GEFÖRDERT VOM
Bundesministerium
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CrESt Projektabschluss

Reference Architectures for Collaborative Embedded Systems

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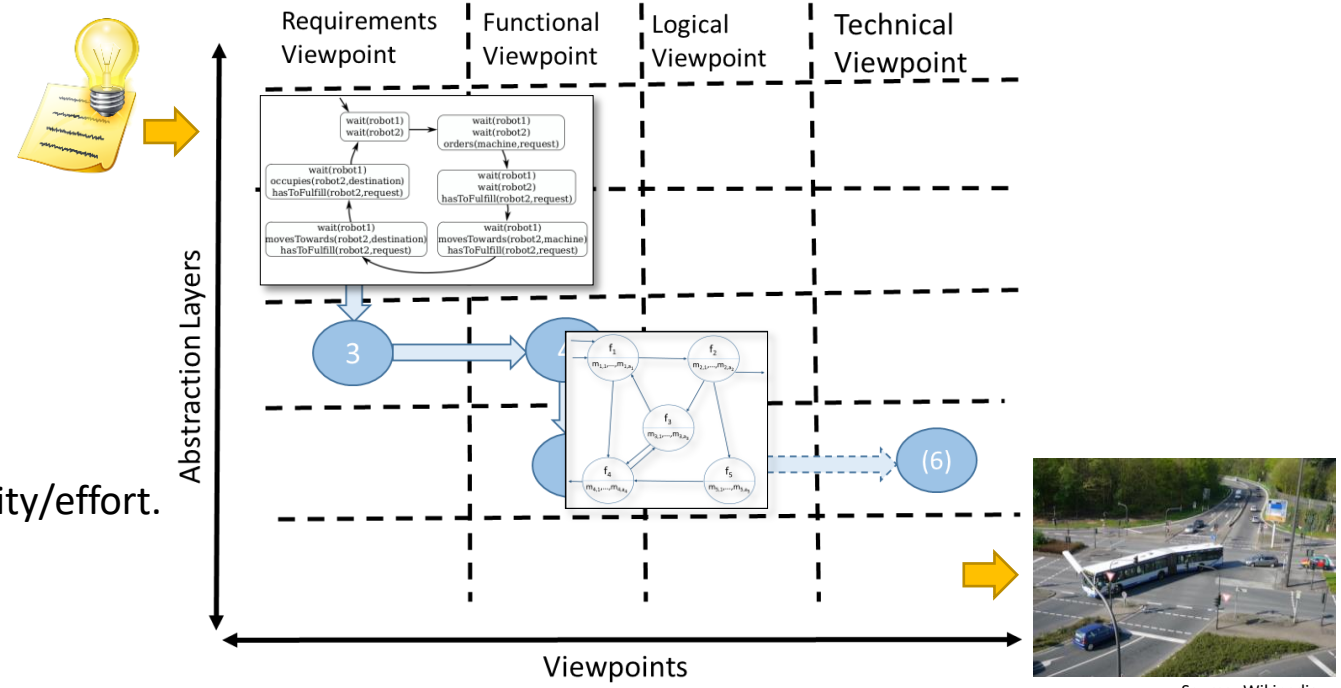
Online, 16.10.2020

Motivation

- CrESt addresses challenges in developing collaborative embedded systems (CES) & groups (CSG).
- Consistent with the SPES_XT modelling framework:
  - Models, Viewpoints, Abstraction Layers
  - Methods, Tools
- *How* to build CES and CSG?
  - What are the relevant aspects that must be covered by the models?

    So that we do not miss anything in the end.
  - What are common building bricks?

    Which we can re-use to reduce design complexity/effort.



Source: Wikipedia

Frameworks & Reference Architectures

- Architecture framework: “**conventions**, **principles** and **practices** for the description of architectures established within a specific domain of application and / or community […]”.

  [ISO 42010-2011 - ISO/IEC/IEEE Systems and software engineering: Architecture description, 2011]

- Reference architecture: “the outcome of **applying the architecture framework** to a class of systems to provide guidance and to identify, analyze and resolve common, important architectural concerns.

