Multi-Agent System Supply Chain Management in Steel Pipe Manufacturing

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Abstract

The proposed work focus large -scale scheduling in the steel pipe industry on the significance and benefits of operating supply chains as an integral part of the modern manufacturing enterprises and also the importance of information sharing as the major requirement for the effective functioning of supply chains. A multi-agent architecture for integrated dynamic scheduling of the steel pipe industry is proposed . The scheduling systems of these processes have different objectives and constraints, and operate in an environment where there is a substantial quantity of real-time information concerning production failures, supplier information , order processing and customer requests. Each process is assigned to an agent who independently, seeks an optimal dynamic schedule at a local level taking into account local objectives, real-time information and information received from other agents. Each agent can react to real-time events in order to fix any problems that occur.

Keywords: *Supply chain, Agent Technology, Multi Agent System and Information sharing.*

1. Introduction

The novel features of the agent include the ability to select between competing vendors, distribute orders preferentially among many customers, manage production and inventory, and determine price, based on competitive behavior. In order to support its global competitiveness and responsiveness to rapid market changes, every manufacturing enterprise has to be integrated not only with its related management systems such as purchasing, design, production, planning and scheduling, control, transport, resources, personnel, materials, quality, etc, but also with its partners, suppliers and customers through heterogeneous

software and hardware environments. Supply Chain encompasses companies and all those activities needed to design, make, deliver and use a product or service. A supply chain typically extends across the multiple enterprises including suppliers, manufacturers, transportation carriers, ware houses, retailers as well as customers and entails sharing forecast, order, inventory, and production information to better coordinate management decisions at multiple points throughout the extended enterprise. The basic characteristics of the supply chain indicate that the efforts associated with the formation of supply chain can be easily extended to the formation of virtual enterprise. Hence, the proposed work intends to focus on the realization of virtual enterprise through the formation of supply chain as the initial step. Agents have revolutionized manufacturing systems. Agent technology provides a natural way to design and implement distributed intelligent manufacturing environments and provides software architecture for managing the supply chain. In distributed intelligent manufacturing systems, the main function of agents is to integrate manufacturing enterprise activities such as design, planning, execution, simulation, distribution, forecasting between suppliers, customers and partners. They are also used to represent various manufacturing sources like products, parts and operations to facilitate different manufacturing activities. With this idea a research activity has been identified to develop a multi agent system model for designing supply chain which result in efficient sharing of information and integrated functioning of various units of an organization and also enhances the communication with other collaborating enterprises

2. Agents in Pipe Manufacturing

A particular agent is allowed to search until a result is achieved in one application instance, while the same agent—executing the same behavior—will use whatever result is available after a certain time in another application instance. This construction also allows for a certain level of

non-determinism in the use of the agent action building blocks [1]. In manufacturing always needed rapid development of third-party domain agents, provide a means to quickly develop complete multi-agent solutions using combinations of domain-specific agents and standard middle agents, a multi-agent systems (MAS) viewpoint, researchers attempting to develop new agents are faced with the problem of constructing a robust environment for executing their agent tasks. This environment must be able to use and Understand network and communication protocols, adapt in the face of failure, and provide a platform for development of the agent tasks themselves. Then the tasks must be organized (programmed) to provide the "intelligence" of the agent code, and multi-agent activity must be supported and coordinated via scheduling and communication protocols [3]. Moreover, better integration as well as coordination among the different nodes in the supply chain through use of information technology has also helped to improve performance in these systems. It means information Technology (IT) plays a major role in the formation of the supply chain [4]. An agent is a software entity that has a set of protocols which govern the operations of the manufacturing entity, a knowledge base, an inference mechanism and an explicit model of the problem to solve. Agents communicate and negotiate with the other agents, perform the operations based on the local available information and may pursue their local goals. This definition has both technical and organizational aspects. Technically, agents possess sufficient knowledge and inferential capability to behave in a manner that would be classified as "intelligent" if performed by a person. Organizationally, agents are entrusted with sufficient authority to make commitments for users. The common characteristics possessed by an agent are Autonomy ,Intelligence, Interaction, Reactivity, Pro-activity /goal-orientation, Learning, Mobility ,Communication/cooperation: A multi agent system views the supply chain as composed of a set of intelligent (Software) agents[5], each responsible for one or more activities in the supply chain and each interacting with other agents in planning and executing their responsibilities.

