Real Time Scheduling Model for Distributed Production Centers

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***Abstract:** Production centers are viewed as single resources to perform multiple activities resulting in manufacturing of some quality and quantitative resources. Scheduling at these units involves assigning factories to supply specific quantities of resources at particular times. It deals with operations mainly Sourcing, Acquisition, Storage of raw materials, Scheduling and management of work-in process, warehousing and distribution of finished products. Adequate Inventory allocation becomes one of the main role in manufacturing centers distributed across various locations. Company use various Inventory management, production planning software products for managing activities. In this paper a Real time Scheduling Model For Distributed Production Centers is proposed based on the various parameters which affect efficient functioning of production units.This model uses agent based mediated approach to co ordination of distributed autonomous agents responsible for performing different activities at various production unit situated across different geographic locations.*

***Keywords:** Production Planning, Inventory management, Distributed scheduling, software multi agents, coordination, interaction, supply chain,*

1 Introduction

Multiple participants operate in the supply chain of a manufacturing enterprise. Events are of dynamic in nature and unexpected situations occur in a multi agent environment and can have significant impact on the ability of participants to meet commitments made to other participants. If the cluster and propagation of commitments are plotted as a constraint graph, an unexpected situation can prevent meeting of a commitment, resulting in an in-feasible constraint graph. Thus feasibility can be reestablished by applying a mediating agent having co ordination information, to attempt reconfigure the commitment graph optimally. This model is applicable to a wide range of multi agent domains where quick response is needed to unexpected events. An example of such a domain is that of supply chain management.

Supply Chain Management

The supply chain is a worldwide network of suppliers, factories, warehouses, distribution centers, and retailers through which raw materials are acquired, transformed, and finished products are delivered to customers. Supply-chain management is the strategic, tactical, and operational decision making that optimizes supply-chain performance. Enterprise resource planning (ERP) software and systems are mainly operational level transactional IT systems wherein information pertaining to acquisition, processing, and communication of information regarding the past and present activities are maintained. Whereas todays business scenarios are dynamic in nature wherein analytical information is of prime importance. Transactional IT systems fail to cater to the needs of analytical information. Systems capable of responding quickly to changes in environment play a vital role in success and survival strategy of organisations. Organisations has to monitor on going processes within and outside. Any occurrence of unexpected external or internal events needs to be addressed by quickly remodeling the strategies so that advantages can be taken if environment presents an opportunity. At the same time cost incurred needs to be kept in check.

In a production enterprise, the entire supply chain is subject to unexpected events for which immediate action plans are key to sustainability. The supply chain starts from the customer order taken by the sales division through planning, production, distribution, field service. Factors effecting Supply chain are many and varied: Materials do not arrive in time, change in the customer order, production facilities fail, unavailability of a particular resource, workers are ill, price change in a resource, late delivery of a resource, breakdown of a machine, an urgent order from a good customer, customer change or cancel orders, and so on. Handling these events requires close coordination and cooperation among sales, marketing, accounting, material planning, production planning, production control,and transportation.

When sales department negotiates a new order or there is a change in existing order, they contact production department. Production department has various options to check for before committing to the order. For example

1) Can the new/modified order be produced internally or subcontracted externally. Will the customer agree to it. What marketing dept and strategies department has to say in this. Will there be a reduced profit in it. Can loss be affordable in this order or any other or-

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der.

2) Can this be scheduled immediately or later on. If needs to be scheduled immediately, will it effect another schedule.
3) Do extra shifts needed to meet the schedules. Are staff ready for it.
4) Are raw material in stock or made available in time. Do suppliers needs to be searched and contacted.
5) How many layers of production, packaging, storage, transportation is involved. Is warehouse available for storage and transportation.
6) What is the shelf life of product and do pricing vary with time and units of production.

Its difficult for the production unit to take any decision on its own. It needs to communicate with no of other divisions of orgasnisation as well as outside bodies to choose the optimal solution.

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2 RELATED WORK

Lesser V R and Durfee [2],[3],[4],[5] proposed negotiation between agents to co ordinate among themselves. Co ordination is performed via a completely distributed algorithm. Distributed algorithms need not be necessarily the best choice.

Sathi A [6] shows that in some cases a mediated solution can be significantly better than a negotiated solution.

J.Christopher Beck [1] This paper presents three algorithm for constraint relaxation. Multi agent communication systems architecture have evolved over a period of time. Further change in architecture and technology will enable faster and easier data access as well as localization of data and operations.

Kumar V [7] Talks about importance of simulation and modeling for modern supply chain management systems especially for information analysis. There is no need to merge transaction systems with analytical systems. Simulation and modeling works wonderful with Traditional TPS systems. Simulating the same data in analytical processing may consume more resource.

