

Chapter 3.5

Hybrid Meta-Heuristics Based System for Dynamic Scheduling

Ana Maria Madureira
Polytechnic Institute of Porto, Portugal

INTRODUCTION

The complexity of current computer systems has led the software engineering, distributed systems and management communities to look for inspiration in diverse fields, e.g. robotics, artificial intelligence or biology, to find new ways of designing and managing systems. Hybridization and combination of different approaches seems to be a promising research field of computational intelligence focusing on the development of the next generation of intelligent systems.

A manufacturing system has a natural dynamic nature observed through several kinds of random occurrences and perturbations on working conditions and requirements over time. For this kind of environment it is important the ability to efficient and effectively adapt, on a continuous

basis, existing schedules according to the referred disturbances, keeping performance levels. The application of Meta-Heuristics to the resolution of this class of dynamic scheduling problems seems really promising.

In this article, we propose a hybrid Meta-Heuristic based approach for complex scheduling with several manufacturing and assembly operations, in dynamic Extended Job-Shop environments. Some self-adaptation mechanisms are proposed.

BACKGROUND

Scheduling Problem

The planning of Manufacturing Systems involves frequently the resolution of a huge amount and variety of combinatorial optimisation problems with an important impact on the performance of

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manufacturing organisations. Examples of those problems are the sequencing and scheduling problems in manufacturing management, routing and transportation, layout design and timetabling problems.

Scheduling can be defined as the assignment of time-constrained jobs to time-constrained resources within a pre-defined time framework, which represents the complete time horizon of the schedule. An admissible schedule will have to satisfy a set of constraints imposed on jobs and resources. So, a scheduling problem can be seen as a decision making process for operations starting and resources to be used. A variety of characteristics and constraints related with jobs and production system, such as operation processing time, release and due dates, precedence constraints and resource availability, can affect scheduling decisions (Leung, 2004) (Brucker, 2004) (Blazewicz, Ecker & Trystrams, 2005) (Pinedo, 2005).

Real world scheduling requirements are related with complex systems operated in dynamic environments. This means that they are frequently subject to several kinds of random occurrences and perturbations, such as new job arrivals, machine breakdowns, employees sickness, jobs cancellation and due date and time processing changes, causing prepared schedules becoming easily outdated and unsuitable. Scheduling under this environment is known as dynamic.

Dynamic scheduling problems may be classified under deterministic, when release times and all other parameters are known and fixed, and under non-deterministic when some or all system and job parameters are uncertain, such as when jobs arrive randomly to the system, over time.

Traditional heuristic scheduling methods, encounter great difficulties when they are applied to some real-world situations. This is for three main reasons. Firstly, traditional scheduling methods use simplified and deterministic theoretical models, where all problem data are known before scheduling starts. However, many

real world optimization problems are dynamic and non-deterministic and, in which changes may occur continually. In practice, static scheduling is not able to react dynamically and rapidly in the presence of dynamic information not previously foreseen in the current schedule.

Secondly, most of the approximation methods proposed for the Job-Shop Scheduling Problems (JSSP) are oriented methods, i.e. developed specifically for the problem in consideration. Some examples of this class of methods are the priority rules and the Shifting Bottleneck (Pinedo, 2005).

Finally, traditional scheduling methods are essentially centralized in the sense that all the computations are carried out in a central computing and logic unit. All the information concerning every job and every resource has to go through this unit. This centralized approach is especially susceptible to problems of tractability, because the number of interacting entities that must be managed together is large and leads to a combinatorial explosion. Particularly since, a detailed schedule is generated over a long time horizon, and planning and execution are carried out in discrete buckets of time. Centralized scheduling is therefore large, complex, and difficult to maintain and reconfigure. On the other hand, the inherent nature of much industrial and service process is distributed. Consequently, traditional methods are often too inflexible, costly, and slow to satisfy the needs of real-world scheduling systems.

By exploiting problem-specific characteristics, classical optimisation methods are not enough for the efficient resolution of those problems or are developed for specific situations (Leung, 2004) (Brucker, 2004) (Logie, Sabaz & Gruver, 2004) (Blazewicz, Ecker & Trystrams, 2005) (Pinedo, 2005).

Meta-Heuristics

As a major departure from classical techniques, a Meta-heuristic (MH) method implies higher-level strategy controlling lower-level heuristic methods.

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