, Co-operation Agent and so on. These agents correspond to the various personnel, organizations, equipments and other roles.

MA is the Heart of the scheduling system. It is responsible for evaluating and scheduling the task entered into the manufacturing system. The Task Agent must have the knowledge about the task as well as the task information. The task information contains the host information and the degree of emergency for the task execution. The Management Agent transfers the information to the Resource Agent for processing. The flowchart in Fig. 2 shows the Communication between MA and other Agents.

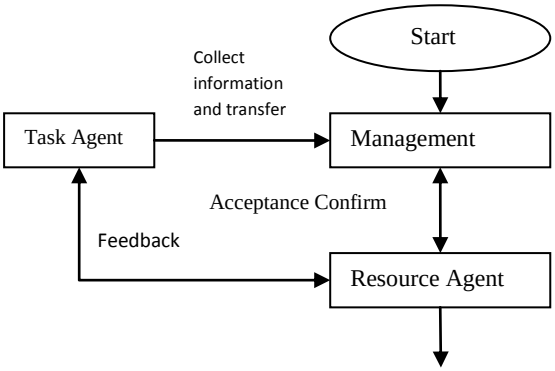

Fig: 2 Flowchart of Management Agent

Resource Agent (RA) constructs the production task to set on the manufacturing unit, entering into the manufacturing system. According to the task processing capacity of the production system Resource Agent determine the task to be performed or not. It generally depends upon the processing time of the task and the equipment availability. After the decomposition of tasks, the tender will be distributed to Equipment Agent (EA). A task processing planning is done by resource Agent and it sends to the supervisor Agent. RA also build the production plan for equipment Agent so that each equipment Agent will process at most one task on a machine. This can only be done before the feedback is received from the Supervisor Agent. The flowchart for Resource Agent is shown below in fig. 3

The major function of **Supervisor Agent** is to simulate the production plan. When the management Agent evaluation is done, the supervisor Agents work will start. It provides the processing route as well as it forward to the Management Agent. Supervisor Agent has significance importance in the production plan. The responsibility of Supervisor Agent is to supervise equipment failure, emergency order i.e. new task entering to the system or cancel order. The Fig. 4 shows the flowchart for Supervisor Agent.

Equipment Agent is a part of manufacturing system. Each task is processed by equipment Agents on the specified manufacturing unit i.e. machine. The major responsibility of the equipment Agent is to put the task on the machine which is scheduled by the resource Agent.

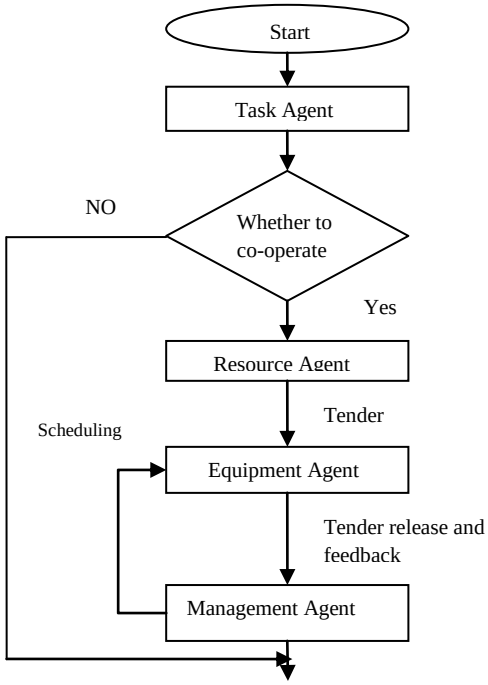

Fig: 3 Flowchart of Resource Agent

It sends command transmission for equipment unit as well as collection of processing information for tasks execution. When the Management ask for bid, the resource agent sends information to the equipment Agent for tender. After that equipment Agents self evaluate and gain knowledge about the equipment status i.e. each equipment Agent with the corresponding machine unit is ready for tender.

