Product/ion-Aware Modeling Approaches that Support Tracing Design Decisions

Christian Doppler Research Association
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Application Context

- Industry Partner: Large-scale Austrian engineering company with focus on engineering and construction of highly automated and high-speed discrete manufacturing systems.
- Multi-disciplinary (mechanical, software, electrical engineering).
- Highly complex production lines.
- Design decision consist of a scope, possible and concrete outcomes as well as rationales.
- Example: “Fragile Product” – Limited transportation speed as a parameter.
Context: Product - Process - Resource (PPR)\(^1\)

Related Work: Product & Process Modeling

**Product modeling**
- Focus on describing structures, assemblies and characteristics of products.

**Process modeling**
- Focus on describing relations, processes, and assembling sequences.
- Example solutions: BPMN 2.0, Petri Nets.

**Resource modeling**
- Focus on describing the structure and behavior of a production system.
- Example Solutions: UML Class Diagrams.
Key Goals:
- Identify promising modeling approaches that combine PPR concepts.
- Understand modeling capabilities to support tracing design decisions.

RQ1. What modeling approaches - in industrial informatics and in business informatics - combine process, product and resource modeling?

Approach:

• Following an adapted literature survey complemented with interviews with domain experts.
• Analysis of 45 Papers regarding modeling languages and requirements.

RQ2. What are PPR modeling capabilities and limitations of modeling approaches that combine process, resource, and product modeling, as foundation for tracing design decisions?

Approach:

• Assessment of existing solutions against identified requirements.
RQ.1 - Results

- Seven graphical modeling approaches identified.
- Elicited from literature and known or used by domain experts.

Observations:
- Most of the approaches focus on one/two aspects of PPR.
- Focus on processes: IDEF0, BPMN 2.0, eEPC, SysML-AD, Petri-Nets.
- Fundamental PPR Capabilities: Formal Process Description (FPD).
- Process descriptions for resources: Sequential Function Charts (SFC).

No “native” and visual PPR modeling approach.
RQ.2: What are **PPR modeling capabilities and limitations** of modeling approaches that **combine process, resource and product modeling** as foundation for **tracing design decisions**?

Which process modeling capabilities are needed?

Basic elements for modeling process engineering knowledge.
- P1 – Basic Workflow.
- P2 – Logical operations (not present in FPD or IDEF0).
- P3 – Meta-processes.
- P4 – Tasks.
- P5 – Comments (defined in BPMN but extensible for other approaches).
- P6 – Organizational Responsibilities (Swimlanes available for BPMN and UML).
## RQ.2 – Results – Tracing of Design Decisions

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Criteria for Tracing Design Decisions with PPR.
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### RQ.2 – Results – Consistency Checking Support

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**Criteria for Tracing Design Decisions with PPR.**
### RQ.2 - Result - Formal Process Description

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Criteria for Tracing Design Decisions with PPR.
RQ.1: Available modeling approaches to support PPR?
- Seven modeling approaches have been investigated.
- FPD supports basic PPR concepts that could be extended.
- However, no "native" and visual PPR modeling language.

RQ.2. Capabilities and limitations for tracing design decisions based on PPR modeling capabilities?
- No modeling approach meets all identified requirements.
- In the evaluation context, FPD provides a promising starting point, however,
  - Need for extensions
  - Hierarchy modeling only implicitly possible.
- No approach allows modeling consistency expressions!
Limitations, Conclusions, and Future Work

Limitations
• Focus on process-centered modeling.
• Focus on a selected set of modeling language approaches.
• Requirements definition driven by industry partner, i.e., they are domain specific.

Conclusion
• Domain experts depend on design decisions from earlier phases.
• Design decisions currently hard to trace throughout engineering roles and phases.
• Formal Process Descriptions (FPD) represent a promising starting point (including some limitations).

Future Work:
• Extend FPD for hierarchy and consistency modeling.
• Consideration of additional modeling approaches and requirements.
• Secure the engineering process for IPR concerns.
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