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A UML model of agile production planning and control system

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Abstract

Agile production planning and control system (APPCS) is a system for planning, scheduling, procurement, and production control. APPCS plays an important role in the competitive environments, such as make-to-order industries, because it excels in immediate uncertainty processing and then guarantees feasibility of the production plan. The uncertainty is often caused by customers who make a change in the order or by suppliers who change their promised items. The customers or suppliers can notify of the change before it really happens. Upon receipt of the change, APPCS responds immediately to achieve higher service level of performance, better resource utilization, and less material loss.

This paper provides a UML model of APPCS. The proposed model concretely defines the APPCS and makes the immediate planning and scheduling possible. In order to testify the model, both instance of the model and its implementation in a simulator are shown.

Keywords: Agile production planning and control system; UML; Planning and scheduling; Production control; Uncertainty

1. Introduction

This paper provides a universal modeling language (UML) description of the agile production planning and control system (APPCS). APPCS, proposed by Sato and Tsai [9], is an integrated system of material requirement planning, job oriented scheduling, procurement, and production control for uncertainty processing on a basis of inventory, released purchased orders, and work-in-process (WIP).

The APPCS has the following characters [9]. (1) A set of demands from master production scheduling (MPS), inventory, purchased orders, and WIP are inputs of the system. (2) An advanced production system (APS) is adopted to produce a feasible production plan. (3) When customers change their request, and/or suppliers cannot maintain start time planned supply, with respect to date or quantity, they give advance notification before the change really happens. Upon arrival of such information, APPCS makes immediate update of the production plan by APS.

APSs are proposed as an enhancement to enterprise resource planning (ERP) systems that rely on MRP logic [5]. APS schedules backward from due date of a demand by netting out quantity of inventory, released purchased orders, and WIP recursively from finished product to raw material. At the same time it reserves capacity of resources for the net requirement to determine the latest possible start time for the demand. If the start time is in the past, then APS schedules

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forward from a start time, usually the present time, to get the earliest possible finish time. A feasible production plan is thus generated.

Planning, scheduling and control are fundamental business processes and the hierarchical nature of them follows the natural flow of decisions in an organization [4]. To integrate these business processes, a job plays an important role in carrying data among these processes. A job is generated as net requirements of finished product, assembly, or raw material in the planning process, the scheduling process determines its start time and finish time, and it serves as a base unit of production control.

The sequence of demands executing planning and scheduling are determined by the earliest due date (EDD) rule. A demand is planned to be a set of jobs by referencing bill of materials recursively. The job of production is transformed into a set of schedules by job oriented scheduling. Job oriented scheduling schedules one job at a time, so that all the operations of a job are scheduled before the next job is considered [7]. APPCS adopts job oriented scheduling in order to work well with the finite-capacity scheduling. A purchase order is generated for a job or jobs that request the same raw material according to various rules.

During production control, a job of production will be released to the shop floor by distributing the schedules to the related work centers. A job of procurement starts when the generated purchase order is released to a vender. Gantt chart provides the resources with graphic understanding of the assigned schedules. A resource processes the operation at the specified work center by following the distributed schedules.

Uncertainty becomes inevitable in modern times. We can view it as an important message from the changing market. Sanchez and Nagi [6] regards a planning, scheduling, and control system that is able to reschedule or recover from many uncertainties of the market as a further research of agile manufacturing system. Tu [13] gave a problem domain to production planning and control in a virtual one-of-a-kind production (OKP) company under uncertainty. Real-time monitoring of production progress, a control structure that can be flexibly extended to cope with the uncertainties, and an adaptive production scheduling algorithms are included in the problem domain. A flexible structure of production control accompanies with the capability of immediate rescheduling is very important to handle the uncertainties.

The proposed APPCS model is equipped with the rescheduling capability based on a job-based structure. An uncertainty can cause some jobs to be unattainable. In APPCS, the invalid jobs and their schedules are first cancelled, and then planning and scheduling runs again to generate another feasible production plan. Silver et al. [5] indicated that the frequent updates from the planning process lead to a poor communication between the planning department and the shop floor. To avoid such a dispute, the jobs that have been released to the shop floor are not cancelled, and the in-processing jobs become constraints for the subsequent planning and scheduling process.

A data model for product data management and planning is available in [2]. This paper showed an augmentation so that APPCS is possible. The formulation of APPCS is described by the UML and illustrated by class diagram, state chart diagram, and sequence diagram. The UML is a language for specifying, visualizing, constructing, and documenting the artifacts of software system, as well as for business modeling and other non-software systems [8]. It is composed of foundation, behavioral elements, and model management packages. A package is a grouping of model elements. The foundation package defines the constructs to abstract a static model.

System requirements of the APPCS are specified in Section 2 and they act as guidelines of system analysis and design in Section 3. The system requirements are compiled and abstracted by following the UML foundation package. All the technical terms used in this paper follow OMG unified modeling language specification. In Section 4, we provide an example of the APPCS model to demonstrate how the APPCS is applied. Finally, a conclusion is provided in Section 5.

2. System requirements of the APPCS

2.1. Production data

Customers request finished products. A finished product is made by assembling necessary assemblies and raw materials. In turn, putting together other