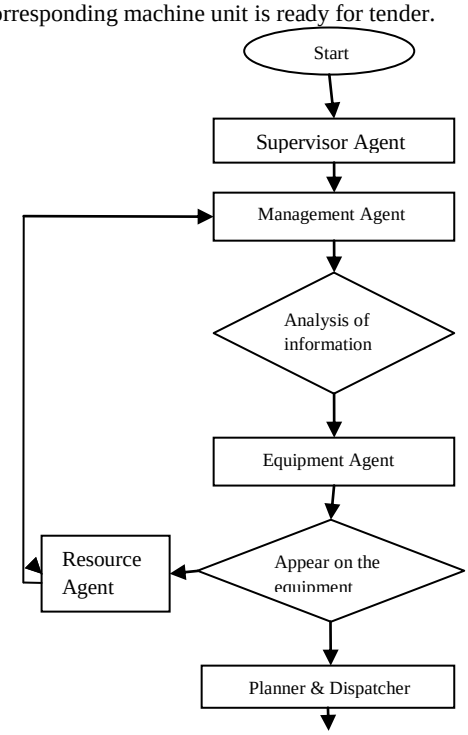

Fig: 4 Flowchart of supervisor Agent

If not means current status of the equipment is whether processing another task or capacity of system is less. Now Equipment Agent ready for tender, the bid value is decided by the equipment agent according to the operation of the tasks. it also send its capability to resource Agent. The Fig. 5 shows the structure of Equipment Agent.

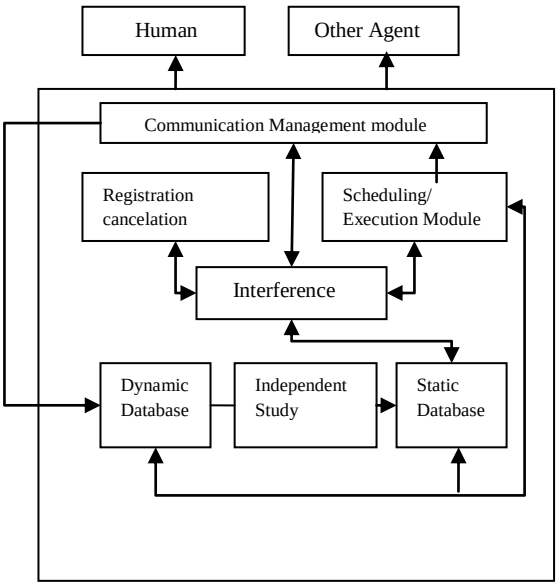

Fig: 5 Description of Equipment Agent

5. DYNAMIC SCHEDULING

Static scheduling denotes all work have been ready for manufacturing at the time of scheduling denotes all work have been ready for manufacturing at the time of scheduling and all the equipments are in normal working states. Also suppose the equipments running states have no change during scheduling and production process but the actual production process are very complex. Sometimes the scenario is different. There may be an interferential factor causes order change, for example emergency order or cancel order; or delivery date change or product quantity change. On the other hand there may be certain machine or equipment breakdown, shortage of raw material, machine timing change etc. These are the some uncertainties which will be scheduled by the Dynamic scheduling process.

Dynamic scheduling method that schedule the unfinished task on the broken down machine as a new task, but did not consider the state before breaking down[7], points that when one machine or equipment breaks down, the executive agents , which represents this machine or equipment, return the unfinished task and refresh the task states and then reschedule [8]. Based on the method above, we give a method which can link the rescheduling better. Via enquiring contract information, set down the machining task in the queue waiting for scheduling. This model includes manager agent MA, task agent, and resource agent (RA). Co-operative work of each agent finishes the task together. MA is the hard core of Multi Agent System and answers for the management of the whole job shop and executes dynamic rescheduling; TA is an important part an answers for redistributing task according to contract information.

5.1 Machine failure

Sometime static scheduling recognizes uncertainties in the production system i.e. machine break down. The monitoring and control system will responsible for identifying the uncertainties. This makes the resource agent send information to Management Agent about the machine failure. The management Agent stop the entire scheduling system immediately and the issue a notice of repairmen. Now the equipment agent sends the current processing status about the machine to resource Agent and it store the data in its file. RA will now checks for next availability of the machine, if its alternate is available then RA will dispatch the task to the equipment otherwise if no alternate is available then Management Agent will recall the task to bid and the reschedule is done. The flow chart is shown in fig. 6