3. Agents Proposed For the Current Work:-

In the current work only those agents which are responsible for storage and purchasing activities are highlighted with the help of concepts of MRP (Material requirements Planning). The following are the details of agents developed for the work reported in this paper.
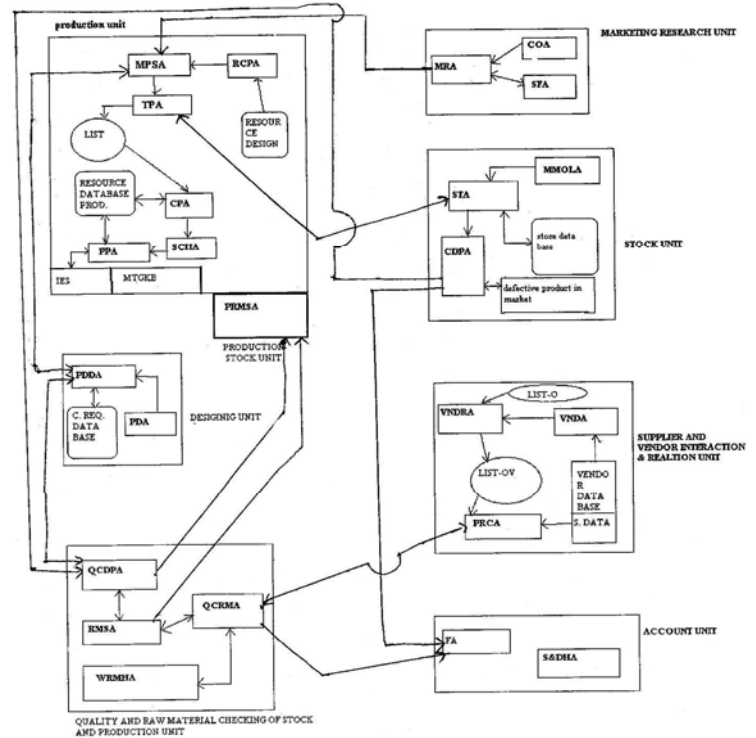
The following are explanations for the components shown in fig.1

SFA-Sales Forecasting Agent, COA- Customer Order Agent, MPSA – Master Production Scheduling Agent, RCPA – Rough Cut Planning Agent, STA- Stocks Agent, PDA – Product Data Agent, TPA – Time Phasing Agent, LIST-O – List of items to be ordered period wise, VNDR – Vendor Rating Agent, VNDA – Vendor Data Agent, LIST – O – V – List of Ordering items with Selected Vendors, PRCA – Purchase Agent, PDDA- - Product Design and development Agent, CPA – Capacity Planning Agent, , PPA – Process Planning Agent, SCHA- Scheduling Agent, MRA—Marketing research agent, PRMSA—Production Raw martial stock Agent, MMOCA—Maximum Minimum Order level Agent, QCDPA—Quality Checking of defective Product Agent, RMSA—Raw Material Stock Agent, QCRMA--Quality Checking Raw Material Agent, WRMHA – Waste Raw Material Handling Agent, FA – Finance Agent, S&DHA—Supplier and Distributor Agent, CDPA—Collection of Defective product Agent, IES – Industrial Engineering Support, MFGKB – Manufacturing Knowledge Base

3.1 Stock Agent (STA)

 This agent is responsible for storing the information regarding the available stock /components/ material and to give access to the data to other agents through negotiation or by sending standard massages. This Agent is also responsible for updating the data before and after each purchasing activity. The updated information is available as output and accessed by Agents for time phasing, and Master production scheduling [6].

3.2 Agent for the generation of Master Production Schedule (MPSA)

Agent for Manufacturing Production scheduling play an important role for the manufacturing activity and the whole process of agent based approach initiates from this stage for atomization. The Agent basically starts receiving the data and information about customer orders, forecast, available capacity from the concerned agents (MRA,COA, SFA, and RCPA) Thus received information is used for the generation of Master production Schedule for given part. This Agent transfer its output to TPA agent.

3.3 Agent for Rough Cut Capacity Planning (RCPA)

This Agent provides a Rough Cut capacity Plan, which will be developed after collecting the relevant data about the recourses from the related agents. This Agent also prepares the capacity planning information required for agents of production planning activities in particular, scheduling[7].

3.4 Product Data Agent (PDA)

This agent is responsible for product data acquisition form PDDA regarding product structure, dimensions, tolerances and other specifications. This Agent is the basic Agent meant for collecting and storing almost all the required information about the product for any reference before, during, and after manufacturing activities. The Agent updates the information continuously so that the other Agents which need the product data can access by sending predefined messages.

3.5 Agent Finance (FA)

This Agent gets the required information about a given part from PDA for processing and computing the bill of material of the part. The Agent also does listing of assemblies and subassemblies parts and raw materials needed for a given end product.

3.6 Agent for Time Phasing (TPA)

The functions of this agent includes collection of information for its tasks from other agents related to bills of material, product data, stores, manufacturing production scheduling. This Agent processes the information and through time phasing of planned orders determines two lists; period wise list of items to be purchased and period wise list of items to be manufactures.

3.7 Agent for Vendors Data (VNDA)

Vendor data Agent is independent Agent interacting independently with the different suppliers available through network and acquires information about the suppliers for

future reference and usage. Specific data includes Cost, Delivery, Quality and purchase terms. It presents the data as item wise list of potential vendors[8].

3.8 Agent for Vendor Rating (VNDR)

This Agent performs the process of vendor rating .It collects data about different vendors through negotiation or by sending standard message to VNDA in a specific format. It uses a well defined procedure based on the recommended values of weightings specified for the following parameters: Cost, Quality, and Lead Time.

