Collaborative Embedded Systems

CrESt

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Dealing with Dynamics and Uncertainty in Open Contexts

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Problem and Principle Solution

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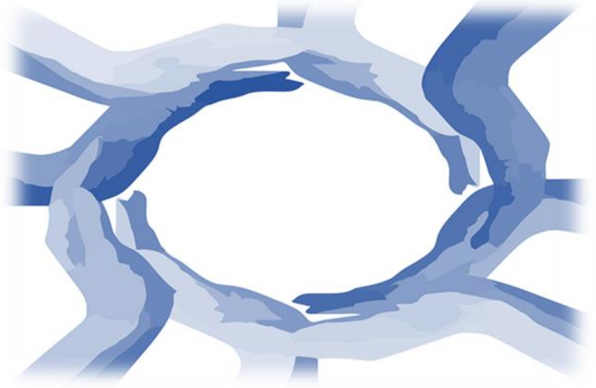
Dynamics and Uncertainty in Open Contexts

Dynamics:
- Collaborative Embedded Systems (CES) form Collaborative System Groups (CSG)
- CSGs can take multiple forms involving different CES

Uncertainty:
- Reliability of sensors, communications, and other systems
- Conflicting information among various sources providing aspects of the information

Open Context:
- No control over the operational context, i.e. the operational context can constantly change
- CES/CSG must properly operate in multiple context situations

Problem 1: It Depends on the Context



Collaborative CPS form groups to achieve goals that individual systems cannot achieve by themselves

Behavior emerges from the interplay of the connected systems that cannot be attributed to a single system

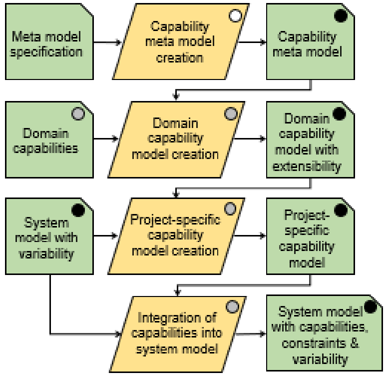
Collaborative group operates in multiple contexts with continuous changes in-between

How can we ensure that the system group is valid depending on its current context?

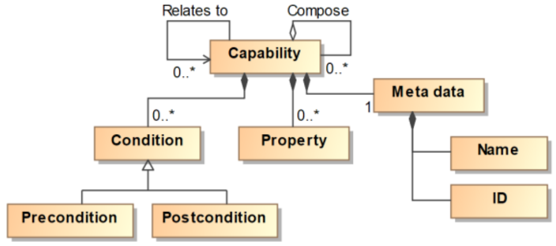
Capability Modeling & Matching

- Using capabilities to describe whether CESs are able to perform a specific task or achieve a certain goal
- Formalizing and documenting capabilities of CESs in capability models to enable their re-use
- Examination whether a CSG configuration actually provides the capabilities required by the context-dependent goal