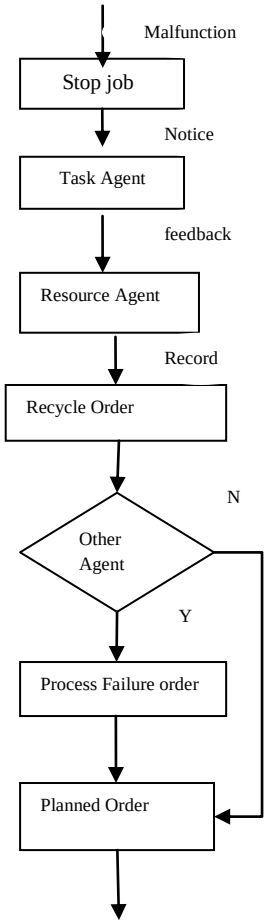

Fig: 6 Flow chart of dynamic scheduling of Machine breakdown

5.2 For emergency order

Now a day, product demand vary time to time due to the market has expanded their area. In manufacturing system new order arrive at any time. Sometime a new order arrive at a time when production system already processing the task. The major importance is to arrange the new order efficiently rather than to be discards. İn the agent clusters, RA informs MA with conventional methods of starting negotiation mechanism. İf the new order cannot be placed to the scheduling, Resource Agent will release production plan for the new order. A fixed deadline period is released by the Resource Agent to complete the task. The releasing process will continue, until emergency order to be rescheduled successfully. The flow chart is shown in fig. 7. Some exceptions are always there such as shortage of raw

materials, the task cannot be completed before its deadline. MA is to recall the corresponding tasks in order to bring the rear scheduling task in the production planning ahead. overcome from this problem, unfinished task is to be scheduled properly.

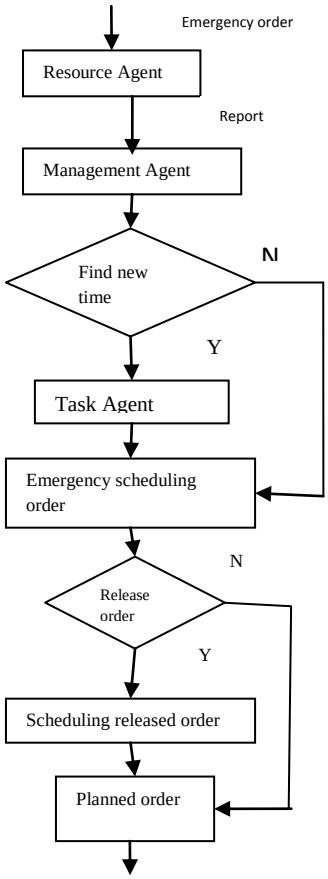

Fig: 7 Flowchart of Emergency order

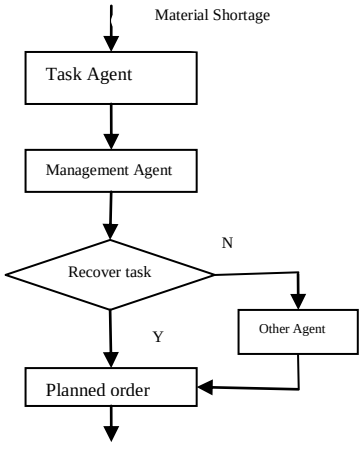

Fig: 8 Flowchart of material shortage

6. MULTI AGENT MODEL REALIZATION

6.1 Contract net protocol- Bidding Mechanism model

Contract-Net Protocol (Contract-Net Protocol, referred to as CNP) [9] is a classic cooperation strategy, put forward Randall Devis and Reid G Smith in the distributed computing for the task and resource allocation issues. It is widely used in multi-Agent System (Multi-Agent System, referred to as MAS) cooperation strategy design. It followed the mechanism of the market of inviting public bidding-bidding-winning mechanism. According to bidding value distributed tasks between agents. The dynamic distribution can be solved by the concerned agent negotiating and completing with each other. Its objective is trying to complete the task with the optimization approach of resources and cost. So, with the local optimization.

In this paper, TA and RA ensure the distribution of each task on each resource according to invite public bidding-bidding mechanism of CNP[10][11]. TA sends inviting public bidding file to RA; RA evaluates throughputs itself and then bids. MA determines the equipments winning the bidding by the bidding information to TA and RA and thus the whole inviting public bidding-bidding process can be completed. Job shop scheduling flow can be realized via sending Information.

