Flowshop Scheduling Using Multiagents with Adaptive Auction

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Abstract:
In The Face Of Globalization And Rapidly Decreasing Of Product Lifecycle, Manufacturing Companies Trying To Improve The Machine Utilization And Product Life Cycle. Flowshop Scheduling Is Major Task For Manufacturing Companies In Terms Of Improving Machine Utilization And Scheduling Of Jobs. Here Agents Are Responsible To Solve Flowshop Scheduling Problem. The Differential Evolution Algorithms Are Employed To Obtain Solutions For Solving Flowshop Scheduling Problem. This Paper Describes Novel Approaches That Use The Price Utilization, Adaptive Auction Mechanism To Solve The Flowshop Scheduling Problem.

Keywords: Flowshop Scheduling, Auctions, Resource Allocation, Bidding, Adaptive Auction, Combinatorial Auction.

1. Introduction

Flow shop scheduling problems can be raised in scheduling Production Management System (PMS) in manufacturing industries systems. To take advantage of the production management system it is necessary togive full attention to the scheduling of such systems. This leads to problems in PMS resource allocation, planning and scheduling. Despite success of PMS in manufacturing industries a number of inefficiencies occur when PMS is used in allocating resources. The main problem is complementarities among resources, i.e when multiple independently allocated in order to complete the single task, an agent will complete with only part of the required resources, and efficiency. This issue is directly stated in a combinatorial auction mechanism. The scheduling problem and resource allocation in this paper originates from a PMS scheduling problem where between multiple agents of operations of a job on the same resource reallocating. Where agents seek to optimize goals by contending for resources from a common pool. When a job has finished processing on this machine it has to be processed in the second machine. For example consider the following problem scenario stated in [2]:

1. There are central pool of resources is available and that comprises multiple identical units of different machine types.
2. There are multiple automated software agents, each having a job list and is responsible to service jobs in its list by solving its respective scheduling problem. In this paper agent is used to solve generalized flow shop problem.

The above problem scenario occurs in variety of applications, like loading and unloading of containers operations and manufacturing. There different types of problems are raised for multiple decision makers contendingfor resources for a common pool and these agents are self interested. Bidding is done for utilize certain combination for machine resources from the pool over certain time periods. In multiple rounds combinatorial auction mechanism that is built on the general equilibrium solution [8] and prices of the machine resources over different periods will iterate over multiple rounds of the bidding process until price equilibrium is achieved.

2. Flowshop Scheduling

Scheduling can be termed as, “The allocation of resources over a period oftime to perform a collection of tasks”. Also, another form ofscheduling is stated as, “It is a function to determine an actual (optimal or feasible) implementation plan as to the time schedule for all jobs to be executed; that is, when, with what machine, and who does what operation”. For example flight scheduling, train scheduling are examples of the scheduling applications. According to the nature of scheduling can be divided into project scheduling and operations scheduling.

2.1 Project Scheduling:

In this scheduling all the activities of the scheduling are carried out in project. A project may be a construction of a building, manufacturing of a computer or maintenance and repair of a factory or a plant etc. Software based approaches are available to tackle this type of scheduling. They are like Graphical Evaluation and Review Technique (GERT), Critical Path Method (CPM) . . . etc.

2.2 Operations Scheduling:

Operations Scheduling can be stated as, "The processing of a set of jobs, in a given amount of time, on already allocated corresponding machines, in a workshop consisting of a several machines including operative workers".Jain [1998] classified available operation scheduling as Job Sequencing, Flow shop scheduling, mixed flow shop scheduling, Job shop scheduling and Open shop scheduling. In Job Sequencing model defines that the sequence or order of the set of tasks to be processed on one machine. The sequence path is selected based on their maximization or minimization of objective functions. Flowshop Scheduling processing of sequence would be same for all jobs or tasks. Flowshop scheduling is used to find out job sequence in machines according to the multiple stages. Flowshop is a shop in which machines are arranged in a sequence Jobs begin processing on initial machine, process through several intermediary machines, and reaches the final machine to complete the scheduling. This flowshop scheduling is shown in Fig. 1. In Flowshop, every job must visit machine exactly once to complete the task and all jobs follow same route for visiting the machine.

In Job shop scheduling every job has its separate processing sequence. Scheduling of jobs complicated compared to flowshop scheduling.

