ProPlanT as a Multi-Agent Technology for Decision-Making Support

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Production planning and resource allocation is a complex industrial decision-making problem. Sophisticated computational model of a manufacturing domain may support this decision making by simulation of multiple variants of alternative plans and thus help identifying the most suitable one (according to defined conditions). Multi-agent system is an example of such a computational model as it can naturally represent the hierarchical and distributed structure of the manufacturing enterprise that is modelled.

This item presents and discusses ProPlanT (Mařík, Pěchouček, Štěpánková, & Lažanský, 2000), a specific multi-agent technology/methodology for production planning and scheduling in the manufacturing domain. This methodology resulted in a framework for decision making support which was successfully applied in several pioneer applications.

AGENT TECHNOLOGIES AND MULTI-AGENT SYSTEMS

Agent technologies and the concept of multi-agent systems are coming from the field of artificial intelligence and computer science, using principles of component-based software engineering, distributed decision making, parallel and distributed computing, autonomous computing, advanced methods of interoperability, and software integration (Mařík & McFarlane, 2005). Operation of an agent-based system is based on collaborative (or sometimes self-interested) interactions of autonomous and loosely coupled software or hardware entities—agents (Wooldridge & Jennings, 1995). An agent can integrate existing software systems for operation of the manufacturing enterprise, hardware modules such as CNC machines, various PLC controllers together with advanced planning systems, simulation environments, diagnostic algorithms, or sophisticated control mechanisms (Shen, Norrie, & Barthes, 2001).

Agent technology is suitable for domains that have any of the following properties:

- highly complex problems need to be solved or highly complex systems need to be controlled;
- the information required for solving problems or controlling systems is distributed and is not available centrally;
- domains that may be naturally distributed into loosely dependent components;
- domains with dynamically changing environment and problem specification; or
- large number of heterogeneous software (and possibly hardware) systems needs to be integrated.

INTRODUCTION TO PROPLANT TECHNOLOGY

ProPlanT is a consolidated technology. It is an outcome of the series of European Union RTD and Trial projects in the area of agent-based production planning. It is based on a collection of various components, which can be put together in order to develop a custom-tailored system for supporting user's decision making in different aspects of production planning. From the user perspective the system is supposed to provide support to the human user when sizing resources and time requirements for a particular order, creating production plans, optimizing manipulation with material resources,

managing and optimizing supply chain relationships, visualizing and analyzing manufacturing processes in middle and long terms and accessing data from outside the factory.

ProPlanT provides technological support for the following problems in manufacturing: easy software integration, complex data representation, data-collection, maintenance, extra-enterprise access, supply-chain integration, communication security, roles based access control, visualization, and emulation/simulation. At the moment, ProPlanT does not feature agents and components for control and real-time diagnostics. They may be included to the system later if they are developed for any ProPlanT based system. Adding new agents increases the usability of the system without affecting agents already present in the system. As a result of the used multi-agent architecture, each software system based on ProPlanT concept is component-based, flexible, reconfigurable, and allows distributed computation and flexible data management.

To be included to the ProPlanT, each component has been integrated in an agent wrapper, which complies with the FIPA[1] standard for the heterogeneous software agents, and thus it can be used in a variety of configuration or independently as a standalone application. System configurations can contain various planning, data-management or visualization agents. The "agentification" process can be also used for integration of software and hardware equipment already existing in the enterprise. Another advantage of the agent-based approach is its ability to process relevant production data, distributed across the entire enterprise. The classical approach when data are collected and processed centrally is difficult especially in situations where the production planning data are voluminous and change frequently. Agent approach allows to process data proactively at the place of their origin and to exchange only important results.

The agent-based technology certainly does not provide an uncomplicated solution of NP-hard planning problems. However, the concept allows integration of heavy-duty AI problem solvers (such as constraint satisfaction systems, linear programming tools, genetic algorithms, etc.). The agent technology is also suitable paradigm for integrating the manufacturing enterprises into a supply chain. From the planning perspective it is irrelevant whether the system reasons about in-house manufacturing workshop or about a subcontracted company. Production managers are often interested in modelling and simulation of the production process. Experimenting with changes in production lines, and how they affect the manufacturing process as a whole, is not a trivial task, but it can be simplified by a built-in simulation environment.

Figure 1. Intra-enterprise architecture