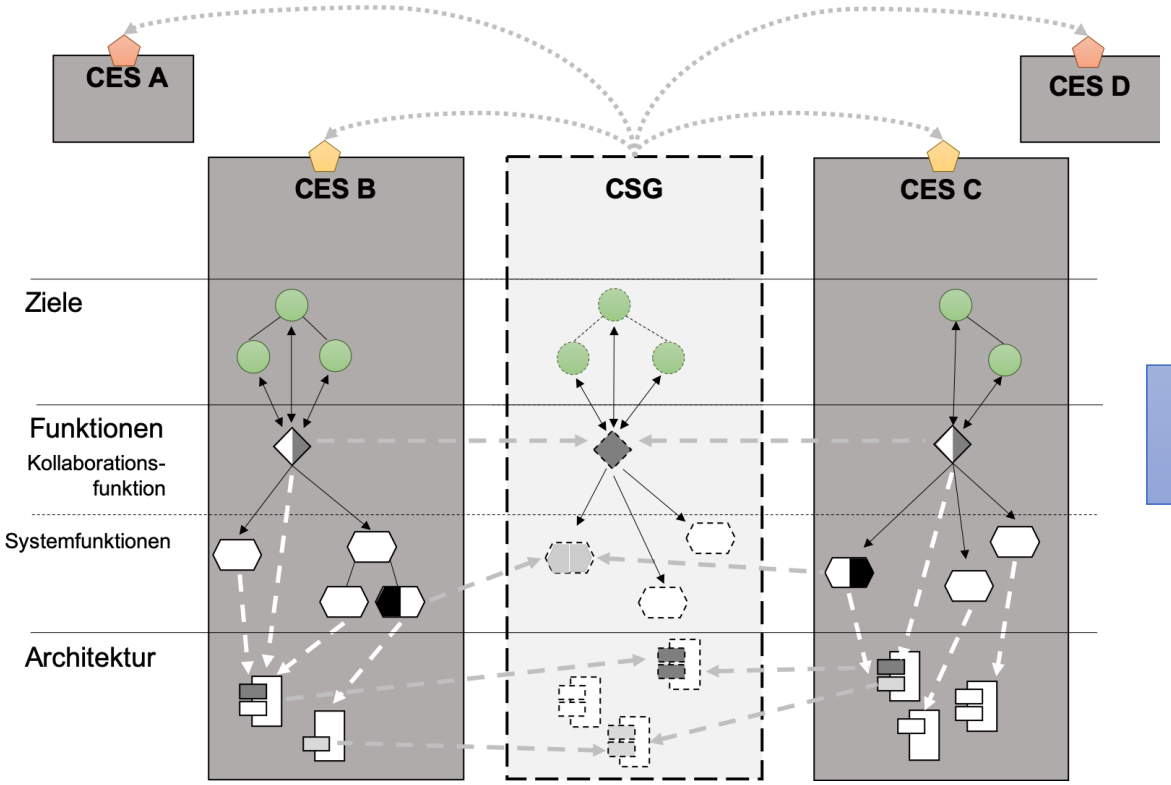
  […]

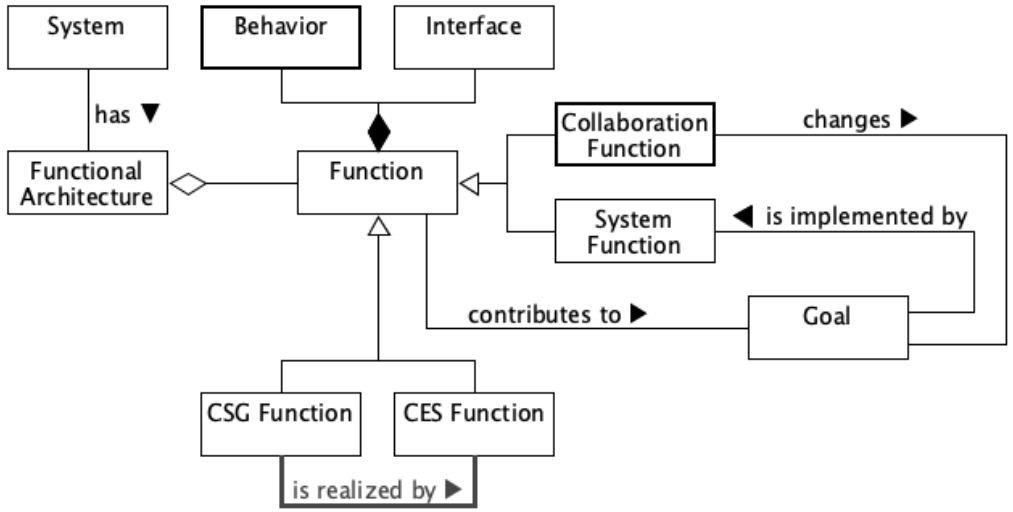
  A reference architecture serves as a **template** for concrete architecture of systems of the class”.

