Constraint Checking for Business Process Management

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Constraint Checking for Business Process Management

Outline of the talk:

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1. Introduction

- Management of dependencies between business processes:
  - Problem: inconsistent process models – potential errors may occur at run-time.
  - Inconsistencies should be discovered in an early stage of modelling.
    - Reduce in time and cost of process maintenance.
    - Increased compliance to requirements on processes.
  - Requirements of business processes depend partly on complex relations between the processes.
  - Usually the results of a foregoing process are needed by a subsequent/concurrent one.

- Dependencies are relations between arbitrary attributes of business processes, examples are:
  - sequential dependencies
  - hierarchical dependencies
1. Introduction

... more precisely

- **Sequential dependencies:**
  - Relations between processes in a sequential order.
  - Relations between the input/output values: the output of a foregoing process is needed as input of a subsequent process.

- **Hierarchical dependencies:**
  - One or more processes can be sub-item(s) of a higher-ordered process.
  - Relations between lower and higher-ordered processes.
  - Relations between the input/output values of the first/last sub-process and the input/output of the higher-ordered process.
2. Consistent Configurations through Constraint Satisfaction

- Consistent configurations of business processes with methods out of the field of artificial intelligence (AI).
  - *Knowledge-based configuration*: using *constraint satisfaction* to model complex relations between (attributes of) components.

- *Constraints* as relations between attributes of processes:
  - algebraic constraints: intensional relations $\rightarrow$ equations/inequations
  - to reduce the possible assignments to variables (problem reduction)
  - for the (early) detection of inconsistencies
  - to generate solutions for a certain problem

- *Constraint Satisfaction*:
  - Characteristic: Propagation of changes throughout a “constraint net”.
  - Techniques for the handling of combinatorial and numerical problems.
A Constraint Satisfaction Problem (CSP) is a triple $CSP(V,D,C)$:

$V = \{v_1, \ldots, v_n\}$ a finite set of variables

$D = \{D_1, \ldots, D_n\}$ associated value domains $\{v_1 : D_1, \ldots, v_n : D_n\}$

$C$ a finite set of constraints $c_i(V_i)$, $i \in \{1, \ldots, m\}$, with

$c_i(V_i)$ to set the subset $V_i = \{v_{i_1}, \ldots, v_{i_k}\} \subseteq V$ in relation,

solution space for $c_i(V_i)$: $\{D_{i_1} \times \ldots \times D_{i_k}\}$

Example:

- Variables: $a$ and $b$ each with the value domain \{0,1,2,3,4,5,6,7,8,9\}
- Constraints: $a + b = 10$ and $a - b = 2$
- Solution: $a = 6$ and $b = 4$
- Note: Besides arithmetic domains also symbolic domains are feasible.
Example of a constraint graph: *map colouring problem*

nodes $\rightarrow$ constraint variables
edges $\rightarrow$ constraints

A possible solution for this CSP:

\[ X = \{\text{red, green, blue}\} \]
\[ Y = \{\text{red, green, blue}\} \]
\[ Z = \{\text{red, green, blue}\} \]
Example: *sequential dependency*

- A constraint has to be satisfied in order that a process is allowed to be the successor of a foregoing process.

![Diagram](image)

- Process 1: attribute: `a`  
  - Constraint pin: $v_1 \leftarrow a$
  - Constraint relations: $0 < v_1 + v_2 < 10$

- Process 2: attribute: `b`  
  - Constraint pin: $v_2 \leftarrow b$
3. Examples

Example: *hierarchical dependency*

- A constraint has to be defined to specify processes to be allowed to be nested sub-items of upper processes, in order to satisfy all requirements of super- and sub-processes.
4. Multi-Level Constraint Problem

• Goal: Handle different levels of nested business processes.

• Flexibility: Different layers of processes in hierarchies define different sub-problems.
  – the need to define different solutions strategies,
  – application of problem specific solving algorithms.

• For each sub-problem another solution strategy can be applied depending on:
  – the value domain of the involved variables,
  – the problem structure defined by the constraint net.

• Integration of local solutions of sub-processes has to be done on the higher-ordered level leading to global solutions and hence globally consistent configurations.
5. Static and Dynamic Use of Constraints

- **Usage of constraint relations for business processes:**
  - **static use → at modelling time:** consistent process model
  - **dynamic use → at runtime:** consistent state of a process instance

- **Static use at modelling time:**
  - constraints connect input/output variables or attributes of processes
  - test for solutions and/or inconsistencies of the static model
    - Example: \( a > b; a = [0..4], b = [5..9] \) → inconsistent model

- **Dynamic use at runtime:**
  - test for solutions and/or inconsistencies during the execution of the business processes
  - user input or calculation results lead to reduced solution space
    - Example: \( a \geq b; a = [0..9], b = [0..9] \) → user input: \( b = 5 \) → \( a = [5..9], b = 5 \)
6. Summary

• Management of dependencies between business processes.

• Avoiding inconsistencies in business process modelling using constraint satisfaction (static/dynamic use).

• Constraints can be used to define arbitrary relations between attributes of business processes, e.g.
  - sequential and
  - hierarchical dependencies.

• Nested sub-problems on different abstraction levels:
  - can be seen as multi-level constraint problem,
  - results have to be integrated to upper levels for global solutions.
Thank you for your attention!
Constraints, Constraint Satisfaction Problem

- **Constraints** as relations between attributes of processes:
  - algebraic constraints: intensional relations → equations/inequations
  - to reduce the possible assignments to variables (problem reduction)
  - for the (early) detection of inconsistencies

- **Constraint Satisfaction Problem (CSP):**
  - Characteristic: Propagation of changes throughout a “constraint net”.
  - Techniques for the handling of combinatorial and numerical problems.
  - In the focus of intensive research and experiences for decades.
  - Efficient algorithms and heuristics:
    - reduction of the problem size/solution space
    - efficient generation of solutions
    - guarantee that specific relations hold