An Architecture of Component-Based CAPP Systems for Agile Manufacturing

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Abstract

Current manufacturing planning software systems (such as computer aided process planning (CAPP) systems) are general and in a closed form, i.e., it is very difficult to modify these systems to respond to a user's dynamically changing needs. These systems are not well suited to agile manufacturing. This research work aims at developing an architecture for rapid development of CAPP systems. The architecture supports the construction of CAPP systems from prepackaged, plug-compatible software components. The specifications of the architecture and its building blocks are defined. A prototype system is under development to prove the concept.

1. Introduction

The manufacturing industry has been pushed to adopt more effective and efficient production strategies to meet the challenge of shorter life cycle, higher quality, lower cost, wider variety of customer demands. This increased emphasis on achieving highly adaptive manufacturing to reduce manufacturing costs and to better utilize manufacturing capacity has led to a critical focus on agile manufacturing as a strategy to achieve these goals. CAPP is considered a crucial link between Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM). Research of over 30 years in CAPP has resulted in a wealth of knowledge on CAPP and many experimental and commercial CAPP systems have been developed as a result. Most researchers have focused on a particular aspect of process planning and very few have addressed the issue of system architecture and integration of sub-systems. The current CAPP systems are general and in a closed form, i.e., it is very difficult to modify these systems to suit a user's dynamic needs. This, along with other obstacles in CAPP research, inevitably resulted in the unsuccessful practical implementation of CAPP, particularly in manufacturing environments with constantly changing products and manufacturing resources. In this study, a novel architecture is proposed for rapid development of CAPP systems for agile manufacturing.
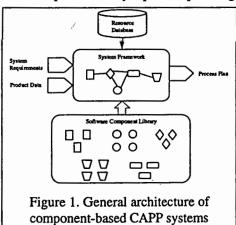
2. The Process Planning Function and Its Decomposition

Process planning involves many complicated planning tasks. Different application domains may have different functional requirements for process planning. In general, the following tasks are performed by a process planning system: (1) process sequence planning; (2) operation planning; (3) shop floor routing planning; (4) control program generation; (5) plan and program validation. In general, these tasks are relatively independent. In other words, a process planning function can be decomposed into several independent tasks. The links between the tasks are the data and control.

3. An Architecture of Component-Based CAPP Systems

In this research project, a novel architecture or infrastructure is proposed for the rapid development of CAPP system for agile manufacturing. This architecture is based on the component-based software system concept and is composed of a framework, a software component library, and a resource database. Figure 1 shows the general architecture of component-based CAPP systems.

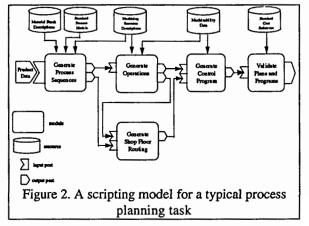Figure 1. General architecture of component-based CAPP systems

3.1 Framework

The framework of the rapid CAPP system development architecture includes the mechanism for constructing CAPP systems from prepackaged, plug-compatible software components. The framework supports the following tasks: (1) selection of software components; (2) definition of the software component flow; (3) compatibility checking of inputs/outputs of adjacent components; and (4) execution of components or the system. In this study, the framework is implemented using a visual scripting approach. Visual scripting supports the interactive construction of CAPP systems from software components by direct manipulation and graphical editing. Figure 2 shows a scripting model for a typical process planning task.

3.2 Software Component Library

The software component library includes a set of software components (programs) for process planning tasks. A software component is specified by its functionality, data interface and resource requirements. It performs a specific task or tasks with the built-in algorithm when all its input

Figure 2. A scripting model for a typical process planning task

ports and resources ports are connected. In this study, software components for five process planning tasks (categories) are specified and developed. In each task, there are a few domain-specific software components. For example, task "generate process sequences" might include the software components for generating process sequences for three different product/process domains: rotational machined parts, non-rotational machined parts and sheet metal parts. The software components within a category have the same input/output port specifications for they are to be connected to components in other categories with the same data interface.

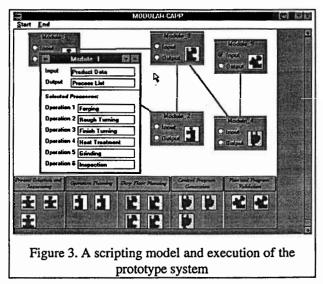## 4. Implementation of the Architecture - A Prototype System

A prototype system is under development to prove the concept of the component-based (modular) CAPP systems. The system is being developed in Visual BASIC on a PC/486 computer in the Microsoft Windows environment. Figure 3 shows an example of the scripting model and execution of the prototype system.

The component-based system structure provides a approach way for manufacturing planning software development. We envision the following for the next generation manufacturing software development. Based on the system requirements, the system developer selects an appropriate architecture/framework for the system. Software components with the standard data interface can be either developed by the experts in the company or purchased on the market (developed by third-party vendors). These components can then be "assembled" together using the architecture to form the software system. The authors' experience has indicated that this form of software development is suitable when the system requirements are dynamically changing. This makes the architecture a perfect candidate for manufacturing planning software development in agile manufacturing.

Figure 3. A scripting model and execution of the prototype system

5. Planned Future Work

The architecture of the component-based CAPP system development provides a new concept for next generation manufacturing planning software development. We envision several ways in which this research may be extended. Among them are extending the component scope and number of software components in the component library, providing an automatic component selection

mechanism, validating the generated systems, and extending the concept to other manufacturing planning (e.g., scheduling, MRP, etc.) software development.

Acknowledgment

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