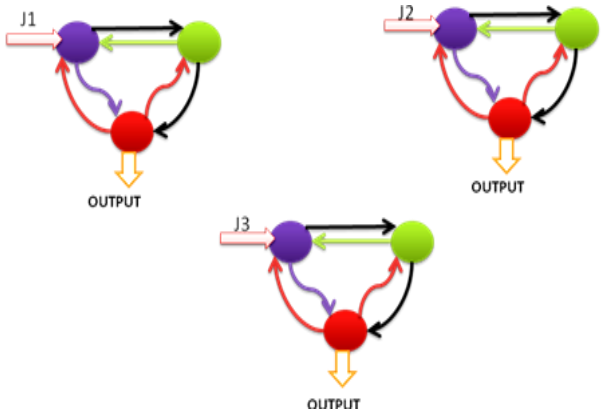

Fig 1. Flowshop Scheduling

A mixed shop scheduling is basically combination of both flowshop and job shop scheduling. In this case some jobs have fixed machine sequence like flowshop and other processed in an arbitrary like job shop [4]. A number of decision rules can be used for job sequence in the machines; they are FCFS, EDD, SPT, CR, and MP...etc.

3. Agent Based Scheduling

Multiagent System is stated as [1], "An agent is computer system which is situated in some environment, and that is capable to perform autonomous action in their environment in order to meet its design objectives". Agents are responsible to solve flowshop scheduling problem in resource allocation and able to perform fast bidding for timeslots to schedule the jobs with specified time. Different types of agents are in this paper, Job Agents and Resource Agent. Job Agent seeks the resources for scheduling the jobs, solving the flowshop problem and able to generate bidding price quickly and participating the auction. Resource Agent is used to conduct auction between Job Agents based on the available resource on that time slot and able to solve conflicts between the Job Agents. In this paper agents are used to solve the flowshop problem and schedule all jobs with less makespan time with maximum utilization of machine resources. Different types of auction mechanisms are described in further sections.

4. Auction Mechanism

The bidding procedure is done in two ways. First, negotiation and auction, these methods are used to solve the conflicts between the bidders and auctioneers. Auction Mechanism is used to solve the conflicts between bidders and auctioneers. Negotiation [1] is the interaction between the multiple agents, used to resolve conflicts. It is useful for making possible proposals those agents to resolve conflicts. Agent negotiation is only applicable for only limited number of agents to solve the conflicts. But auction is used to solve this problem between the agents. An auction [6] is a mechanism to allocate resources to set of bidders on basics of bids.In a traditionalauction, the auctioneer wants to allocate a resource to a single bidder from among a group of bidders. There are four differenttypes of auctions are available:English auction, Dutch auction, First price sealedbid auction, and Vickrey auction. An English auction is an iterative auctionwhere the bidders submit their bids

monotonically increasing order of bids. Thisprocess continues until a price is reached where a single bidder who is willing to buy. The item or resource isallocated to that bidder at the final bid price. The Dutch auction is exactly same as English Auction but it reverse of the price, i.e., bids price is monotonically decreased by auctioneer until there is a bidder who willing to buy that item at currently announced price.In both auctions one important note that can observed as they are iterativein nature and price signals are continuously being fed backto the bidders. In this paper Adaptive Auction mechanism and Combinatorial Auction are used for allocating resources to the bidders. Adaptive Auction Mechanism [6] is ananalytical process. This Adaptive Auction Mechanism is useful for online auction because auctioneer's doesn't know behavior of the bidders. This adaptive auction mechanism is used to maximize a given objective function based on observed outcomes. Over view of this approach is given in [6]. A parameterized mechanism shows that one or more auctions are conducted by a population of various bidders, potentially unknown bidding strategies. Result is input to the evaluator module; it revises the mechanism parameters and maximizes the seller's revenue. Any number of auction parameters is considered such as reserve prices, auctioneer fee…etc. The selection of mechanism is the key active element here. This mechanism doesn't depend on repeated interactions with the repeated bidders. It assumes that bidder's behavior remains constant. It helps to predict auction result as a function of the mechanism. This mechanism is commonly used in sequential auctions, auction design choice…etc. Combinatorial Auction Mechanism [7], is a kind of super market, where bidders can place all bids on combinations of items, rather than individual items. In this mechanism all the items should be traded at once, unlike the single-good auction. This mechanism helps to select the particular resources for the particular period and allocating the resources to particular Scheduling agent.

The price is calculated based on the resource utilization by using general equilibrium solution [8] and also calculating revenue for the auctioneer.

5. Bidirectional FLOWSHOP

This section givesa brief introduction about how multiple agents handle number of jobs. This Bi-Directional Flowshop Scheduling under Critical Operation Sequence helps in handling the jobs with specific settings [2]. The objective of function is to minimize sum of the weighted tardiness and penalty and makespan cost. Based on the definition ofBidirectionalFSP with multiple renewablemachines and COS constraints [11], the resource allocation problem is to allocate the multiple renewable machines to contendingjob agents, while schedulingis to generate a schedulefor each job agent with the allocated resources. Given the jobrelease time, due time, and tardiness penalty, theobjective is to minimize the weighted sum of makespan cost andtardiness penalty. The system overview is shownin Fig. 2.

