6-Tank-System: A Model-Factory for Patrol-Blending

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Introduction

Scheduling, especially production-scheduling has to cope with the complexity and uncertainty of the scheduling task. We have developed a framework called FReSCO (Framework to Represent and Solve Constraintbased Optimisationproblems) to tackle such problems [Pontow, 2001]. We want to extend this framework; especially its functionality to cope with the uncertainty in the problem and test it on a real system. We decided for a real system instead of a simulation because we expect to get a lot of unexpected behaviour and therefore real uncertainty that we do not get with a simulation. For this we have started to build up a model-factory for the patrol-blending in a refinery: the 6-tank-system, which is described in this technical report.

Patrol-Blending

In the following we describe the patrol-blending in the Holborn-Europe-Refinery in Hamburg, Germany that we want to model with our 6-tank-system [Glismann, 2001].
Blending patrol means mixing different components according to predefined recipes. Two different types of patrol (Regular and Premium) are produced mixing six different types of components (butane, heavy-cracked Naphta, light-cracked Naphta, isopentane, reformat and methyl-tertiary-butyl-ether (MTBE)). There are two so called blenders and each can produce both types of patrol. There are also six component-tanks and two product-tanks that must be considered in the scheduling problem. The component-tanks are continuously filled by the upstream refinery-facilities apart from the MTBE-tank; this component is purchased. The layout of the plant is given in Fig. 1.

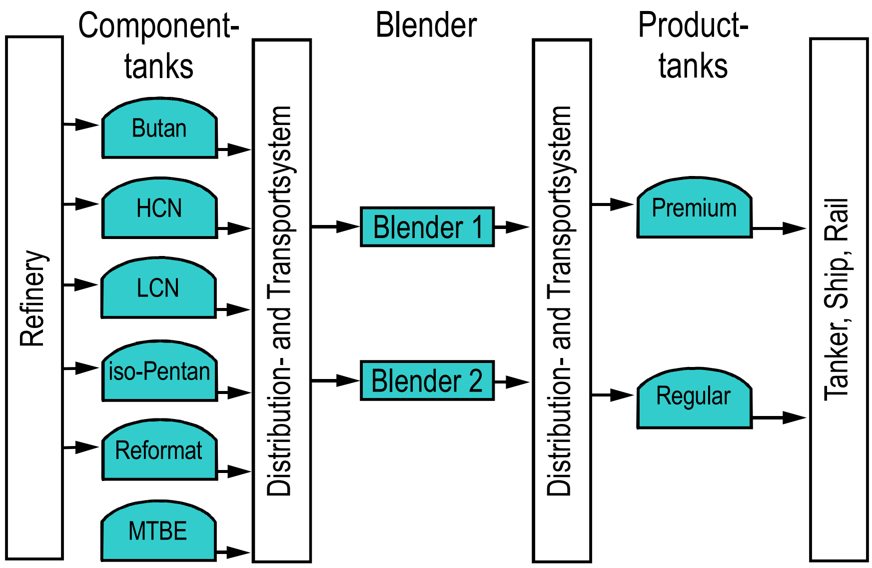

Fig. 1: Layout of patrol-blending facilities

The 6-tank-system

In the following we describe the layout of our model-factory that is derived from the patrol-blending facilities in the Holborn-Europe-Refinery.
The layout of our 6-tank-system is represented in Fig. 2. We have got six tanks equipped with a filling- and a draining-valve and three level- and one temperature-sensors; four of the tanks have also a heating facility. All tanks are connected by a pipe-system and two pumps can circulate the fluid in the pipe-system in the represented way according to the state of the electromagnetic valves. Pump1 can only operate on the first three tanks (Tank1.1, Tank1.2 and Tank1.3) whereas Pump2 can operate on all six tanks. The whole fluid in our model-factory comes out of the Reservoir.