  [S.-W. Linet al., “The Industrial Internet of Things: Reference Architecture”, IIC Technology WG, 2018]

Architecture Frameworks

Example: Function modelling framework (ontology / meta model)





Reference Architectures and Methods developed in CrESt

- Reference Architecture for Trust-Based Digital Ecosystems
- Reference Architectures for Adaptable and Flexible Factories (EC1)
- Dynamic Architectures and their Extraction (EC2)
- Reference Architecture for Handling Uncertainty in Data-Driven Components (EC5)

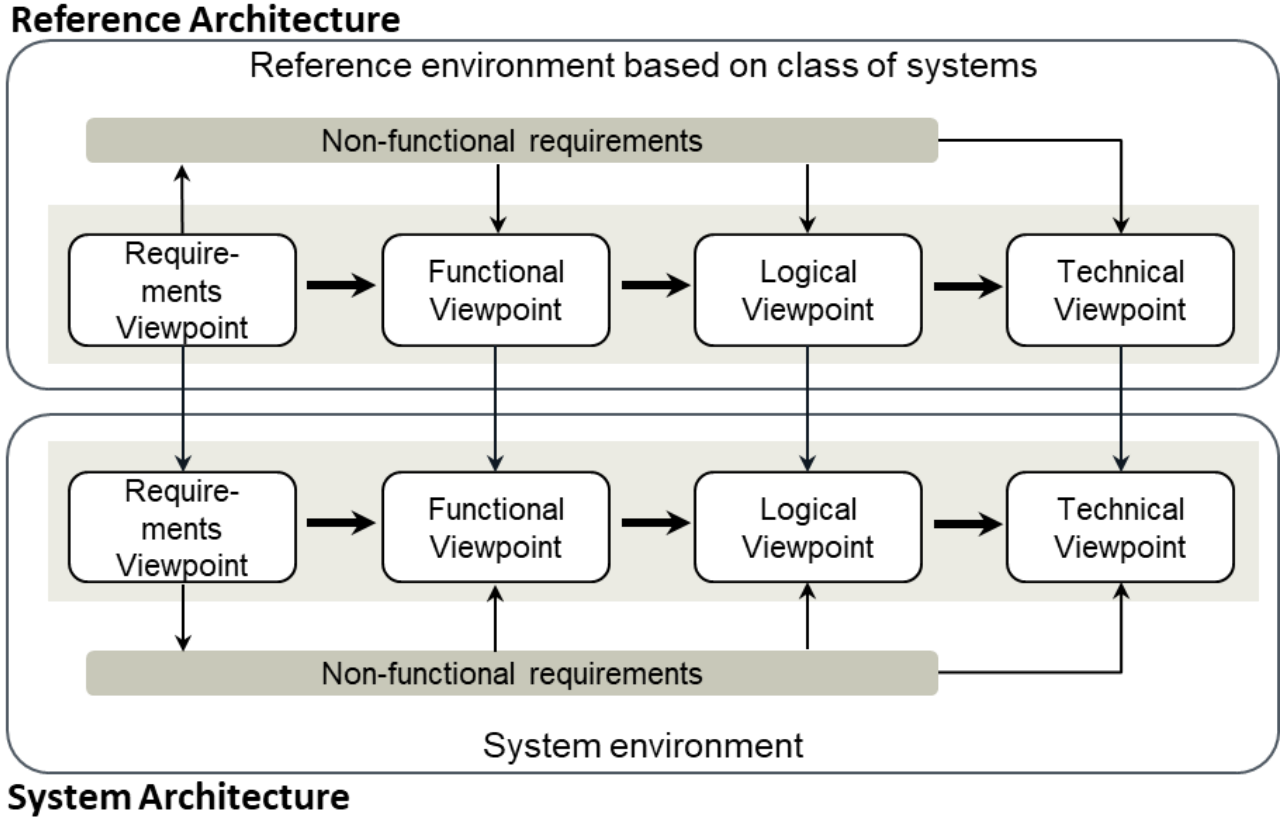
Example 1: Reference architecture design for cyber physical systems

Goal

- Design a blueprint for system architectures of a specific class of systems.
- System architecture shall integrate all disciplines of cyber physical systems.

