Chapter 1
Scheduling in Flexible Manufacturing Systems: Genetic Algorithms Approach

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ABSTRACT

Flexible manufacturing systems have many advantages like adaptation to changes and reduction of lateness. But flexible machines are expensive. The scheduling is a central functionality in manufacturing systems. Optimizing the job routing through the system, while taking advantage from the flexibility of the machines, aims at improving the system's profitability. The introduction of the flexibility defines a variant of the scheduling problems known as flexible job shop scheduling. This variant is more difficult than the classical job shop since two sub-problems are to be solved the assignment and the routing. To guarantee the generation of efficient schedules in reasonable computation time, the metaheuristic approach is largely explored. Particularly, much research has addressed the resolution of the flexible job shop problem by genetic algorithms. This chapter presents the different adaptations of the genetic scheme to the flexible job shop problem. The solution encodings and the genetic operators are presented and illustrated by examples.

INTRODUCTION

Flexible manufacturing systems are characterized by multipurpose operations and flexible job routing. A multipurpose operation can be processed at least by one machine, with possibility of variable performances. In ordinary systems, the route of every job is fixed and every operation of a job is allocated to

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a unique machine. In flexible manufacturing, an operation can be allocated to a suitable machine from a set of alternatives which are identical or similar in functionalities. One can distinguish two types of flexible manufacturing systems: totally flexibility where every operation can be processed by every machine and partially flexible systems where a pool of machines is associated to each operation (Figure 1).

A fabrication order can evolve in the system through different paths. It can visit the same machine more than once. The flexibility has demonstrated its efficiency for system performance by reducing latencies and work in progress. Flexible machines allow rapid adaptation to changs and re-routing flexibility in presence of breakdowns or bottlenecks. Flexible manufacturing systems have a high development cost since flexible machines are more expensive than the mono-purpose ones. The scheduling functionality is a central key of profitability in flexible manufacturing systems. The allocation in space (machines) and in time of parts processing have to be optimized to take advantage from machine flexibility.

The use of flexible machines defines a generalization of the scheduling problem known as the flexible job shop problem (FJSP). This problem has attracted many researches. Due to the combinatorial number of possible schedules and the strongly NP-hard nature of FJSP (Garey et al., 1976), exact methods that can guarantee solution optimality will not return results in a reasonable amount of time. Indeed, a significant attention has been paid in the literature to techniques of achieving efficient approximation algorithms which offer a good compromise between computation time and solutions qualities including genetic algorithms, tabu search, simulated annealing among other heuristics and metaheuristics.

Actually, much research literature addressed the genetic algorithm approach to solve the FJSP because of their ability to perform global search and provide good solutions in a short computation time. Otherwise, crossover and mutation operators in a genetic process can easily combine affectation schemes and adopt different sequencing strategies to conduct an effective parallel and sampled search to intelligently locate promising area in the solution space. The objective of this chapter is to present how the genetic resolution scheme was adapted to solve the flexible job shop problems. The solution encoding and the genetic operators, crossover and mutation, are described and illustrated with examples.

Figure 1. Flexible manufacturing systems