3.9 Supplier and Distributor Agent (S&DHA)

This agent performs the function of handling the suppliers and distributors and handling their payment mode also by interact with finance agent

3.10 Sales Forecasting Agent (SFA)

This agent performs the function of forecasting of sales in the market

3.11 Customer Order Agent (COA)

This agent performs the function of handling the order of customer.

3.12 Product Design and development Agent (*PDDA*)

This agent performs the function of designing and developing the product and directly collect the information related to it from PDA and then forward the information to the MPSA in production department.

3.13 Process Planning Agent (PPA)

This agent interact with the scheduling agent and directly share the information with the Industrial Engineering Support, & Manufacturing Knowledge Base.

3.14 Scheduling Agent (SCHA)

This agent interact with CPA and main function is concern to the scheduling of the processes and forwarded the information to PPA.

3.15 Capacity Planning Agent (CPA)

This agent is mainly concern with the capacity of the production plant and forwarded the information to SCHA after working on the information which it share from

resources data base of production plant and List of the processing phase after time plane.

3.16 Market Research agent (MRA)

The basic function of this agent is to set up the marketing research logic with collection of the information from COA & SFA and forwarded it to MPSA.

3.17 Production Raw Martial Stock Agent (PRMSA)

This agent performs the function of handling the stock of production department so that no overloaded stock and no lack of stack condition faced by the production department.

3.18 Raw Material Stock Agent (RMSA)

This agent mainly deals with the operation of handling the stock of raw material for the plant and it got feed from the QCRMA and pass on to QCDPA[9].

3.19 Quality Checking Raw Material Agent (QCRMA)

This agent deals in quality checking of the raw material and directly concern with the purchasing agent , if the material is up to mark the it pass to the RMSA other wise WRMHA and give the detail of billing material to the Financial and purchase agent.

3.20 Waste Raw Material Handling Agent (WRMHA)

If the raw material is not up to mark the it consider as a waste material and it handle by the WRMHA.

3.21 Quality Checking of defective Product Agent (QCDPA)

 If the final product have some defect and collect the product from the market or from the ware house after final checking before deliver it to the customer, the quality check performs on this product to check in which place of the phase of production is required for the recycling of this product, and all these are controlled by quality checking of defective product agent.

3.22 Purchase Agent (PRCA)

 This agent has main function of purchasing the raw material on the basis of demand, this agent control the activity of the suppliers and demands[10]

3.23 Collection of Defective Product Agent (CDPA)

These agent controls the activity of collection of the defective product from the customers and from the company stock.

3.24 Maximum and Minimum Order Level Agent (MMOLA)

This agent control the minimum and maximum order level in the stock in ware house so that the company never faces the bullwhip condition[11].

4. Manufacturing Functions Through Agents

As mentioned above, agents communicate and negotiate with the other agents, perform the operations based on the local available information and may pursue their local goals. For manufacturing activity in enterprise the agent technology can help improve the responsiveness, economy of speed and quality of work provided the software agent is suitably modeled. The agents described in the previous section are expected to perform activities related to purchasing activities based on MRP concepts. The activities performed are development of rough cut capacity planning, master production schedule, time phasing of orders for the preparation of period wise list of items to be purchased, identification of vendors, Vendor rating and selection of vendor for each item and preparation of purchase orders.

The MPSA draws the information from MRA (MRA from SFA and COA) and also from RCPA, CDPA and PDDA. The TPA agent then obtain all required data and information from STA and MSPA using standard messages. Apart from these the TPA also has to link with product data files. The TPA generates a list of period wise items form purchased and manufactured items. The list of items to be purchased will be sent to the VDRA for the selection of vendors which in turn will communicate VNDA. The VNDA will independently interact with potential vendors on the network along with data query files. This process continues till satisfactory level of data acquisition occurs to a significant level. The data of potential vendors will be transferred to VDRA for performing vendor rating on the basis of the parameters such as unit cost, lead time, transportation cost and quality in terms of defective percentage. The required weightings for these parameters are obtained though interactive mode. The results of each vendor are grouped for vendor performance rating (VPR). The TPA which has collection of logical procedures generates the required out put leading to purchasing and scheduling activities. This output has been made possible through effective sharing of information between all the agents. For this the required information has been represented as objects using the concepts of object oriented programming. various agents are executed for the Master Production Schedule shown .A list of vendors was used for these components. The output as list of purchased items and

list of manufactured items. MPSA also got the information from QDCPA and MRA and PDDA. Where the QCDPA link with RMSA than QCRMA in linear pattern, where QCRMA link with purchase agent and waste raw material handling agent.

5. Conclusions

Supply Chain encompasses all those activities needed to design, manufacture and deliver a product or service needs a mechanism or frame work for information sharing. Agent-based manufacturing is a new way of thinking about and applying information. With this idea an attempt is made to provide a multi agent system model for the supply chain management. In the proposed model each agent performs a specific function of the organization and share the information with other agents. There by the most important requirement of effective supply chain i.e information sharing is achieved in the proposed model. In the current work a part of the model related to purchasing activity and the other parts of the model such as functions related to process planning and scheduling activities for the list of items to be manufactured is highlighted.

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