ON EVENT-TIME MODELS FOR SUPPLY CHAIN SCHEDULING

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ABSTRACT

In this presentation, it is argued that scheduling problems in a supply chain are inherently different than the scheduling problems in traditional systems. It is further claimed that "lot streaming" is the modeling paradigm to accurately represent the scheduling problems in supply chains. It will then be shown that "event-time modeling" scheme is an appropriate modeling approach for lot streaming problems of scheduling. Finally, it will be demonstrated that "constraint programming" is a viable computational procedure for these models.

SCHEDULING IN SUPPLY CHAINS

Today's supply chains differ from the integrated logistics systems of the past primarily because of the autonomous nature of its constituents. In the traditional approach to integrated logistics, the entire system is treated as a monolithic entity, whereas today's supply chains are usually comprised of components that are autonomous entities with competing interests. These constituents of the supply chain, such as manufacturers, wholesalers, and retailers, will be better off if they operate in co-operation. Similar situation arises in supply contracts. [3] Co-operation via supply contracts results in a win-win outcome for all parties concerned. The same is true for supply chain scheduling, which is concerned with timing and amount of material handling moves throughout the supply chain. Supply chain scheduling has replaced the integrated production planning and scheduling systems of traditional logistics; and cooperation is essential in scheduling operations in supply chains.

At the "Factory Scheduling Conference" held at Carnegie Institute of Technology in May 1961, William Pounds argued that production scheduling problem was not "… a visible one in many firms because other parts of the firm have absorbed much of the impact of poor scheduling." [10] If the due dates were not routinely met, it was customary to give protracted due dates; if there were a bottleneck machine, the problem was solved by acquiring another machine. Although the changing nature of business competitiveness demands highly advanced production scheduling systems, sufficient emphasis is still not being given to scheduling in supply chains. In the indexes of two recent handbooks on supply chain management, 6 out of 765 pages in Graves & de Kok [7] and only one page out of 817 pages in Simchi-Levi et al. [11] directly refer to scheduling. de Kok & Fransoo [6] suggests the following explanation: "Decisions with regard to the different components of planning of supply chain operations have traditionally been analyzed independently from one another by the researchers. Research addressing the scheduling problem, the (multi-echelon) inventory problem, and the aggregate capacity planning problem have hardly been interconnected while maintaining their own characteristics." Both in practice and in research literature, production planning problems customarily are posed as periodic review processes. On the other hand, detailed scheduling problems extend over relatively shorter planning horizons and require continuous time domain.

Lot Streaming Paradigm

A major problem in production planning is how to handle sequencing requirements on resources, whereas models of traditional machine scheduling cannot handle lot sizing. Lot streaming may provide the necessary conceptual framework for integrating lot sizing and machine scheduling. Basically, lot streaming is moving some portion of a process batch ahead to begin a downstream operation. Classical machine scheduling theory envisions an operation as an elemental task to be performed. It is assumed that "[t]he processing times of successive operations of a particular job cannot be overlapped. A job can be in process on at most one operation at a time". [5] This assumption is justified when jobs are monolithic entities. But for scheduling production lots, where each lot consists of a number of units, this assumption may be overly restrictive. The processing time of such a lot is comprised of a (usually "detached") setup time and the sum of the processing times of each unit in the lot. For instance, when the machine is available, it is not reasonable to delay its setup until all the items arrive from the upstream machine. Lot streaming, in this context, was introduced in papers by Baker [7] and Trietsch [12]. In a later joint work, they discuss the practical importance of this approach. [13] A number of manufacturing management innovations, such as Group Technology (leading to cell based manufacturing, resulting in shorter lead times and reduced work in progress inventories), Just-in-Time Systems ("lot size of one"), and OPT/Synchronous Manufacturing (transfer vs. process batches) paved the way to lot streaming theory, which provides a rigorous analytical treatment of these issues. In the recent years lot streaming attracted considerable attention in machine scheduling research. Chang & Chiu [4] present a comprehensive review of lot streaming literature. There does not seem to exist a unified approach to solving lot streaming problems. Probably this is due to the fact that a general model for lot streaming problems does not exist. The event-time modeling approach provides such a paradigm.

Event-Time Models

In event-time modeling events are ordered sequence of material handling moves (interstage material transfers). There are two types of events:

- *exogenous events* whose time of occurrence are given (as parameters of the problem), such as demand occurrences or order deadlines, and
- *endogenous events* whose occurrence times are decision variables of the model, such as WIP movements.

Essentially, the model is formulated as a multi-item periodic review process with variable period lengths. Detailed formulations of these models are given in Benli [2].

Constraint Programming

The basic framework of logic-based modeling [8] makes event-time models computationally viable utilizing the specific features of constraint programming. Constraint programming makes it possible to handle the exogenous events whose times are fixed and the endogenous events whose times of occurrence are decision variables in the same model. ILOG's constraint programming software, OPL studio [9] allowing for variable subscripts, makes it possible to handle conditional constraints.

CONCLUSIONS

The problem that we are concerned with in this study is scheduling problems in supply chains. The primary contention has been that the constituents of a supply chain need to cooperate, rather than compete, in order to achieve overall, as well as individual, maximum benefits. In order to analyze this, it is essential to have a concise but comprehensive formulation. This formulation, in addition to being computationally viable, must account for exogenous events, such as demand occurrences and other deadlines, as well as the endogenous events that are decision variables in the model. It has been maintained that event-time modeling accomplishes this. Furthermore, logic-based modeling framework of constraint programming makes it possible to handle exogenous and endogenous models in the same model. This work presents an approach to a modeling paradigm for scheduling problems in supply chains.

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