Abstract

With the popularization of global manufacturing and informatization, manufacturing companies are faced with multiple pressures brought by technological innovation and increased competition, including transition of production mode, dynamic demand of market, and other abnormal factors such as equipment failures. As a result, Enterprises have to improve the quality of production management as soon as possible. Flexible Job Shop Scheduling Problem (FJSP) occupies an increasingly important position in the production scheduling problem. Compared with the traditional job shop scheduling problem, FJSP has more flexibility in process planning and equipment selection, resulting in much more difficulties among problem solving. As an important module of production management, dynamic scheduling system is the key to control production cost and ensure productivity and quality, and is helpful to improve enterprises’ core competitiveness when facing complex and changeable manufacturing environment.

In recent years, multi-agent theory has become one of the research hotspots of distributed artificial intelligence and has been widely used in the construction of large complicated systems. In the multi-agent system (MAS), each agent is given autonomy, sociality, and initiative. Therefore the MAS can solve complex problems stably and efficiently through flexible information interaction among various agents. During the research of FJSP, considering the complex and ever-changing manufacturing environment in which the company is located, this paper takes aim at constructing a flexible production dynamic scheduling system with multi-agent theory, and the main work as follows:

(1) The multi-Agent based structure model of flexible production dynamic scheduling system is established. This paper analyzes the actual requirements of enterprise production management process and divides the business into five types of agents including management agent, resource agent, algorithm agent, process agent and monitor agent. The resource agents are build as resource agent group with Hierarchical control structure base on the distribution of enterprises’ manufacturing resources. Also the resource agent group and other agents are connected with a distributed structure.

(2) This paper defines cooperative mode between Agents in MAS under distributed manufacturing environment. The central idea is to ensure the high efficiency of the system's production scheduling and the rapid response to the production environment by regulating the interaction of information between agents. Therefore, it defines cross-regional production task decomposition strategy and abnormal scheduling strategy. The former strategy aims to utilize enterprise’s distributed resources and technologies located in different regions through the process of decomposition and distribution of production tasks; the latter strategy defines the consultations and cooperation between Agents when abnormal factors such as equipment failures and emergency orders occur to achieve rapid response to the dynamic manufacturing environment.

(3) This paper apply an improved ant colony algorithm to solve the scheduling problem in FJSP. The objective of the scheduling system is to minimize the makespan. Considering there are some disadvantages when using traditional ant colony algorithm to solve FJSP such as slow convergence speed, easily to stagnation, an improved ant colony optimization based on the flexible process planning features of FJSP is proposed in this paper, and the main improvements are to redefine pheromone updating rule and uniformly distribute the initial position of the ants. This improved algorithm is encapsulated in the algorithm Agent which provides computing services to the resource agent group.

(4) The flexible production dynamic scheduling system based on multi-agent is implemented. Based on the distributed structure model, this paper designs the software architecture for the scheduling system. During the implementation of the system, this paper use object-oriented technology to encapsulate the properties and function of each Agent. This paper design communication mechanism based on TCP/IP Socket. Also the communication model of Agent is implemented by thread pool and message queue. Finally, this paper verifies the effectiveness of improved ant colony algorithm, cross-regional production task decomposition and abnormal scheduling strategy via this scheduling system.

Key Words: dynamic scheduling system, multi-agent system, flexible job shop scheduling problem, distributed resource, improved ant colony optimization, system development