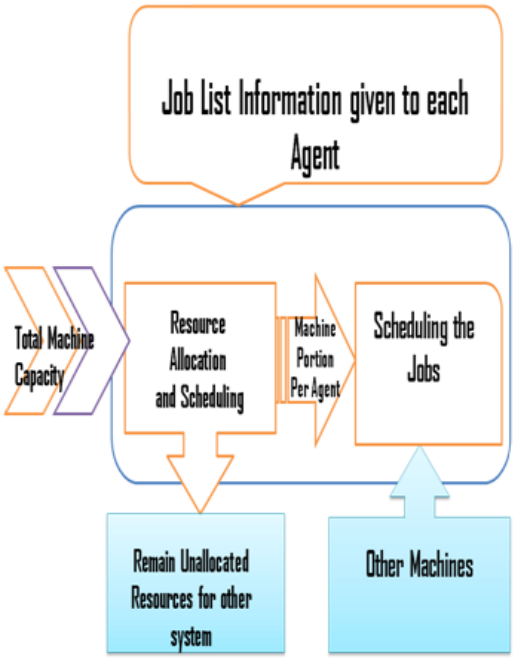

Fig. 2.Resource allocation and scheduling for multiple agents

In BiFSP resource allocation and scheduling is preplanned, but allocating the resources to agents is difficult and does not consider the dynamics such as system failure, breakage. This method is concentrated only on centralized allocation and prescheduling. This problem can be explained in container terminal for loading and unloading the goods from yard to land. With the help of decision parameters calculating the resource utilization and cost estimation for that resource. These calculations are given below.

- Partitioning the total time into time horizon {1, 2, 3,..Tot} into F frames,{T_f:1<f<F}, all agents will be in same time partition.
- $P_{i,j}^{l}$,lϵ{1,2,….N},iϵ{1,2,…M},jϵ{1,2,…..o_i}:processing time of operation j in job i in job l.
- D^l is due time for job l.
- W_d^l delay penalty of job l.
- W_m^l makespan price for job l.

Machine capacity and Constructive Heuristics Methods and Repair Heuristic Methods used for scheduling the jobs on machines. Continuous-Time-Domain use for resource allocation for different agents may have different timeslots.

Calculating machine capacity as follows

Machine Capacity

$$MC_{k(t)} = \sum_{m_{ij}=k} w_{ij} \quad (1)$$

$$W_{ij}(t) = \begin{cases} 0, & if\ t \le Time_i^j \\ 1, & if\ t < Time_{ij}^s \le Tin \\ 0, & if\ t > Time_i^j \end{cases} \quad (2)$$

Resource utilization is obtained and calculating the prices for those utilized resources by using Price Adjustment Methods [8, 9]. Notations are stated in Table 1.

TABLE I. LIST OF NOTATIONS

Symbol	Description
N	Total number of Agents
Tot	Total Number of periods
F	Total Time Frames
o_i^l	Total number of operations for job i in job list l
D^l	Due time of job list l
W_d^l	Delay penalty of job l
W_m^l	Makespan price for job l
$Time_{ij}^s$	Start Time of operation j in job i
$Time_{ij}^e$	End Time of operation j in job i

6. Resource Allocation And Scheduling

Although the adaptive auction mechanism can improve the speed of the bidding for obtaining feasible solutions through reallocation resources that has not been fully utilized after the auction process is completed. For each non-fully utilized resource, allocate the spare unites to the agent l. After each reallocation, agent will reconstruct its schedule and recalculate its objective value (Makespan Tardiness Cost for agent$l$), but allocation and scheduling, where information and decisions are decentralized [7]. Combinatorial Auction Mechanism that allows agents to participate in bid for the resources needed in a multi-period. This Mechanism is used to show how agents can decide optimal bidding strategies to respond to price adjustment strategies from the auctioneer.
The price adjustment process was based on tatonnement process which was originally proposed by Walras [9] and enhanced by many other studies like Wellman [8].This process resolves resource conflicts by updating the price based on excess demands iteratively. Several price adjustment process methods are available for calculating price for the particular period. Although the adaptive auction scheme can improve the speed of convergence and achieve feasibility, it often resultsas a local optimal solution. It is possible to obtain better

solutions through reallocation of resources that has not been completely utilized after the auction process is completed.

7. Conclusion

In this paper, an adaptive auction mechanism and combinatorial auction mechanisms are discussed, solving the conflicts between the agents for resource allocation. Although discussion is centered on the flowshop scheduling problem, these auction mechanism are used for generates the bid in each agent, based on the requirements of the resources on particular timeslot resources are allocated with minimum makespan time and these algorithms are readily replaces by another algorithms with modifications for increasing the system performance and reducing the total makespan time of jobs in future enhancement work.

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