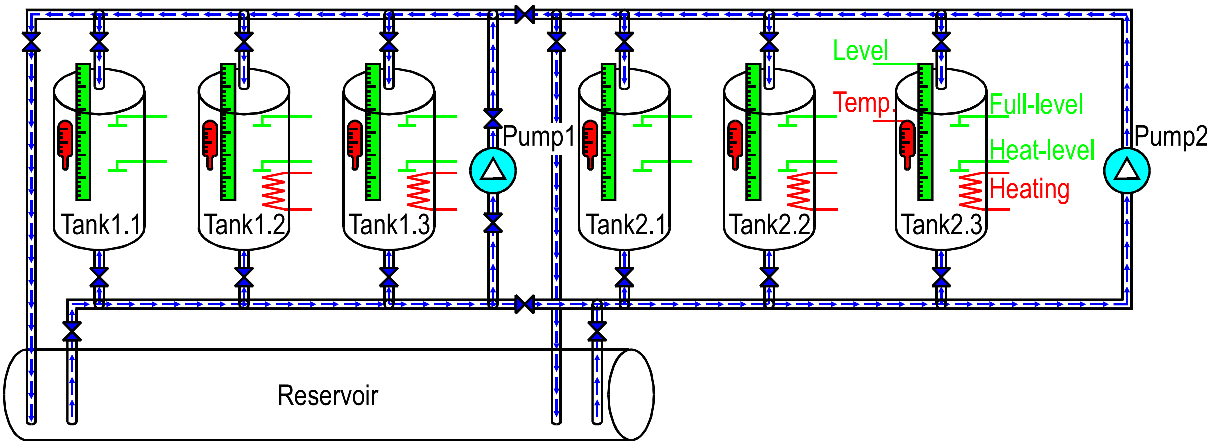

Fig. 2: Layout schema of 6-tank-system

Instead of producing patrol in our laboratory we produce hot water which is less dangerous. We have got four different component-tanks (Tank1.2, Tank1.3, Tank2.2 and Tank2.3) with water of four different temperatures (20°C, 25°C, 30°C and 35°C). Water of each temperature between 20°C and 35°C can be mixed from the water in the component-tanks according to the equation $T_{mix} = (m_1T_1+m_2T_2+m_3T_3+m_4T_4) / (m_1+m_2+m_3+m_4)$ known from thermodynamics but we define only a number of allowed products and allow only a few different recipes for the production of each product; an example is given in Tab. 1. The products are mixed in the blenders Tank1.1 and Tank2.1.

	Water 20°C	Water 25°C	Water 30°C	Water 35°C
Product 22.5°C	80%	0%	10%	10%
	70%	15%	10%	5%
	65%	20%	15%	0%
	50%	50%	0%	0%
Product 25°C	0%	100%	0%	0%
	50%	0%	50%	0%
	60%	0%	20%	20%
	30%	45%	20%	5%

Tab. 1: Recipes for waterproduction

The whole model-factory is controlled by two Siemens S7 PLCs (Programmable Logic Controllers). The S7 PLCs control the pumps and states of the valves. They also measure the temperatures and levels in the tanks. We want to implement an interface that bridges the gap between the scheduling-system (e.g. FReSCO) and the PLCs. The scheduling-system should communicate with the interface through a high-level data format (e.g. Gantt-charts). The interface should map these highlevel information into appropriate control commands for the PLCs. It also should compare the current state of the factory with the provided schedule and indicate a deviation. A possible structure for this communication is represented in Fig. 3.

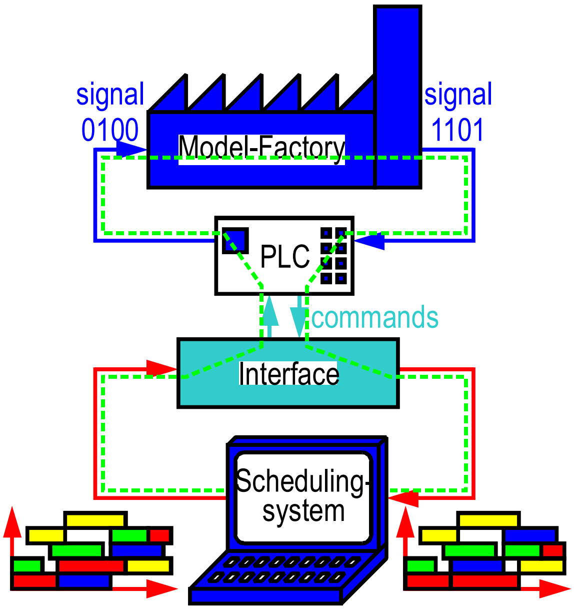

Fig. 3: Control-flow in the model-factory

In the refinery only the patrol-production-processes have to be scheduled under the consideration of time- and resource-restrictions. In our model-factory also the production of the components (hot water in the component-tanks) must be scheduled.
In the following we describe the processes and the needed resources. The production of a component requires the performance of two processes. During the first process the water is pumped by one of the pumps from the reservoir through the pipe-system into the component-tank. To perform this process a suitable pump, the pipe-system and a sufficient capacity in the tank must be available. During the second process the water must be heated to the predefined temperature. For this the heating facility of the tank is switched on and the water is circulated by a suitable pump from the draining-valve through the pipe-system and the filling-valve back into the component-tank.

