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A generic decision support tool to planning and assignment problems: Industrial application & Industry 4.0

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Abstract

Decision support tools are essential to help the management of industrial systems at different levels: strategic to size the system; tactical to plan activities or assign resources; operational to schedule activities. We present a generic and modular decision support tool to solve different problems of planning, assignment, scheduling or lot-sizing. Our tool uses a hybridization between a metaheuristic and a list algorithm. The specification of the considered problem is considered into the list algorithm. Several tactical and operational problems have been solved with our tool: a problem of planning activities with resources assignment for hospital systems, a lot-sizing and scheduling problem taking into account the setup time for plastic injection, and a scheduling problem with precedence constraints. At the strategic level, this tool can also be used as part of the Industry 4.0 to design reconfigurable production systems. This paper summarizes some problems solved with the proposed tool, and presents the evolution of our tool.

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Keywords: Agile manufacturing; Scheduling algorithms; Heuristic searches; Resource allocation; Industrial production system.

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1. Introduction

Industry 4.0 is the main international program which aims at improving the operational system in companies. More
companies are concerned by this approach. Thanks to Internet of things, “things” are connected to ease the communication, but other improvements may be envisaged. An integration of the whole production system is needed. Managers need to fully control the production, the actual one and the future one. Decision Support Systems are needed to help managers to decide. Because of Industry 4.0, more data are available, more variability can be considered, so DSS become necessary. How can the future demand be integrated without major changes in the actual layout? The production system needs to be flexible to face the variety of products and the quantities of products. A lot of problematics are concerned by this 4th industrial revolution: sizing of the shop floor, sizing of resources, planning of activities, assignment of resources, scheduling of activities. To propose some decision support tools to help the manager, new trends need to be considered such as continuous improvement, Big Data or collaborative robotics [1]. For instance, it would be necessary to use the data in the shop floor to treat them in real time to adapt the schedule and the planning to the hazards, a link with the used ERP by the company needs to be done. Thanks to collaborative robotics, flexible production means can be used in our future flexible and agile production system, which will be reconfigurable. Many companies are actually thinking about converting their actual system into a reconfigurable production system.

We propose a decision support tool which can be used to design reconfigurable production system. At a beginning, three static problems have been studied, in which the demands are already known. We focused on many problems: planning, scheduling, resources assignment. These problems can be summarized: they represent a system in which activities have to be done over a horizon planning. Each activity has some characteristics such as processing time and needed resources. Some resources are available to process the activities. The system is ruled by some constraints. Different objectives can be achieved such as optimizing the productivity of the system. Once this tool has been validated for the static problems, we can focus on the dynamics ones: the demands are not completely known, they can vary in quantity and/or variety of products.

Section 2 presents the generic and modular decision support tool we developed. Some examples of problems that have been identified and solved are presented in Section 3. Our future work will focus on the reconfigurable production systems, presented in Section 4. This paper ends by a conclusion in Section 5.

2. Generic and modular decision support tool

2.1. Genericity

The proposed tool, illustrated by Fig. 1, uses a hybridization of a metaheuristic and a heuristic, specifically a list algorithm. A single solution based metaheuristic or a population based metaheuristic can be used. The encoding used by the metaheuristic is a list Y of activities. List algorithm L considers the activities according to their order in list Y, to plan and assign them to the required resources, considering the problem constraints. This builds solution X. Objective function H evaluates solution X. According to this evaluation, the solution is chosen or not by the metaheuristic. At the end of the computation, the given solution by the hybridization is the best list Y^* of activities: the one which optimizes the objective function by applying the list algorithm. This hybridization can be used to solve many problems: only the list algorithm and the objective function need to be specific to the considered problem by integrating the different constraints which rule the system, and the objectives to achieve.

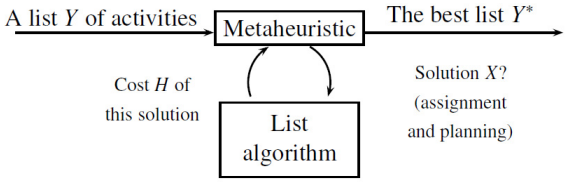

Fig. 1. Hybridization Metaheuristic – List algorithm