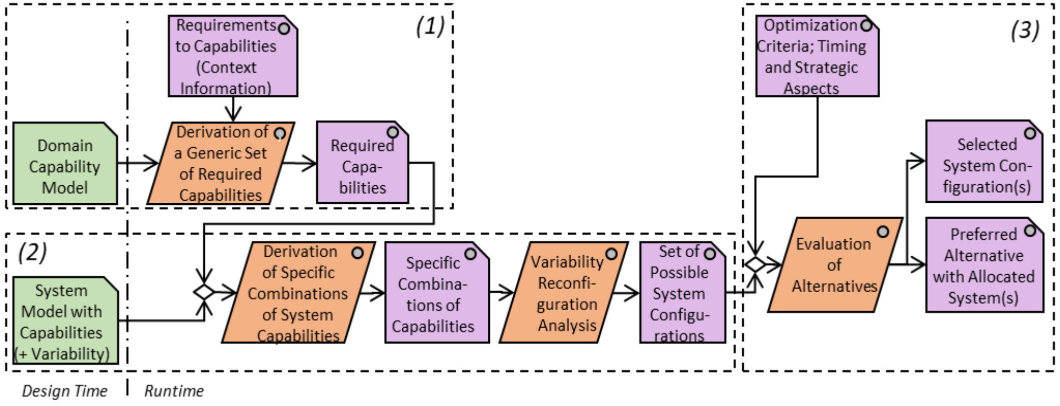
Capability modeling approach



Capability meta model



Matching method



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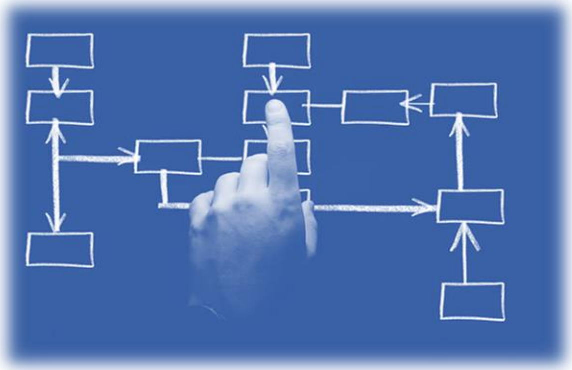
Problem 2: How Certain is the Context

Collaborative embedded systems operate in highly dynamic environments and face various uncertainties during operation

Systems need to be able to cope with such uncertainty autonomously during operation