Y. Srinivasa Rao and Mukul Chandorkar[10] emphasizes on trackability and traceability for supply chain systems. Traceability is one of the most important and challenging issues in SCM given decentralized nature of data as well as ownership and maintenance of data.

[9] Explores Multi agent communication systems for Supply chain management. Cool language for designing multi agent technology may not be preferred and modern technologies are better and faster.

3 PROPOSED SYSTEM

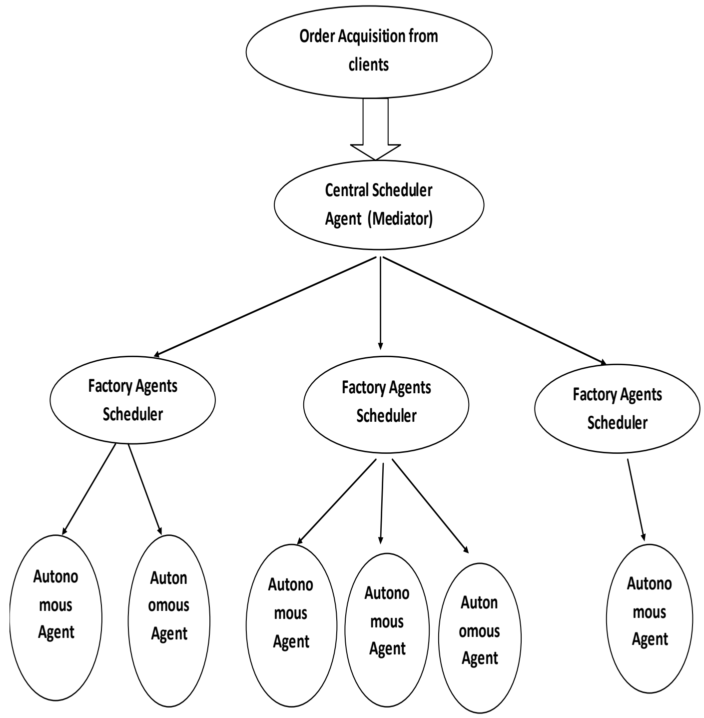

Fig 1- Flow graph from order acquisition to distribution of activities to Agents.

An entire supply chain is divided into highly structured activities. Each factory is viewed as single unit consisting of multiple agents.[Fig 1]. Each agent is autonomous and can be assigned multiple activities. They work towards fulfilling the global goal of supply chain. Each activity has no of parameters like start time, duration, quantity and quality of product. However agents at different factories will produce different quality and incur cost for the same activity. Activities are scheduled to meet all the commitments needed to fulfill an order. As activities are inter dependent and time bound they pose various challenges to meet commitment. The inter dependency among activities within a single order and different orders produce constraint graph.

When an activity is assigned to an agent, it is ensured that all constraints like completion time, quality, completion of previous activity, availability of resources are met. However with the occurrence of an unexpected event an autonomous agent may not be able to meet the constraint. For example if a factory performing an activity A1 breaks down and another activity A2 depends on the output of A1. A2 will no longer be able to meet its commitments. Its necessary to evaluate alternatives and choose one with least negative global impact.

A constraint relaxation algorithm takes an infeasible constraint graph and tries to optimise to find solutions with minimum cost to produce a feasible graph.

Each agent is software agent responsible for co ordinating with other agents.

3.1 Order acquisition from client: In this phase orders are taken from client from various locations. Negotiating with customers about price, due date, change of order, cancelling their orders. Logistic agent is responsible for co ordinating between plants, suppliers, and distribution centers. It co ordinates with logistics agent in case of change of order. The orders are passed to the central scheduler to further subdivided into various tasks.

3.2 Central scheduler Agent (Mediator): Central mediator agent is the main controlling authority of production scheduling. After receiving the order, mediator agent divides it into various sub activities. Each sub activity can be scheduled separately. Few of them are interdependent on each other. They can be scheduled at few of the available factories. However their quality and cost of manufacturing will differ from factory to factory. So mediator has to take into consideration quality and cost issues while scheduling activities. Mediator has all co ordination knowledge.

During activity scheduling, start time and finish time will have on the overall impact on the scheduling cost. Dynamically calculated estimates have been shown to be superior to static ones.

Estimates will be calculated many times during scheduling, so we require the calculation to be efficient using the number of local conflicts as an estimate for the global conflicts created by an assignment.

