Planning and Scheduling
An Overview

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Abstract. In this paper, we give a short overview on the AI-fields Planning and Scheduling.

1 Introduction

The fields of Planning, Scheduling and Configuration have many things in common and are often tackled by similar techniques. The general topics of interest in these fields include: applications and architectures, knowledge representation and problem solving techniques, domain-specific techniques, heuristic techniques, distributed problem solving, constraint-based techniques, iterative improvement, integrating reaction and user-interaction, learning in the context of planning, scheduling and configuration.

2 Planning and Scheduling

Planning and scheduling are research as well as application areas that have quite a lot of interdependencies to configuration. Therefore, both will be described here and the relations to configuration will be shown. From this we see the need for a regular exchange of ideas between the groups working on these topics. As a consequence, a GI[1] special interest group covers the areas of planning, scheduling, design and configuration (PuK)[2].

Planning and scheduling have common subjects but also differ in some ways. Both rely on activities that have to be performed in order to achieve given goals. All the activities need resources and a set of constraints has to be observed in order to get valid solutions. Sometimes even a definition of optimality for the solution is given. The result of both planning and scheduling is often called a *plan*, but we will differentiate between *plan* and *schedule*. One of the main differences between planning and scheduling is the use of temporal issues. Scheduling in nearly all cases has to deal with concrete temporal assignments of activities to resources, whereas planning mainly deals with the order in which the activities have to be performed, i.e. planning focuses on "what has to be done" whereas scheduling focuses on "when this has to be done".

[1] http://www.gi-ev.de
[2] http://www-is.informatik.uni-oldenburg.de/~sauer/puk/puk.html

Artificial Intelligence (AI) provides not only the paradigms for problem solving but also the representation formalisms which allow the explicit representation and use of knowledge in investigated domains.

2.1 Planning

The task of planning is to find control algorithms that enable agents of all kinds (robots, humans, machines etc.) to synthesize courses of action that achieve their goals [1, 2, 4]. Generally, for the definition of a planning problem one needs a description of the initial world, a description of the goals – i.e. the situation of the world to be achieved, and a set of possible actions that can be performed and lead to changed situations. The plan as the output of the planning process then shows the sequence of actions to be executed in order to achieve the desired goal.

Research develops formalisms for an effective modeling of the situations and actions and for the implementation of planning algorithms that solve planning problems at hand. Widely used is a representation based on logic and algorithms for efficiently searching the combinatorial search space. Most of the systems developed are domain-independent and therefore allow planning in different application areas.

Application areas of planning range from process and project planning (e.g. ship building, shuttle maintenance etc.) to special problems like elevator control. Very popular are the planning systems competitions held in conjunction with the AIPS (AI Planning Systems Conference) which is one of the main forums on the subjects of AI planning and scheduling.

2.2 Scheduling

Main task of scheduling is the creation of schedules, which are temporal assignments of activities to resources where a number of goals and constraints have to be regarded [3]. The order of activities can be an output of a planning system. For the definition of a scheduling problem we therefore need the activities to be scheduled, the resources to be used by these activities and constraints (e.g. technical restrictions on the use of resources that must be regarded or economical constraints) that should be fulfilled, e.g. reducing the cost of inventory. Additionally, goal functions are often used to compare solutions or to find "optimal" solutions.

Scheduling problems can be found in several different application areas, e.g. the scheduling of production operations in manufacturing industry, computer processes in operating systems, truck movements in transportation, aircraft crews, etc.

Research develops algorithms that find or create schedules of the activities over a longer period. This is called predictive scheduling and assumes a stable environment. In real world scheduling scenarios this is hardly the case, so the other important task of scheduling is the adaptation of an existing schedule due to actual events in a dynamic environment, e.g. breakdowns of resources or

changing demands for products. This is called reactive scheduling and up to now often ceded to human schedulers who have to repair the schedules using their knowledge and experience in the particular domain.

Most scheduling systems rely on rule- and constraint-based representation of scheduling knowledge and for the creation, respectively adaptation, of schedules, all kinds of AI problem solving approaches have been investigated. Most popular are heuristics and constraint-based approaches, but we also find genetic algorithms, iterative improvement strategies, fuzzy systems, neural networks and case-based reasoning approaches.

Because there are several application areas for scheduling, especially within engineering and economics, there are a lot conferences where the research results are presented. These range from meetings of the AAAI special interest group on manufacturing (SIGMAN) over IJCAI workshops, the IAAI (Innovative Applications of AI) and AIPS to conferences on system sciences.

2.3 Exchanging Ideas of Planning and Scheduling

Exchange of ideas in all the areas mentioned above is motivated due to the following issues:

- In some application areas, planning and scheduling tasks are strongly interconnected, e.g. in some parts of steel production where the production process and the production schedule have to be determined for every new production order. Therefore one of the research tasks is the combination of planning and scheduling to find the best solutions for those kinds of problems.
- Plans and schedules usually are created within a dynamic environment where the plan or schedule often becomes invalid due to events from the environment. So there is the need for an adaptation to the actual situation. Therefore plan repair and reactive scheduling are important research areas acting on similar topics.
- All the areas use similar AI paradigms for problem solving as well as for representation issues. In some cases, the problem description (e.g. when using AND/OR trees in scheduling and configuration) and the search space look quite similar, so results of the research activities may easily be adapted to the other domain.

3 Summary

In this paper, we give an overview of existing scheduling, planning, methods.

References

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