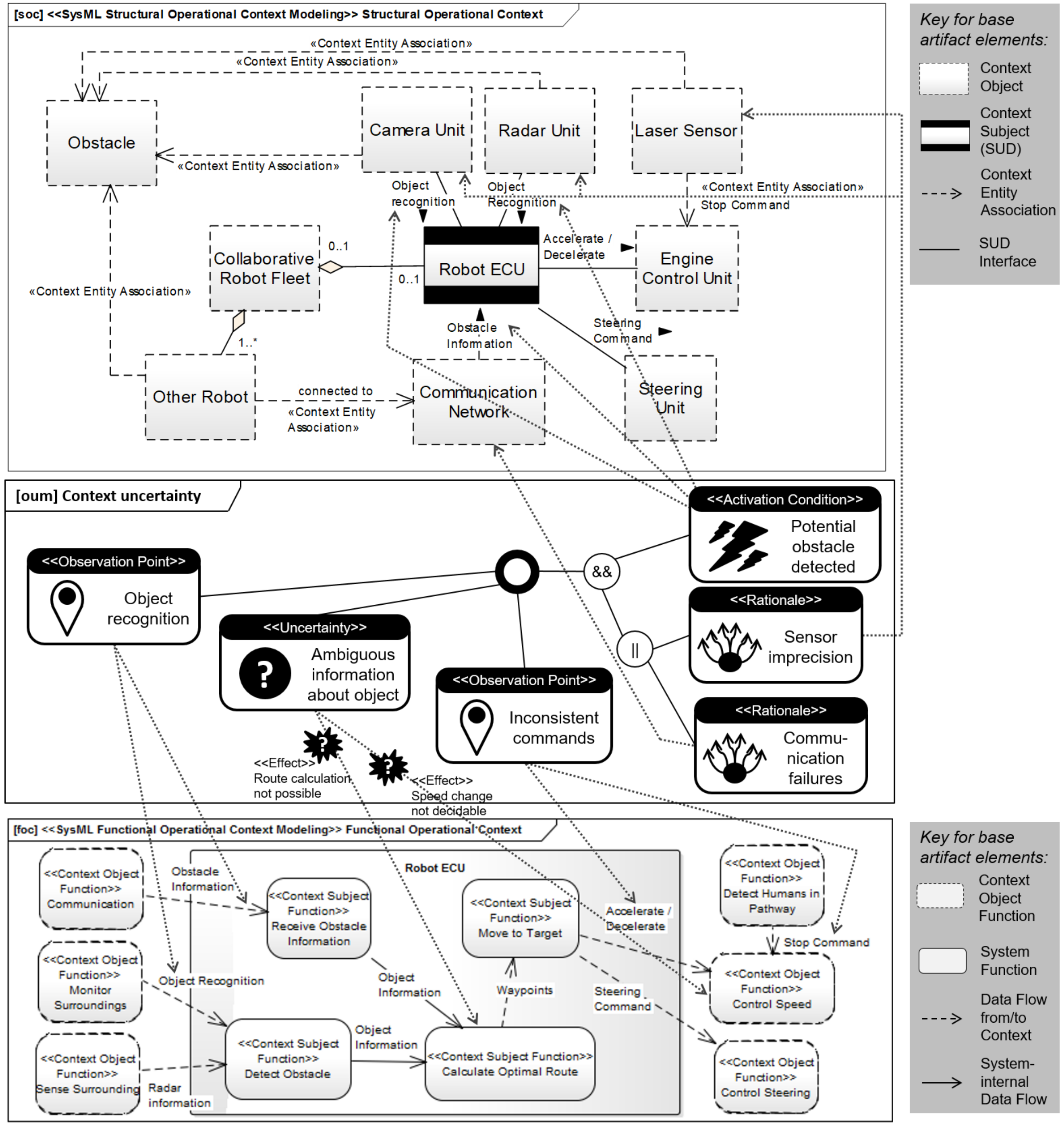


Especially in early phases, engineers and stakeholders need support in analyzing potential runtime uncertainty

How can we systematically consider uncertainties?

Uncertainty Modeling

- Uncertainty needs to be considered in different engineering artifacts throughout the entire development process
- Orthogonal uncertainty modeling allows to link effects, causes, and mitigations for uncertainties across multiple engineering artifacts
- This reduces redundancy while allowing for cross-relation analyses of uncertainty



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Application Example: Smart Factory

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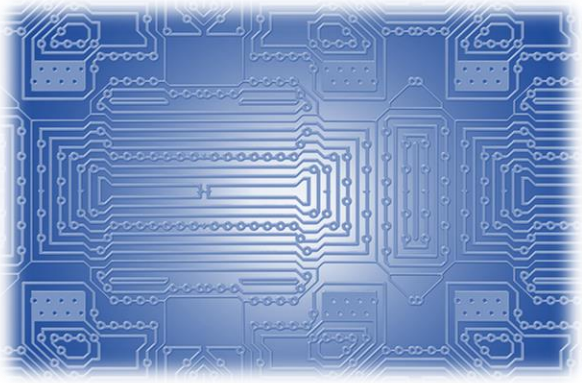
Use Case

Smart factories consist of mostly independent production systems that can be configured and combined individually based on the desired product



Reconfiguration:
Groups of production systems are fairly stable but modifiable (structural, temporal, functional)

General goal:
Coordination of resources so that desired products can be produced as efficiently as possible under changing constraints (e.g., availability of resources)

Problem:
Production request for an individualized product

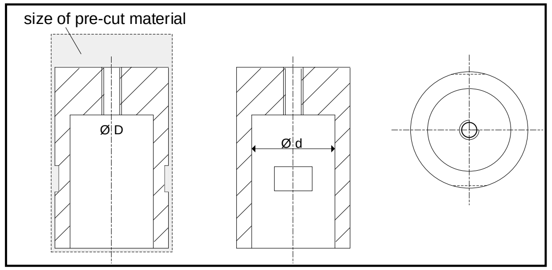
How can we examine whether the factory's collaborative production systems can form a suitable CSG for the fulfillment of this production request?