The ability to efficiently, accurately estimate the cost of scheduling decisions is a key to finding good schedules. Further, the ability to dynamically select the sub graph over which cost gathering will be done, independent of constraint type will improve the accuracy and efficiency of estimates

3.3 Factory Agent Scheduler : It is responsible for maintaining information about autonomous agents. Information about autonomous agents are passed to mediator on a real time basis. It passes scheduling information to autonomous agents. It acts like mediator responsible for passing information between mediator and autonomous agents. Failure of this agent becomes a bottleneck for efficient functioning of system

3.4 Autonomous Agents: Autonomous agents are responsible for producing activities assigned to them. They don't have any information about other agents present in system hierarchy. They don't possess any co ordination knowledge.

4 ESTIMATION ALGORITHM FOR CONSTRAINT RELAXASATION

Scheduling activities are modeled using variables and constraints. Constraints represent precedence relationships and the resource requirements of activities. Constraints are further categorised into hard constraints and soft constraints. Hard constraints are those which can not be compromised at the time of scheduling. Example A particular activity cannot be manufactured at all factories. Precedence relationship needs to be maintained during scheduling and rescheduling. Soft constraints are those which can be compromised at the time of scheduling, example cost of manufacturing.

Each activity consists of three variables, start time, end time, execution time.

All resources are of unit capacity. No resource is used by more than one activity at any time point.

Many scheduling problems are over constrained due to the unavailability of resources (e.g. due dates, release dates, and precedence constraints).

Constraint relaxation is assignment of values to variables and the relaxation of some constraints so that all constraints are satisfied and the cost is as small as possible [Fig 2]. Constraint relaxation changes the problem definition, so a solution to a problem with some relaxed constraints is different from a solution to the original problem

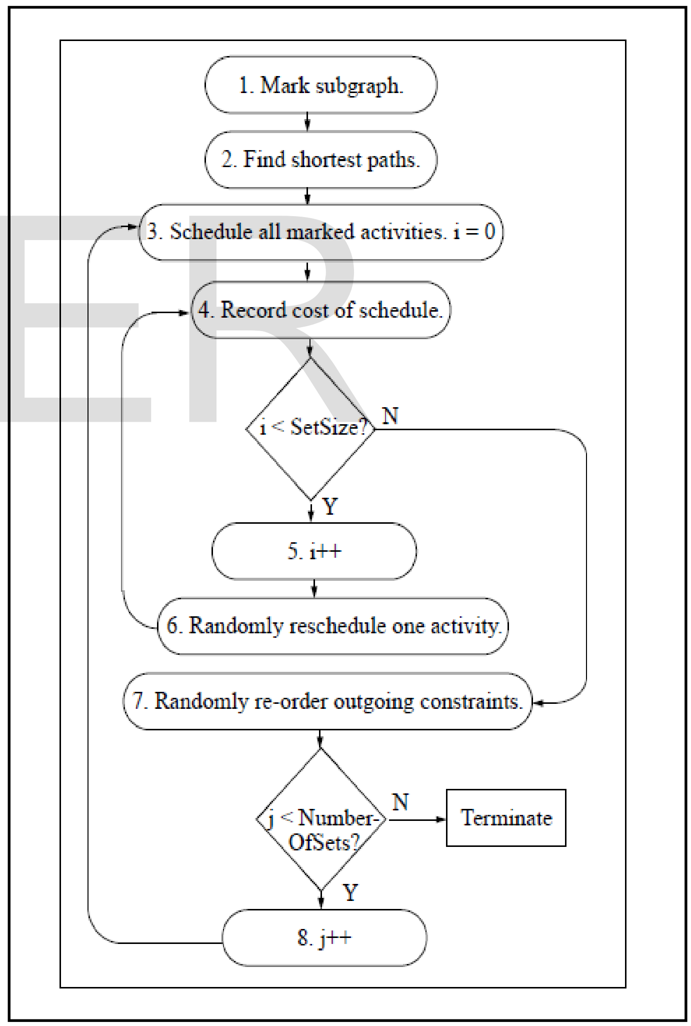

Fig 2- Flow graph for constraint relaxasation estimation

5 EXPERIMENTAL RESULTS

In this section, Experimental results of the proposed system are shown. Initially there are five factories as shown in Table 1. There are five orders with their due date as shown in Table 2.
Orders are sub divided into activities with their production time requirement as shown in Table 3. Each activity is mapped to factories with their quality outcomes and cost of production as shown in Table 4. Scheduling of Activity A11 ……A52 is shown in Table. Activities are to be scheduled from 30-SEP-2014 in each factory.

