Agent-based Workflow Management for RFID-enabled Real-time Reconfigurable Manufacturing

George Q. Huang\textsuperscript{1}, YingFeng Zhang\textsuperscript{2}, Q. Y. Dai\textsuperscript{3}, Oscar Ho\textsuperscript{1} and Frank J. Xu\textsuperscript{4}

\textsuperscript{1} Department of Industry and Manufacturing Systems Engineering  
The University of Hong Kong, Hong Kong, China  
Email: gqhuang@hku.hk

\textsuperscript{2} School of Mechanical Engineering  
Xi’an Jiaotong University, Xi’an, Shaanxi, China  
Email: xjtuzyf@mail.xjtu.edu.cn

\textsuperscript{3} Faculty of Information Engineering  
Guangdong University of Technology  
Guangzhou, Guangdong, China

\textsuperscript{4} E-Business Technology Institute  
The University of Hong Kong  
Hong Kong, China

Abstract

Recent developments in wireless technologies have created opportunities for developing reconfigurable manufacturing systems with real-time traceability, visibility and interoperability in shop floor planning, execution and control. This chapter proposes to use workflow management as a mechanism to facilitate an RFID-enabled real-time reconfigurable manufacturing system. The workflow of production processes is modelled as a network. Its nodes correspond to the work (process), and its edges to flows of control and data. The concept of agents is introduced to define nodes and the concept of messages to define edges. As a sandwich layer, agents wrap manufacturing services (e.g. machines, RFID devices and tools) and their operational logics/intelligence for cost-effectively collecting and processing real-time manufacturing data. Some referenced frameworks and architectures of manufacturing gateway, shop-floor gateway and work-cell gateway are constructed for implementing the RFID-enabled real-time reconfigurable manufacturing system. The shop-floor gateway is mainly discussed where three key components (workflow management tools, MS-UDDI and agent-based manufacturing services management tools) are integrated. By means of web service technologies, each agent can be registered and published at MS-UDDI as a web service that can be easily reused and reconfigured as a workflow node according to the workflow of a specific production process through workflow management to a server for reconfigurable goals. The methodologies and technologies proposed in this chapter will allow manufacturing enterprises to improve shop-floor productivity and quality, reduce the wastes of manufacturing resources, cut the costs in manufacturing logistics, reduce the risk and improve the efficiency in cross-border customs logistics and online supervision, and improve the responsiveness to market and engineering changes.
14.1 Introduction

With the increasing competitiveness and globalisation of today's business environment, enterprises have to face a new economic objective: manufacturing responsiveness, i.e., the ability of a production system to respond to disturbances that impact upon production goals, and consequently, its ability to adapt to changing production conditions of shop floor level.

Even if many manufacturing companies have implemented sophisticated ERP (enterprise resource planning) systems, the following problems are suffering from:

- Customer orders, process plans, production orders and production scheduling are conducted in separate systems that are not integrated.
- The availability of raw materials is not known at the time of production scheduling. The scheduler has to visit each inventory area to count the available materials before starting scheduling.
- Shop-floor disturbances such as machine breakdowns and maintenance are not fed back and considered when planning the production order, resulting in unbalanced lines.
- The loading level of work orders at specific machine is unknown to the scheduler and production planner, leading to further line unbalances.
- WIP inventories are highly dynamic – changing frequently between production stations or lines.
- Errors and confusions in handling WIP items are common – leaving a piece of hand-written paper form on the stack and leave the pallet wherever a space is spotted.
- Separate personnel are responsible for auditing the materials at the shop floor and warehouse. But the frequencies of such inventory audits are not high enough or consistent with the frequencies required by the production planning and scheduling systems.
- Separate personnel are responsible for entering the shop-floor data into the computer terminals, usually towards the later stages of their shifts. Any left-over data entries would be completed until the next shift.

Therefore, it is essential to adapt advanced manufacturing technologies and approaches (both software and hardware) to cope with the highly dynamic manufacturing requirements. In recent decades, rapid developments in wireless sensors, communication and information network technologies (e.g., radio frequency identification – RFID or Auto-ID, Bluetooth, Wi-Fi, GSM, and infrared) have nurtured the emergence of wireless manufacturing (WM), reconfigurable manufacturing system (RMS) as core advanced manufacturing technology (AMT) in next-generation manufacturing systems (NGMS).

The RMS was introduced in the mid-1990s as a cost-effective response to market demands for responsiveness and customisation. The RMS has its origin in computer science in which reconfigurable computing systems try to cope with the inefficiencies of the conventional systems due to their fixed hardware structures and software logic. Here, reconfiguration allows adding, removing or modifying specific process capabilities, controls, software, or machine structure to adjust production capacity in response to changing production demands or technologies.