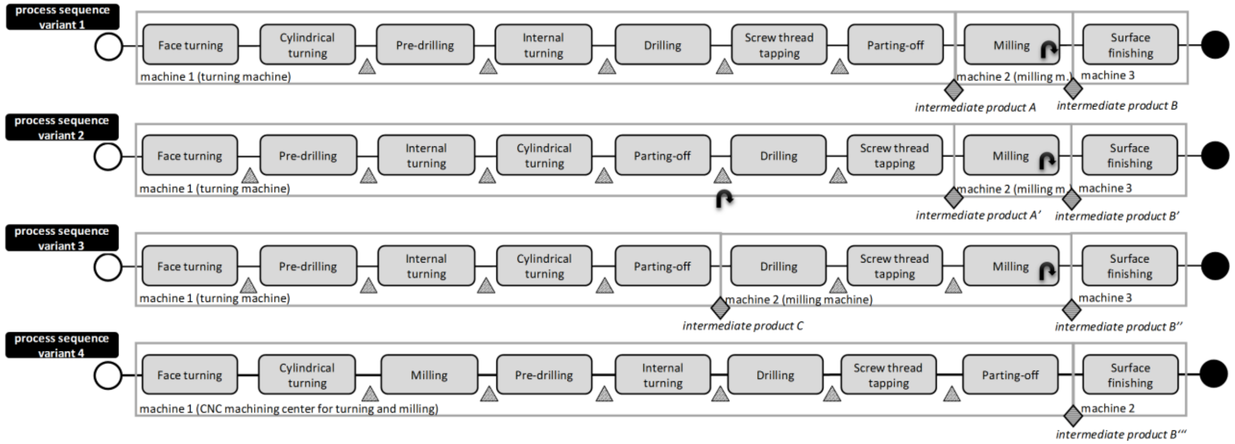
Suitable machines providing the required capabilities need to be identified for each production step.

Difficulties:

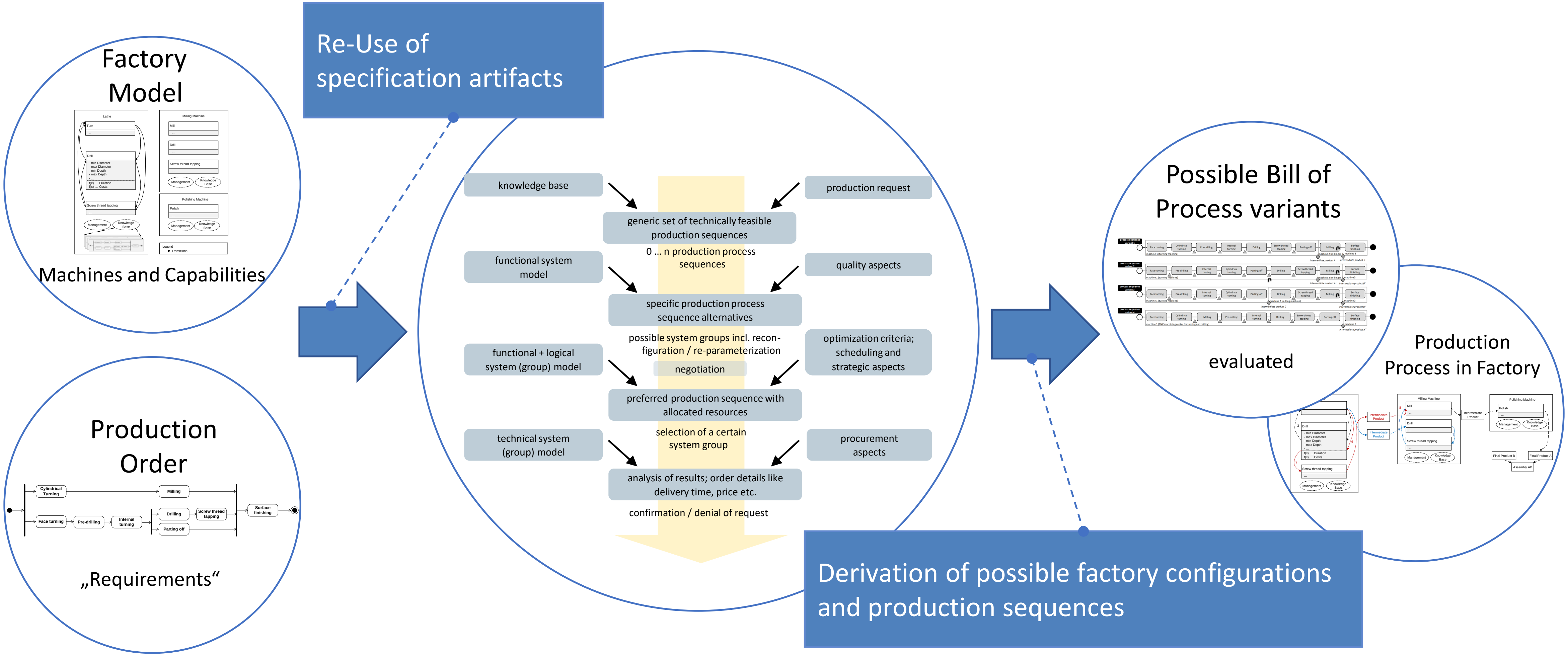
- Often, there is more than one possible sequence of production steps.
- Some process steps may be allocated to different machines.
- The optimal sequence of production steps depends on the capabilities of the available machines and the quality requirements of the product.

