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MAKE – A SYSTEM FOR MODELLING, OPTIMISING, AND ANALYZING PRODUCTION IN SMALL AND MEDIUM ENTERPRISES
A bit of history

A ten years ago ...
... there was SOFSEM 2002

- paper: Modelling Resource Transitions in Constraint-Based Scheduling
- Visopt ShopFloor system
  - generic scheduling engine based on constraint satisfaction
  - complex model
  - for large production companies (Tnuva, Degussa, Bayer, ...)

loading

cleaning

cooling

heating

unloading
This work

- scheduling again
- using constraint satisfaction techniques again
- but now for Small and Medium Enterprises

A new vision:

- using small and compact model to which complex problems are translated (reformulated)
- still using a generic scheduling engine (hence applying constraint satisfaction)
Motivation

- increased competition even for SMEs
- SMEs cannot move to low-wage areas
- SMEs can compete by built-to-order or even engineered-to-order high-quality products
  - high variability of products
  - low number of items
- this requires optimization techniques beyond the current practice (Excel sheets)
- SMEs cannot afford expensive and hard-to-customize optimization tools
Our goal

- Bring optimization technology to regular users that are not experts in optimization
- How?
  - familiar user interface
  - advanced and flexible optimization techniques
  - hidden from the user (no complex set-up)
  - full customization of produced results
MAK€ system

performance prediction and optimisation tool
1. specify how a particular product is manufactured
2. enter a work order from a customer
3. generate a schedule for the order
4. display the generated schedule in the form of a Gantt chart
The problem

- How to formally describe (manufacturing) processes?
- How to find a production plan/schedule?
- How to present the result to the user?
Problem formulation
Formal model

- description of workflow as a Temporal Network with Alternatives
- the first task is to select a valid process

The problem of selecting a problem containing given operations is **NP-complete**!

- typical workflows have a specific structure
Nested workflows

- workflow is obtained by task decomposition

The problem of selecting a valid process containing given operations is tractable.

However, if we add temporal constraints then the problem becomes NP-complete again.
Solving technology

- constraint satisfaction techniques
  - inference + search

- Variables
  - Boolean variables $V_X$ to describe selection of operation
  - temporal variables $T_X$ to describe time allocation

- Constraints
  - $V_X = \sum_{i=1,...,k} V_{Yi}$
  - $V_X \cdot V_Y \cdot (T_X + a) \leq T_Y \land V_X \cdot V_Y \cdot (T_Y - b) \leq T_X$.
  - $V_X \cdot V_Y \cdot (T_X + \text{Dur}_X) \leq T_Y \lor V_X \cdot V_Y \cdot (T_Y + \text{Dur}_Y) \leq T_X$.
Summary

- a novel formal model of workflows with a nested structure and alternatives
- theoretical complexity of the problems
- generic optimization techniques for generating production plans/schedules
- implemented and used in practice
Future?

Future is now!

- FlowOpt system
  - workflow editor enforcing the nested structure
  - verification of workflows prior optimisation
  - interactive Gantt Viewer with automated corrections
  - performance analyser

- Next steps
  - stronger analysis of factory performance
  - automated design of workflows
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