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# Development of an intelligent agent system for collaborative mold production with RFID technology

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**Abstract**

This paper presents a multi-agents system called agent-based collaborative mold production (ACMP) system. ACMP supports the collaborative and autonomous mold manufacturing outsourcing processes. The mold manufacturing outsourcing processes involve not only many manufacturing sequences but also many collaboration partners. ACMP provides autonomous features to handle three major tasks in outsourcing. They are vendor selection, task selection, and real-time outsourcing task progress tracking. This research applies the analytic hierachy process (AHP) decision models to solve the vendor selection and task selection problems. In addition, radio frequency identification (RFID) technology is adopted to provide a real-time tracking capability for remote collaboration, control and monitoring among outsourcing partners.


*Keywords:* RFID; Intelligent agent; Collaborative process management

## 1. Introduction

With the development of information technology (IT), many companies realize that competitiveness comes from accurate and real-time information visibility. In many industries, processing information collection to provide decision supports is crucial for agile design and manufacturing. Backend information systems, such as manufacturing execution systems (MES) and enterprise resource planning (ERP) systems, depend on the information feedback to adaptively control the processes. However, not all processes can be carried out in one location. For economical consideration, many companies have adopted an outsourcing strategy to broaden their capacity and productivity. The outsourcing process is a collaborative process, which involves stakeholders such as original brand manufacturers (OBMS), product designers, mold designers and manufacturing suppliers. During a collaborative process, a primary company needs to communicate with its outsourcing partners (OP) for several purposes, e.g., requesting for quotations, confirming the quality requirements, notifying the design changes, reporting progresses and acknowledging sample qualification results. These status data are the key elements for agile collaboration. This collaborative process forms an extended-enterprise [1], which is a virtual organization connected by internet and IT. However, the integrations of collaborative processes are challenging for both primary companies and their partners. Particularly, some partners are too small to be IT adequate. These small suppliers cannot afford to install MES or ERP systems let alone operate sophisticating enterprise applications. Hence, the communication model remains the conventional ways, such as using telephone, fax and e-mail. The progress updates usually depend on human monitoring and feedback. The status changes for various events and tasks during product development and production processes are not reported in real time. This leads to a situation that critical decisions cannot be made promptly and accurately. Therefore, an autonomous software agent platform is developed in this research to solve the problem. The agent technology, differs from

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conventional approach, uses networked software objects which are long-lived, autonomous, proactive and adaptive.

This research is based on a scenario of mold outsourcing collaboration shown in Fig. 1. It shows an OBM [2] designs the outer cover of a mobile phone and subcontracts the mold fabrication to four OP. The goal of this research is to develop a multi-agent system to support collaborative mold production outsourcing. The system framework consists of eight types of agents and their collaborative behavioral capabilities. In order to convey any status changes in real time, the system uses radio frequency identification (RFID) technology to transform the physical processes and statuses into information flow. Receiving data from RFID middleware, the system conveys all changes to corresponding agents automatically. The agent-based collaborative mold production (ACMP) system forms a real-time collaborative command and control environment. With autonomous interactions between intelligent agents, structured decisions can be made automatically, which are faster and more consistent than human decision making for collaboration effectiveness and quality.

The paper is organized as follows. Section 2 discusses the related literatures in collaborative system development. Section 3 analyzes the process models of mold fabrication and its outsourcing activities. Section 4 focuses on the system analysis of the agent-based collaborative mold production (ACMP) system. Section 5 presents the system design and agent behavior model. Section 6 describes implementation details and agent decision models. Finally, the conclusion of the research is drawn in Section 7.

## 2. Literature review

Mold design and fabrication consists of a series of key processes that usually takes several months to complete. The processes, through mold design, machining and final assembly, involve not only a great deal of design knowledge but also valuable manufacturing know-how [3]. The time-to-market of new products pressures the product design and production processes in many aspects. Early supplier involvement (ESI) is defined as a form of vertical integration between manufacturer and its suppliers in the early stage of product development [4]. In practice, ESI is a strategy to leverage partners' capacity in design and manufacturing. Many research works show that adopting ESI strategy could benefit the efficiency and quality of product development. However, there are critical issues need to be addressed before a company adopting the ESI strategy, e.g., the communication and interoperation, supplier selection and process integration [5]. The communication and process integration are crucial in design and manufacturing outsourcing. Currently, there exist web-based design collaboration platforms for design visualization [6], online meeting [7], document sharing [8,9] and real-time status visibility [10]. The goal of a collaboration system is to enable a distributed environment for a primary company and its outsourcing suppliers. For example, the WeBid project [11] proposed a bidding environment for suppliers to participate in the prime's product development. In our previous research, a Collaborative Mold Integrated Design and Manufacturing (CMIDM) platform [12] focuses on the collaborative processes integration and provides information sharing and processing flow integration for the primary company to plan, monitor and

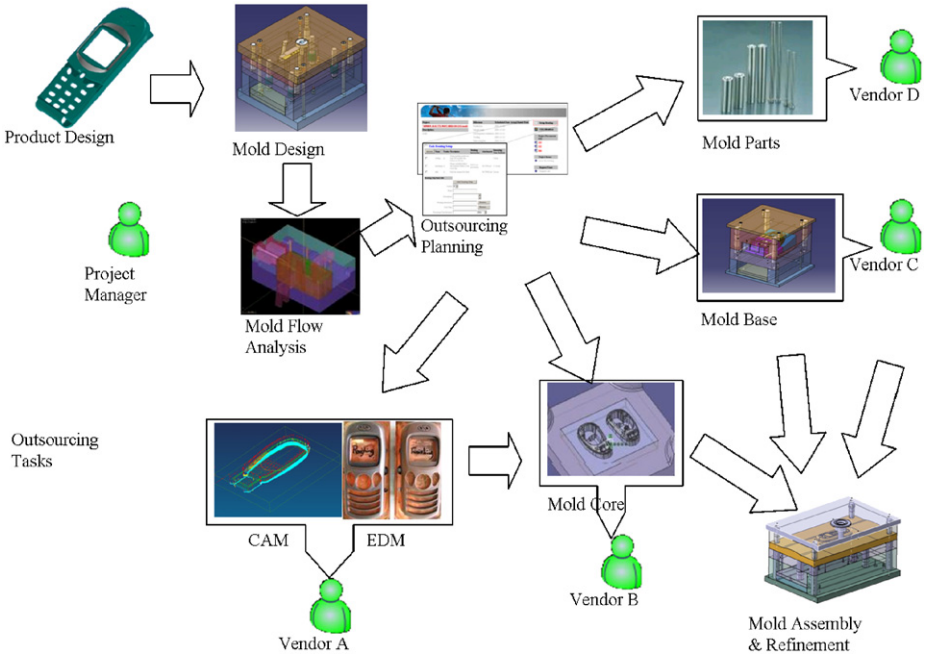


Fig. 1. The mold outsourcing scenario.