EXAMPLE





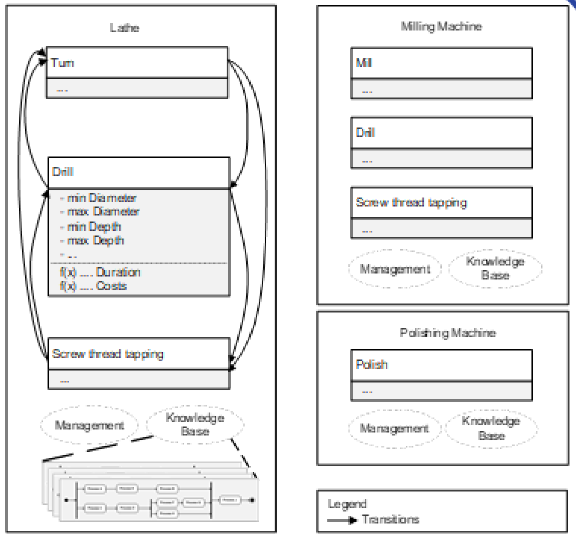
Solution approach



Using different views

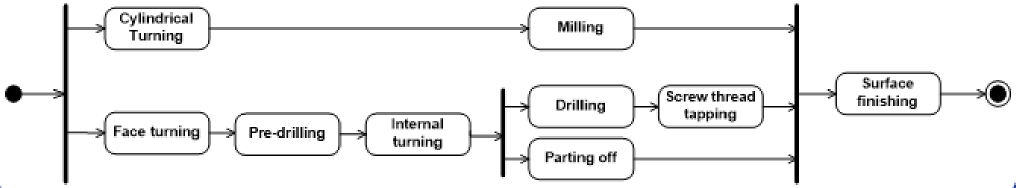
Function view

- Factory-specific function view with production functions, calculatory functions and management functions as well as a knowledge base
- Showing machines and their functions (i.e. provided capa-bilities)



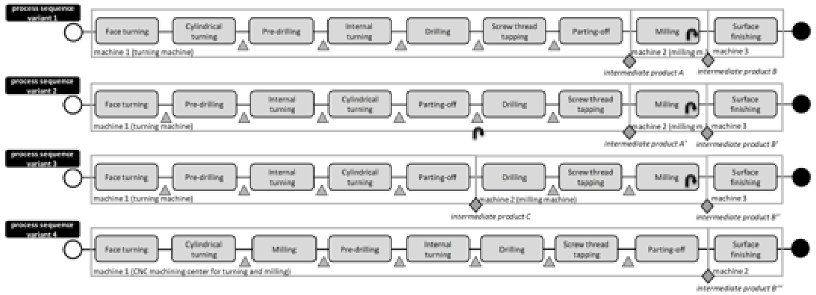
Production view

Showing the capabilities required for the fabrication of a certain product (generic, factory-independent Bill of Process)

