Chapter 3
Negotiation Protocol Based on Budget Approach for Adaptive Manufacturing Scheduling

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ABSTRACT

The research proposed concerns the development of a multi-agent scheduling approach able to support manufacturing systems in different dynamic conditions. The negotiation protocol defined budget approach is based on a financial asset that each part obtains when it is released into the manufacturing system for processing. The part spends the budget to perform the manufacturing operations by the workstations; the virtual market in which part agent and workstation agents coordinate the decentralized system. A fuzzy tool is proposed to assign the budget to each part based on the objectives pursued. A simulation environment based on Rockwell ARENA® platform has been developed in order to test the proposed approach. The simulations are used to compare the proposed approach with classical dynamical scheduling approaches proposed in literature. The results show how the proposed approach leads to better results, and it can be selective among the different priority of the parts.

INTRODUCTION AND MOTIVATION

Nowadays, the competition is played in a market environment characterized by demand fluctuations, new product introduction, reduction of the products life cycle and random disturbances.

Some disturbances can be: the failures of manufacturing machines or technological equipment; the importance of the parts can be modified; the objectives of the manufacturing system can change; etc. In this environment, a static scheduling approach leads to reduce drastically the performance of the manufacturing system when

exceptions occur. Therefore, the manufacturing systems need to dynamic scheduling to keep a high level of the performance when the conditions change. The dynamic scheduling concerns the possibility to take all decisions based on the current state of the manufacturing system. Ouelhadj and Petrovic (2009) classified the dynamic scheduling in three categories: completely reactive scheduling, predictive–reactive scheduling, and robust pro-active scheduling. (Mehta and Uzsoy 1999; Vieira et al. 2000, 2003; Aytug et al. 2005; Herroelen and Leus 2005). In briefly, the completely reactive scheduling is obtained taking the decisions in real time without a global scheduling in advance. The robust pro-active scheduling is performed building the scheduling in advance trying to capture the exceptions in advance. The predictive-reactive scheduling is a compromise between the two above opposite approaches.

The architecture to support the scheduling approaches in manufacturing systems can be classified in centralized and decentralized systems.

The centralized architectures are not flexible enough to adapt themselves to the dynamism and complexity needed in dynamic manufacturing system conditions.

The main requirements of a dynamic scheduling approach are the following:

- Agility: it is the ability to adapt quickly the scheduling to the dynamic conditions of the manufacturing system;
- Scalability: it is the possibility to add resources into the architecture and the expansion is possible without disrupting the entire architecture established
- Fault tolerance: the architecture can reduce the impact of failures occurred to any parts of the architecture.
- Computational efficiency; the problem of scheduling can be more complex to resolve in a single step.

The above requirements can be obtained by a decentralized architecture (Shen et al., 2001). The Multi Agent Systems are able to support the development of decentralized architecture. A MAS is an artificial system composed of a population of autonomous agents, which cooperate with each other to reach common objectives, while simultaneously each agent pursues individual objectives (Ferber, 1999). Among the several definitions agent, Woodbridge and Jennings (1995): "*an agent is a computer system that is situated in some environment, and that is capable of flexible and autonomous action in this environment in order to meet its design objectives. By flexible we mean that the system must be responsive, proactive, and social*". Multi-agent systems (MAS) have already demonstrated their potential in meeting such complex requirements (Monostori et al., 2006). In manufacturing, such as systems have demonstrated their ability to build up agile and reactive behaviour in various settings like enterprise integration and supply chain management (Swaminathan et al., 1996), dynamic system reconfiguration (Shen et al., 1998), learning manufacturing systems (Monostori et al., 1996), distributed dynamic scheduling (Chiuc and Yih, 1995; Váncza and Márkus, 2000), as well as factory control (Brennan, 1997).

A MAS to pursue a global objective needs to implement a coordination mechanism among the autonomous agents. The most common coordination mechanisms used are the Contract net protocol (Smith 1980), market based, auction based (Siwamogsatham and Saygin, 2004) and game theory (Zhou et al., 2009b).

In this chapter, a coordination mechanism based on market-like approach is proposed. The market like approach works like a classical marketplace where the increase of the demand for a product causes its price to rise, and vice versa, to fall. In the case of the manufacturing systems, the resources become the products and parts are buyers asking for these products.

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