Giffler and Thompson Procedure Based Genetic Algorithms for Scheduling Job Shops

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Summary. This chapter addresses two well known job shop problems, namely the classical job shop scheduling problem (JSP) and the flexible job shop scheduling problem (FJSP). Both of them belong to the category of the toughest NP-hard problems. Genetic algorithm (GA) based heuristics that have adopted Giffler and Thompson (GT) procedure, an efficient active feasible schedule generation methodology for JSP, are discussed to solve the following job shop scheduling (JSS) models: JSP for single-objective criterion (minimization of makespan time), JSP for multi-objective criterion (minimization of weighted sum of makespan time, total tardiness and total idle time of all machine) and FJSP for makespan time criterion. The chromosome representation of the GAs proposed for the JSPs is the combination of priority dispatching rules '*pdrs*' (independent *pdrs* one each for one machine), which on decoding provides an active feasible schedule using GT procedure. The chromosome representation of the GA for FJSP consists of two strings of size equal to the total number of operations: one string for machine assignment that reduces the FJSP to a fixed route JSP and the other string is a permutation representation of priority numbers each corresponding to an operation that is used for resolving the conflict that arises while generating actives feasible schedules with GT procedure. The performance tests and validations of the proposed GAs are discussed along with future research directions.

1 Introduction

Scheduling involves the allocation of resources over a period of time to perform a collection of tasks (Baker 1974). It is a decision making process that exists in most manufacturing and production systems, transportation and distribution settings and in most information-processing environments (Pinedo 2005). Scheduling in the context of manufacturing systems refers to the determination of the sequence in which jobs are to be processed over the production stages, followed by the determination of the start-time and finish-time of processing of jobs (Conway et al. 1967). An effective schedule provides the basis for utilizing the plant effectively and attaining the strategic objectives of the firm as reflected in the production plan.

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The most common manufacturing system worldwide is the job shop. Job shops are associated with the production of small volumes/large variety products and operate in a make-to-order environment (Groover 2003). Hoitomt et al. (1993) mentions that approximately 50 to 75 % of all manufactured components fall into this category of low volume/high variety and due to the market trends this percentage is likely to increase. Even though flexible manufacturing systems are today's keywords that frequently appear in many research agendas, scheduling of job shops still receive ample attention from both researchers and practitioners due to the reason that job shop scheduling problems exist in many forms in most of the advanced manufacturing systems (Kutanoglu and Sabuncuoglu 1999). Besides, analysis of job shop scheduling problems provides important insights into the solution of the scheduling problems encountered in more realistic and complicated systems (Pinedo 2005). In this context, this chapter focuses on scheduling job shops which is an important task for manufacturing industry in terms of improving machine utilization or reducing lead time or adhering to due dates.

1.1 Job Shop Scheduling Problems

The classical job shop scheduling problem (JSP) is the most popular scheduling model in practice (French 1982, Brucker 1995, Pinedo 1995). It has attracted many researchers due to its wide applicability and inherent difficulty (Jain and Meeran 1999). The formulation of the JSP is based on the assumption that for each part type or production order (job) there is only one processing plan, which prescribes the sequence of operations and the machine on which each operation has to be performed. The n x m classical JSP involves n jobs and m machines. Each job is to be processed on each machine in a predefined sequence and each machine processing only one job at a time. It is also well known that JSP is NP-hard (Garey et al. 1976).

In practice, the shop-floor setup in a job shop typically consists of multiple copies of the most critical machines so that bottlenecks due to long operations or busy machines can be reduced (Ho et al. 2007). Therefore, an operation may be performed on more than one machine. Job shops also consists of multipurpose machines such as numerically controlled (NC) machines that are loaded with tool magazines and are capable of performing several different types of operations (Vaikartarakis and Cai 2003). Due to the overlapping capabilities of these machines, a given operation can be performed by more than one machine. However, in real life it has been a practice that machining operations are assigned to a certain machine tool during the process planning stage and the assignment of machine tools over time to different operations is performed during the scheduling stage. Recently, researchers considered the integration of process planning with scheduling by allowing alternative machine tool routings for operations at the scheduling stage (Hankins et al. 1984, Chryssoulouris and Chan 1985, Wilhelm and Shin 1985).

Unlike the JSP, the research on jobs shop scheduling associated with multiple routings is rather very limited even though it has more practical applications and advantages than the JSP. Two different scheduling models of job shop associated with multiple routings are addressed in the literature. The first model is referred as job shop scheduling with alternative machine tool routings, which was first addressed by Iwata et al. (1978). The same model was later addressed by Brandimarte (1993) as flexible job shop scheduling problem (FJSP). The second model is usually referred as job