Table 1 – List of Factory

Name of Factory
F1
F2
F3
F4
F5

Table 2 – List of Order details

Order No	Due Date
O1	5 NOV 14
O2	30 OCT 14
O3	3 NOV 15
O4	16 OCT 15
O5	25 FEB 15

Table 3 – List of Orders divided into activities

Order Id	Activity Id	Duration
O1	A11	5
O1	A12	25
O1	A13	11
O2	A21	10
O2	A22	19
O2	A23	20
O3	A31	8
O3	A32	6
O3	A33	12
O3	A34	17
..		
..		
O5	A51	5
O5	A52	8

Table 4– Activity to factory mapping with their quality and cost parameter.

Activity Id	Factory Name	Quality	Cost
A11	F1	100	6000
A11	F3	60	6000
A11	F4	40	8000
A11	F5	100	6600
A12	F3	100	8000
A12	F4	40	8000
A13	F1	100	6000
A13	F3	60	5000
A21	F1	86	5900
A21	F2	100	9000
A21	F5	90	7500
A22	F4	100	5000
A22	F5	100	6000
A23	F3	100	6060
A23	F4	60	7000
A31	F2	90	4000
A31	F3	100	4600
A31	F5	89	5600
A32	F1	100	5000
A32	F5	90	6000
A33	F2	100	4600
A33	F4	90	8000
A33	F5	100	7900
A34	F2	100	7800
A34	F3	100	4600
A34	F4	89	6900
..			
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A51	F3	100	3000
A51	F5	90	4000
A52	F2	100	7400
A52	F3	95	8000
A52	F5	100	9000

Table 5 - Actual activity schedule in factories

Activity Id	Factory Name	Schedule From	Schedule To	Duration	Quality	Cost
A11	F1	30-SEP-14	4-OCT-14	5	100	6000
A12	F3	30-SEP-14	24-SEP-14	25	100	8000
A13	F1	04-OCT-14	14-OCT-14	11	100	5000
A21	F2	30-SEP-14	9-OCT-14	10	100	9000
A22	F4	30-SEP-14	18-OCT-14	19	100	6000
A23	F3	24-SEP-14	13-OCT-14	20	100	6060
A31	…					
A32	…					
A51	F3	24-DEC-14	28-JAN-14	5	100	7400
A52	F5	30-DEC-14	1-JAN-15	8	100	9000

Case I - .Scheduling of Order O1

O1 order consists of activities A11, A12, A13.

Mediator agent refers to the table 4 to gather information for possible allocation of factory to each of the order activities. To allocate activity A11 to a factory agent, there are four possible options of F1, F3, F4, F5. Both F1 and F5 will give 100 percent quality. Since cost of production for F1 is less compared to F5, F1 will be preferred to get optimal result. F1 is assigned to perform activity A11 from 30-SEP-14 to 4-OCT-14. Similarly Activity A12 and A13 will be scheduled in factories F3 and F1 respectively.

Case II - .Scheduling of Order O3

O3 order consists of activities A31, A32, A33, A34.

Mediator agent finds that order O3 needs to be delivered urgently and activities cant be scheduled serially. In order to maintain quality A31 needs to be scheduled at F3 from 13-OCT-14 to 20-OCT-14, A32 at F2, A33 at F2, A34 at F3 from 20-OCT-14 to 6-NOV-14. Scheduling A31 and A34 at F3 will result in infeasible solution as delivery date is 3-NOV-14.

There are few possible options to solve this situation.

1) Schedule A34 at F2 and meet the dead line of delivery by 3-Nov-14. Here the cost will increase from 4600 to 7800.
2) At factory F3, currently two activities A12 and A23 are scheduled. Scheduling A12 at F4 will have reduced quality of 40 but cost will remain same.
3) A23 can be rescheduled to F4 with reduced quality of 60 and increase cost of 7000.

If the global motive of supply chain is of profit rather then quality then activity A34 will be scheduled at F2 and meet the dead line.
If quality cant be compromised compared to meeting the deadline then A34 needs to be scheduled at F3 and increase the dead line.
If reduced quality is acceptable then A31 can be scheduled at F2 and meet the deadline or A34 can be scheduled at F4.

Case - III Unexpected Break down of Factory F2

Factory F2 has activity A21 scheduled. Breakdown or unexpected events at F2 will lead to re schedule of activity A21. Rescheduling to F5 will be preferred as F1 will result in infeasible solution.

4 Conclusion

We have presented a central agent who acts like a mediator to solve infeasible conditions. Mediator agent collects all information from each factory and stores them centrally. Real time collection/updation and storage of data may pose as a challenge for larger problem sets. With huge data sets applying relaxasation algorithm will produce many near optimal solutions. Choosing one option will be again difficult. Organisational policy related to ownership and sharing of data may prohibit the mediator to have all the information needed to function efficiently.

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