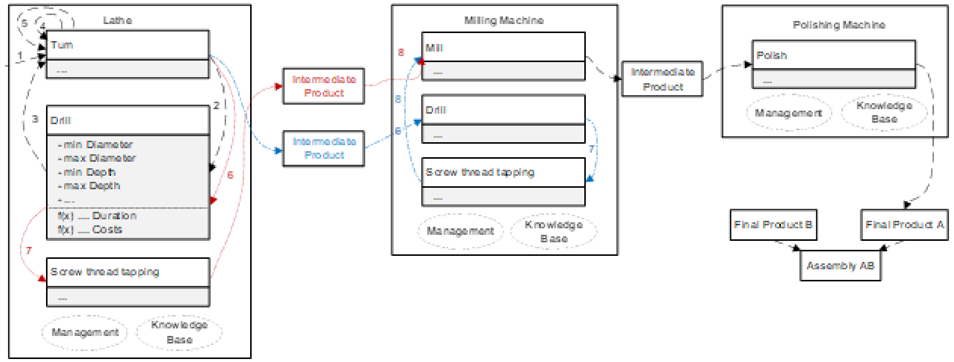


Integrated View

- Evaluation of different Bill of Process variants after matching the required capabilities to the provided capabilities of the factory



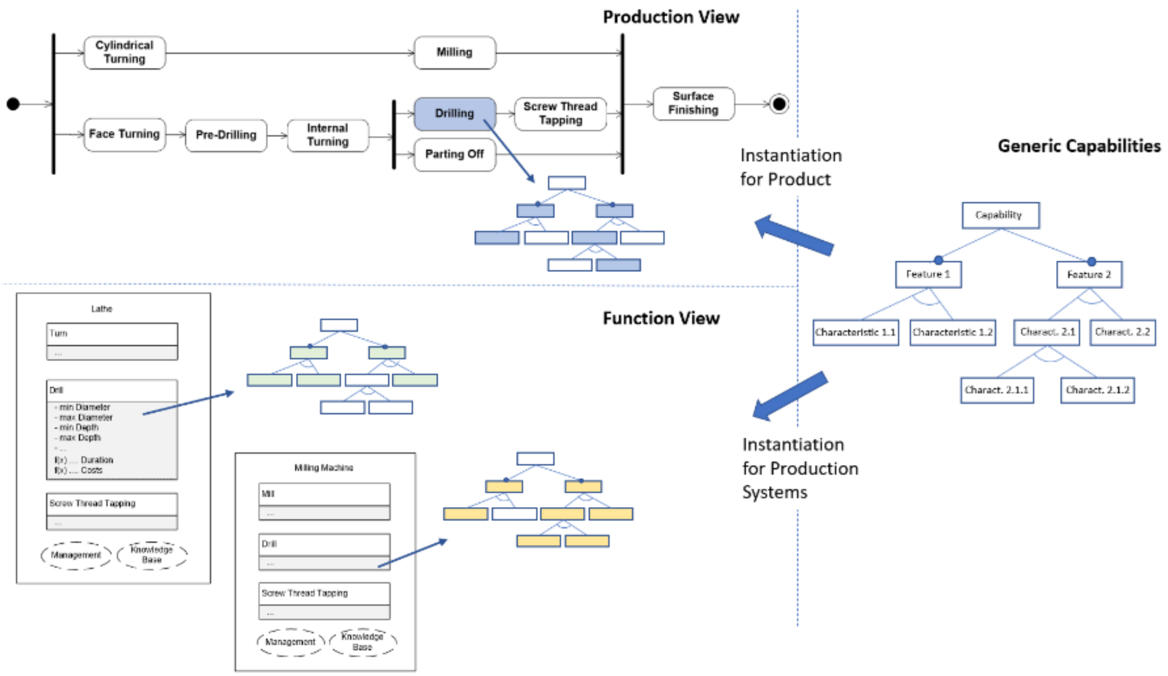
- Modelling the production process including intermediate products for different Bill of Process variants



