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A design and application methodology for hierarchical production planning decision support systems in an enterprise integration context☆

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Abstract

Literature review on hierarchical production planning (HPP) shows that a methodology for the design and implementation of such systems is necessary. An overview of its main advantages and limitations is presented. At each stage of the methodology critical aspects are highlighted and some solutions are provided. The elements of the HPP decision support systems and its operation are described in an enterprise integration context and taking profit from the new information technologies. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Hierarchical production planning; Decision support systems; Methodology; Enterprise integration; Information technology

1. Introduction

Production planning [1] is a complicated task which requires cooperation among multiple functional units in an organization. For solving the problem of production planning powerful optimization models have been constructed by means of the formulation of mathematical programming. The result [2] may be a large scale model that is difficult to assemble, optimize or interpret as a single, monolithic entity. But the effort needed to record and update all data required by monolithic models, the difficulty in solving large mixed-integer programs as well as their assumption of a centralized decision-making, neglecting established organizational structures, obstructs the applicability of this type of models.

A classical approach to overcome these difficulties of implementation is hierarchical production planning (HPP). The idea of HPP and scheduling was initiated by Hax and Meal [3]. The HPP approach recognizes and represents the planning process by a series of mathematical models and partitions the decision process into modules or subproblems with different planning time horizons. It also aggregates and disaggregates information through the various hierarchical levels. To ensure effective decision-making, a strong linkage must exist between these models at each hierarchical level.

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In this paper we analyze (Section 2) the advantages and limitations of existing HPP systems. In Section 3 some concepts of enterprise integration are outlined. In Section 4 we establish a design and application methodology for HPP decision support systems in an integration enterprise context. This methodology tries to avoid some critical design and implementation aspects of such a system, analyzing the different approaches in the existing literature and proposing alternative methods. The purpose of this paper is to present the methodology for theoretical foundations. An application to the tile industry is nowadays being developed and the results will be provided in the sequel.

2. Advantages and limitations of HPP systems

Various HPP applications are reported in the literature such as: steel manufacturing [4–6], metal can manufacturing [7,8], metal parts fabrication [9] tile industry [10], shoe production [11], motor industry [12], detergent manufacturing company [13], milk powder manufacturing [14], furniture company [15], metal-mechanic company [16], batch size production [17] and multi-machine environment [18].

The fundamental advantages of the hierarchical approach to complex problems are: reduction of complexity, coping with uncertainty, parallel with hierarchical organization of the physical system, improvement of the manager's overall insight due to the use of aggregated figures, reduced need for detailed information and better forecasting [19].

However, in spite of its advantages HPP has had a reduced application by managers. Its lack of acceptance may be in part a consequence of the major HPP limitations:

1. Each method has been observed to be "situation dependent", that is, it is only suitable for a limited range of planning situations. Hence the identification of the most appropriate method and models to use can present problems to production planners because they are not directly transferrable to other planning situations [20].
2. Intrinsic difficulties of quantitative models: The mathematical procedures used by existing methods are also complex for manufacturing management to understand; hence management is reluctant to use such techniques.
3. Insufficient communication between designers and users of a system and consequently inadequate implementation.
4. Models require specific types of data items that are difficult to collect and quantify (e.g. costs of recruitment and training of new staff, effects of redundancy on employee morale, productivity reductions resulting from working longer hours due to overtime and length of time required for a new employee to become fully productive in terms of both output rate and quality).
5. A major weakness in HPP systems is that they require reruns in case unexpected external or internal events occur [21]. Any cause (such as machine breakdowns, changes in firm orders) which endangers the validity of the current production plan leads to the regeneration of the entire plan.
6. Sequential solution of a hierarchy of subproblems may lead to suboptimatily, inconsistency or even infeasibility if one ignores the intimate way in which subproblems are related. For instance, it is not sufficient to have a good aggregate planning procedure and a good detailed planning procedure in a two-level hierarchy. Both models should be carefully integrated (consistency conditions, aggregation–disaggregation schemes).

It is our thought that some division of mental labour is needed and some form of hierarchical control is required. Consequently, it will be enough to appropriately enhance HPP paradigm, providing solutions to avoid some of the above mentioned pitfalls.

3. Previous concepts of enterprise integration

The proposed methodology is developed in an enterprise integration (EI) context. EI is to facilitate materials, information, decisions and control flow throughout the organization, linking functions with information, resources, applications and people, with the goal of improving the enterprise