Web-Based Technologies Integration for Distributed Manufacturing Scheduling in a Virtual Enterprise

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ABSTRACT

Today’s manufacturing enterprises face enormous competitive pressures stemming from the current dynamic and open business context. Global competition and market demand for customized products and services, delivered ‘just in time’, exert real stress on businesses. Recently, new production paradigms, such as the extended enterprise, as well as agile, virtual and networked manufacturing, have appeared in response to the increasingly dynamic conditions of the marketplace. These new concepts prompt geographically dispersed manufacturers to build alliances with their suppliers and customers in order to work more closely with them. They need to work to build manufacturing networks which bridge large sections of the supply chain. In this context distributed scheduling problems are challenging tasks to researchers and practitioners that have been gaining increasing popularity over the years. This is partly attributed to the fact that multi-site production and networked manufacturing environments are increasing as a consequence of globalization. In this paper a web based system for technologies integration for supporting distributed scheduling in a Virtual Enterprise, by combining a simulation-based approach, with the Hungarian algorithm, for solving job-shop scheduling problems is presented, in order to show how the authors can benefit from this technologies integration for supporting collaborative distributed manufacturing scheduling.

Keywords: Collaborative Distributed Manufacturing Scheduling, Manufacturing Enterprises, Manufacturing Networks, Technologies Integration, Technology Integration, Virtual Enterprise

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INTRODUCTION

Nowadays stakeholders need to communicate with domain experts and their tools, which may be geographically dispersed over heterogeneous computing platforms. Moreover, technical difficulties and ontological issues such as distributed computing, application integration, and distributed information sharing confuse collaborative manufacturing tasks. This is being increasingly more difficult as manufacturing environment have changed from traditional single-site manufacturing to decentralized multi-site manufacturing network in the last decades.

Companies have established new manufacturing sites in different locations or formed strategic relationships with business partners, in order to increase their responsiveness to market changes and to share resources more effectively and efficiently, through integrated manufacturing systems environments (Yaqiong, Man, & Zhang). In this context, collaboration among different sites becomes more critical. Thus, development of appropriated approaches, integrated for enabling accurate distributed and concurrent manufacturing project, planning, scheduling and execution, in order to maximize the overall benefits of business partners within such a networked scenario, subject to a set of settings, have become even more challenging and the integration of scheduling approaches for distributed scheduling suite well for this purpose (Chan & Chan, 2009; Newton, 2012; Yang, Chen, Zhang, & Zhang, 2011).

Therefore, in this paper we propose a web based scheduling system for supporting decision-making under the scope of distributed manufacturing scheduling. The proposed system is applied to a job-shop scheduling problem where a set of jobs’ components have to be processed on a set of machines and next subject to an assembly line for obtaining final articles.

Manufacturing scheduling is an activity that affects all branches of organizations (industrial, trade and services). Its dynamics occurs through the operationalization of the basic functions of scheduling (orders release, allocation of jobs to production resources or vice versa, jobs sequencing on each resource of machine, and detailed jobs programming, defining its starting and finishing times on each resource/machine), in order to successfully promote activities related to each enterprise. Scheduling is particularly important in creating wealth and satisfying the needs of society and is particularly challenging, given that organizations are continually exposed to markets generally very dynamic and competitive.

Seeking to obtain an optimized manufacturing schedule, we integrate the Hungarian algorithm through an application developed in Visual Basic and another mathematical model developed through the Excel’s Solver, on which the model was implemented for resources allocation and sequencing of jobs. Moreover, this implementation is combined with a simulation-based approach, by using the ARENA Software.

The Hungarian algorithm was proposed by Harold Kuhn (1950) to solve problems of maximum matching in bipartite graphs. Since that time it has been widely implemented and used, having achieved significant results in several areas (Wikipedia, 2012).

The ARENA was released in 1993, by Systems ModelingTM and consists of a set of modules used to illustrate a real situation, through various graphical user interfaces (Act Solutions, 2012). Through ARENA, we will simulate a manufacturing facility consisting of six machines and an assembly line, where components of articles are produced, being next assembled to produce three final articles.

The objective of combining and integrating the Hungarian algorithm, the Excel Solver model and ARENA simulation is to reduce the time needed to produce the articles, determining the optimal sequence of first shipment of raw materials for the machines that produce the components and then the optimal sequence of delivery and production components for assembly lines, for producing the respective final articles.

The problem is to find the value of decision variables that ensures the maximization of income, which in this article is to reduce the