Visopt ShopFloor System: Integrating Planning into Production Scheduling

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Abstract

Traditional planning deals with the problem of finding activities to satisfy a given goal while traditional scheduling solves the problem of allocating known activities to limited resources and to limited time. In many real-life problems both tasks should be accomplished together. We give an example of such integrated planning and scheduling problem and in the software demonstration we show how the problem is solved by the Visopt ShopFloor system

Keywords: applications of planning and scheduling, planning and scheduling with complex domain models, constraint reasoning for planning and scheduling

Introduction

Integrating planning and scheduling is a hot research topic especially in the planning community. This integration usually means adding time and resource restrictions to the planning problem. Because solving traditional planning problems is hard, adding time and resource constraints may make the problem even harder. Therefore, some researchers propose to keep planning and scheduling separated (Srivastava and Kambhampati, 1999). In particular, the planning problem is solved first, i.e., the set of activities is generated, and the scheduling problem is solved next, i.e., the activities are allocated to resources and to time. This is useful, if the planning space is large - if it is hard just to find a valid plan. However, in many real problems it is pretty easy to find a valid plan but it is more complicated to find a good plan in respect to available resources and time. In (Barták, 1999b) we argued for a more tighten integration of planning and scheduling where time and resource constraints play an important role in guiding the planner. The basic idea is to post time and resource constraints as soon as the planner introduces some activity. Then these constraints help the planner to decide among the alternative activities in a forward or backward chaining style of planning.

An Example Problem

Let us consider the following problem where the goal is to plan/schedule production on two machines in such a way that the user demands are satisfied. The machines may run either in a parallel mode or in a serial mode (Figure 1). In the parallel mode, the batches of both machines run in parallel and a worker is required. One final item is outputted from the batch and duration of this batch depends on the experience of the worker (see below). In the serial mode, the first machine pre-processes the item (3 time units) that is finished in the second machine (additional 3 time units). There is no delay for moving the item from the first resource to the second resource.

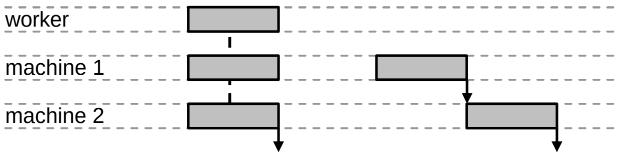

Figure 1. The final product can be produced either via a parallel production when two machines run in parallel and a worker is required (left) or via a serial production when the item is pre-processed in the first machine and then finished in the second machine (right).

During the parallel production, a by-product is produced. This by-product can be recycled only on the second machine and we need three by-products to get a single final item. Recycling takes 2 time units and it must be done immediately after the three batches of the parallel processing.

Both machines require cleaning after eight production batches or sooner and the cleaning must be done at the same time on both machines. Moreover, cleaning cannot be done if there is some non-processed by-product. At the beginning, both machines are clean.

The above transition scheme can be easily described via a state transition graph where each state is tagged by a minimum and a maximum number of batches processed in this state (Figure 2).

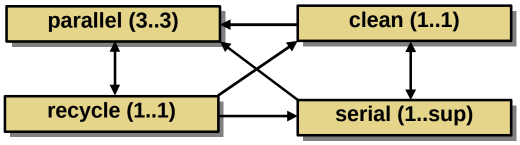

Figure 2. Behaviour of the second resource can be described using states with a minimum and a maximum number of batches per state (in brackets) and using a transition scheme between the states.

The worker, who is necessary for parallel processing, is a beginner. After four production batches, the worker becomes experienced. The parallel production takes 3 time units for the beginner and 2 time units for the experienced worker. Moreover, the worker is available only in the following time windows (0..10), (30..40), (60..70).

The task is to plan/schedule production starting from time 0 in such a way that 5 final items are ready at time 20 and additional 25 items are ready at time 100.

Visop ShopFloor At A Glance

Visopt ShopFloor is a commercial system for production scheduling. The system is not designed for a particular factory but it can be applied to various scheduling problems. The main difference of Visopt ShopFloor from traditional schedulers is a tight integration of the planning component, i.e., the system plans what batches are necessary to satisfy the demands and it schedules the batches to available resources and time.

Visopt ShopFloor is particularly designed to solve complex problems like the example problem from the previous section. For these problems, it is typical to have resources with complex behaviour so sequencing of batches cannot be arbitrary. Moreover, there are several processing routes how to satisfy the demand and the choice of the route cannot be done in advance because it depends on the resource and time constraints. Notice that pure planning, i.e. the choice of batches to satisfy the demand, is rather easy there. What makes the problem complicated is integration of the scheduling constraints.

The Visopt ShopFloor system consists of two independent components: the ShopFloor graphical user interface for problem modelling and the solver. After modelling the problem, the ShopFloor GUI generates a formal model that is passed to the solver. The solver returns the plan (schedule) which is then displayed as a Gantt chart (Figure 3).

The solver behind the Visopt ShopFloor system is based on constraint satisfaction technology; it is completely implemented in SICStus Prolog, (currently version 3.8.7). We use the ideas of problem modelling described in (Barták, 1999a), more details about the system can be found in (Barták, 2002a). The paper (Barták, 2002b) describes how to model the complex transition schemes and the paper (Barták, 2003) explains what constraint technology is used to integrate planning into scheduling.

The Results

The Visopt ShopFloor is intended to solve scheduling problems which require some planning capabilities. In particular, batches are planned during scheduling because their appearance depends on allocation of neighbouring batches like in the example problem.

Figure 3 shows a Gantt chart of the plan produced by our solver (less than one second on 1.7 GHz Mobile Pentium 4). We can see that this plan satisfies all the production rules, in particular using the recycling and the cleaning batches. Also duration of the parallel batches decreases when the worker became experienced (roughly at time 35).

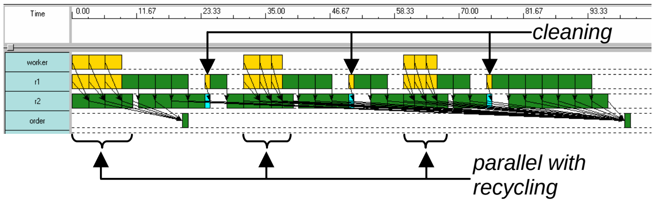

Figure 3. The Gantt chart of the plan for the example problem.

Acknowledgements

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