The production of a product is a little bit more complicated. For each component that is needed for the product an own process is needed. During such process the component is pumped from the component-tank through the pipe-system by a suitable pump into one of the blender-tanks which is required to be empty. Afterwards the mixing process is invoked during which the water is circulated by a suitable pump from the draining-valve through the pipe-system and the filling-valve back into the blender-tank. The manufacture of the product finishes with a process that pumps the product through the pipe-system by a suitable pump back into the reservoir.
The relations between order, product, processes and resources in our model-factory can be represented using our generic application model (Fig. 4) [Pontow, 2001].

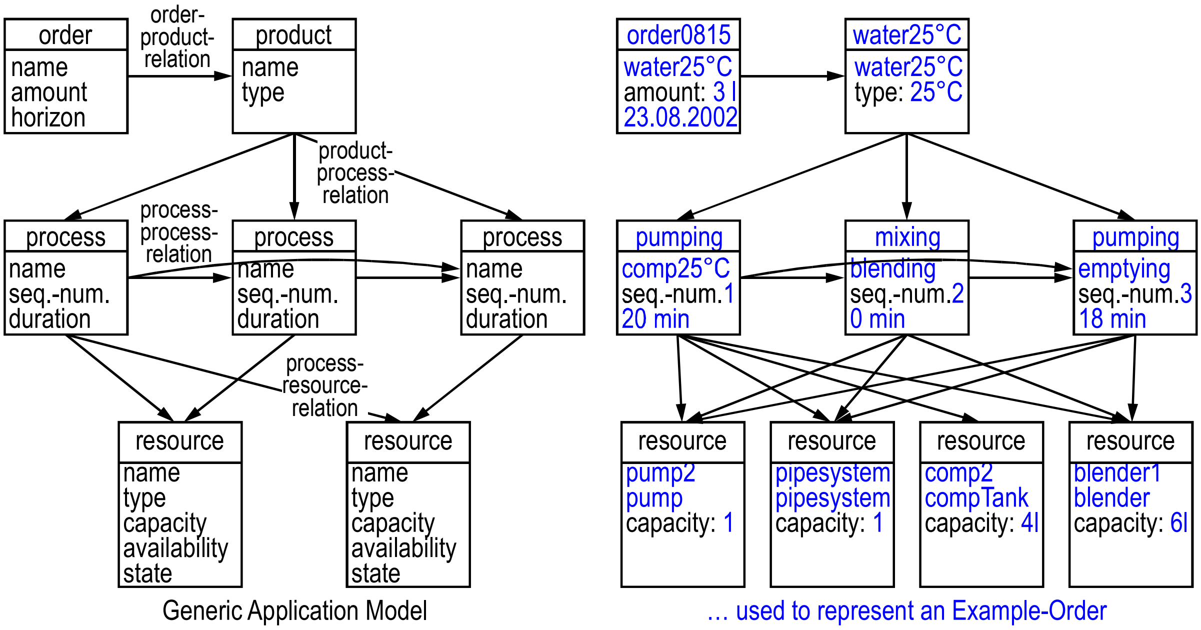

Fig. 4: Example for the representation of an order using the generic application model

Discussion of uncertainty

There are different sources of uncertainty in our model-factory. The main one is the reservoir which is used as the source for the component-tanks and also as product-tank, which results in a more or less unknown temperature of the water inside the reservoir. Some further sources of uncertainty of minor influence are listed below:

- Environmental temperature
- Volitional imprecision of the sensors
- Delivery rate of the pump (depending on the length of used pipes)

References

[Glismann, 2001] K. Glismann; *Integrierte Planung und Steuerung von Blending-Prozessen*; VDI Verlag; Düsseldorf; 2001

[Pontow, 2001] S. Pontow; *Theorie und Anwendung constraintbasierter Planungsverfahren*; Shaker Verlag; Aachen; 2000