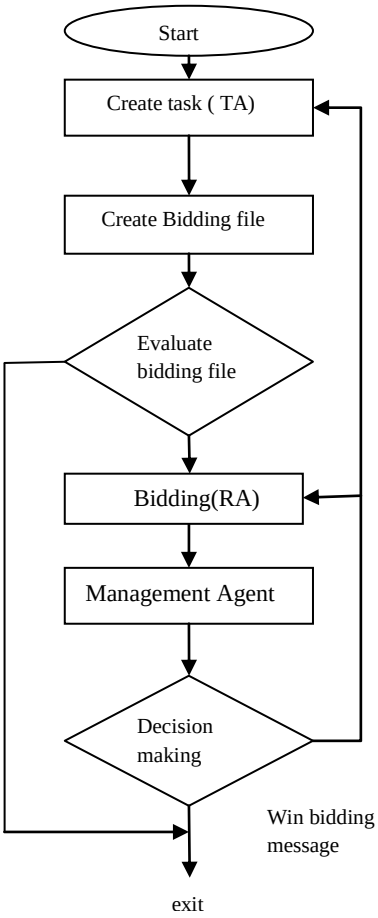

Fig: 9 Flowchart for Inviting Bidding

Agent model's realization

The information include; (a) agent style, for example Task Agent; (b) physical address of agent ; (c) content of information.

There are three ways to link between agents:

1) link by "to"

   After initializing an agent connects other agents using the address afforded b " to"

2) link by "from"

   After receiving the request, the agents inspects the connecting preview of the agent sending to the address afford by "from".

3) Link by "goto"

   Agent sends itself to the machine whose address afforded by "go to".

6.2 Agent model's realization

This model based on multi-agent negotiation of CNP adopts c/s structure for communication and realizes communication via the communication port of the numerical control system. Ra and equipments are connected by controller Area Network (CAN) bus and transmits data two ways between numerical control equipments.

1) Management Agent- manages harmonize and control the whole system and its built on server side. Each RA and TA register with registration from afforded during initialization. MA can get the information about the task and the available resources according to the registration. Information about the task and the available resources according to the registration from (Table 1).

Table 1. Table of Registration

Machine Id	Machine Type	Registration Time	Note
1201001	1	08-10-20	
1201002	1	08-10-20	
1201003	2	08-12-01	
1201004	2	08-12-01	

Decompose the task received by contract information to from task information for TA and MA memories it to the task table (Table 2).

Table 2. Table of Plan

Plan id	Plan Name	Due-date	Note
1010001	A	15-3-14	

MA collects bidding value of each RA and form bidding table. Then, confirms the winning RA according to the bidding value and afford the machining contract made by contract table and the winning RA. The RA will be droved to machine work piece (table 3&4).

Table 3. Table of Bidding

Machine-Id	Bid-Number	Bid-Value
1201001	1	1233
1201002	1	1288
1201003	1	1322
1201004	1	1444

Table 4. Table of Pact

Plan-Id	Machine-Id	Bid-number	Bid-Value
1010001	1201001	1	1233

2) Resource agent- It is built on client side. When the successful registration is done Resource Agent starts to wait for inviting public bidding. Now RA will receive a bidding file which will evaluate the task according to the production state and ability of the system. It then evaluates a feasible bidding value and fills in the bidding document and sends it to Management Agent shown in Fig 8.

When RA receives the winning bidding message, the task will be schedules on corresponding machine. After successful completion of the task, the resource agent will wait for the new task for new bidding, entering to the manufacturing system. The monitoring and control agent will maintain the entire system and machining process real time with resource Agent. If any changes occur during the static behaviour of the production system i.e. Failure of equipment or adding new machine, the resource Agent will directly report to management Agent about the uncertainties. Now Management will recognize about the entire system disorder and it will start dynamically reschedule the production system.

7. CONCLUSION

The job shop scheduling based on multi agent system provides better way of scheduling. In this paper, the contract net protocol based on Multi Agent System is introduced to reschedule the manufacturing system. The agents based methodology affords a scheduling mechanism for dynamic and rapid response to market production. It provides a new way of solving equipments failure or machine beak-down, emergency order, shortage of raw material and the repairment in the process of production system.

Because of large resources and dispersive objective of job shop, job shop scheduling in a multi dimensional, non –convex function, discrete and non-linear optimization decision-making problem. There are different combination modes in different stages.

The job shop scheduling problem based on Agent system emphasizes developing the system's flexibility and timing feedback. Since considering the problem in scheduling machine in job shop and the problem faced in it is machine failure. To overcome this problem this has proposed a model for Job Shop Scheduling problem.

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