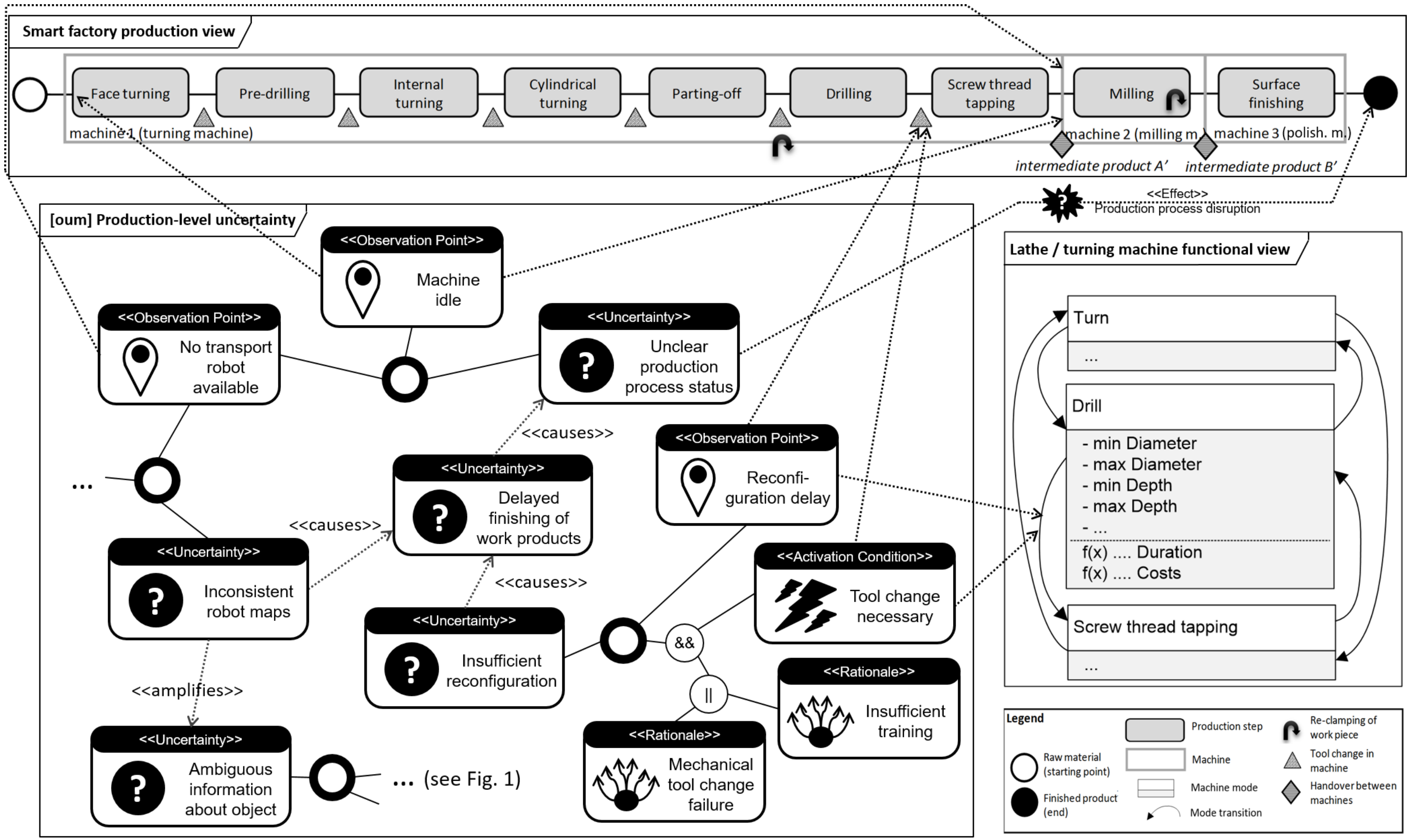
Using capabilities for the producibility check of an individualized product

- Generic capabilities can be taken from domain capability models
- Instantiated capabilities in the production view are considered “required capabilities” for the production of a product
- Instantiated capabilities in the function view are considered “provided capabilities (skills)” (with system-specific constraints)
- The production view acts as a generic Bill of Process (i.e. the identified required capabilities are product-specific, but not resource-specific)

Required and provided capabilities



Considering Uncertainty



Example of an Orthogonal Uncertainty Model for the Production and Function View of the Smart Factory

Viele Dank!

Fragen ?