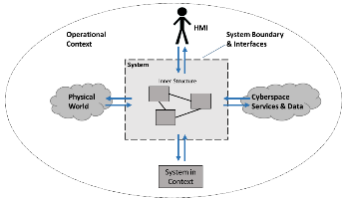
Method

- Based on SPES_XT Modeling Framework.
- First and crucial step is definition of class of systems for which the reference architecture is designed.
- Next steps follow SPES_XT Modeling Framework, but wrt. defined class of systems.



Example 1: Reference architecture design for cyber physical systems

Reference architecture for collaborative systems

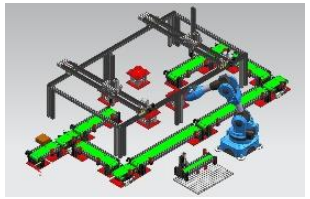


- Based on CrESt system model, which is an overarching and common result of the funded project.

Reference architecture for adaptable and flexible factories

- Based on reference architecture for collaborative systems,
- Industry 4.0 application scenarios, and
- general requirements on factories.

System architecture for factory model demonstrator

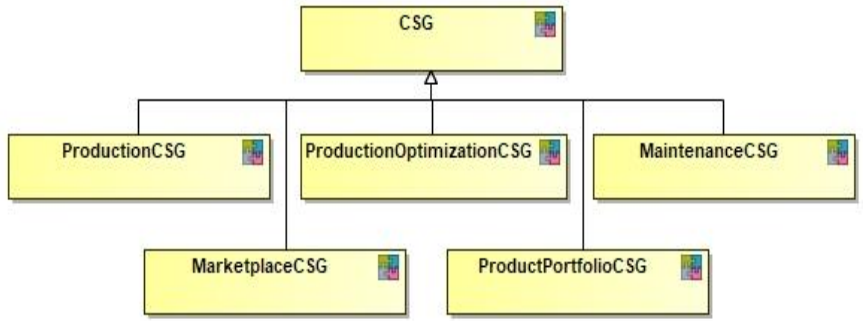


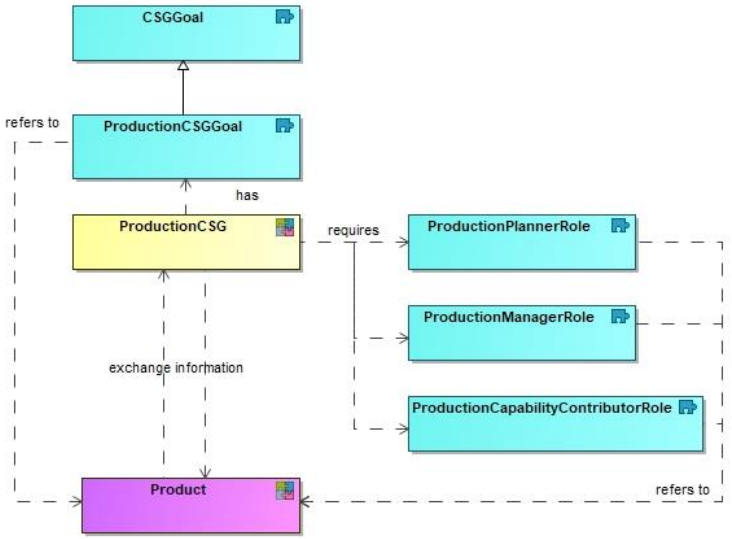
- System architecture derived from reference architecture for adaptable and flexible factories,
- Real-life factory model example.

Example 1: Reference architecture design for cyber physical systems

Reference architecture for adaptable and flexible factories results in cross-discipline system architectures for cyber-physical systems considering Industry 4.0 concepts.

- Identified goals are represented by specific collaborative system groups (CSG):
  - Manufacturing of a product as specified within customer-specific production order,
  - Optimization of production based on operation data,
  - Maintenance of the factory to keep the factory in good state,
  - Collaboration between factories via marketplaces,
  - Product portfolio development based on operation and customer order data.
- Production systems contribute to CSGs by implementing required roles.

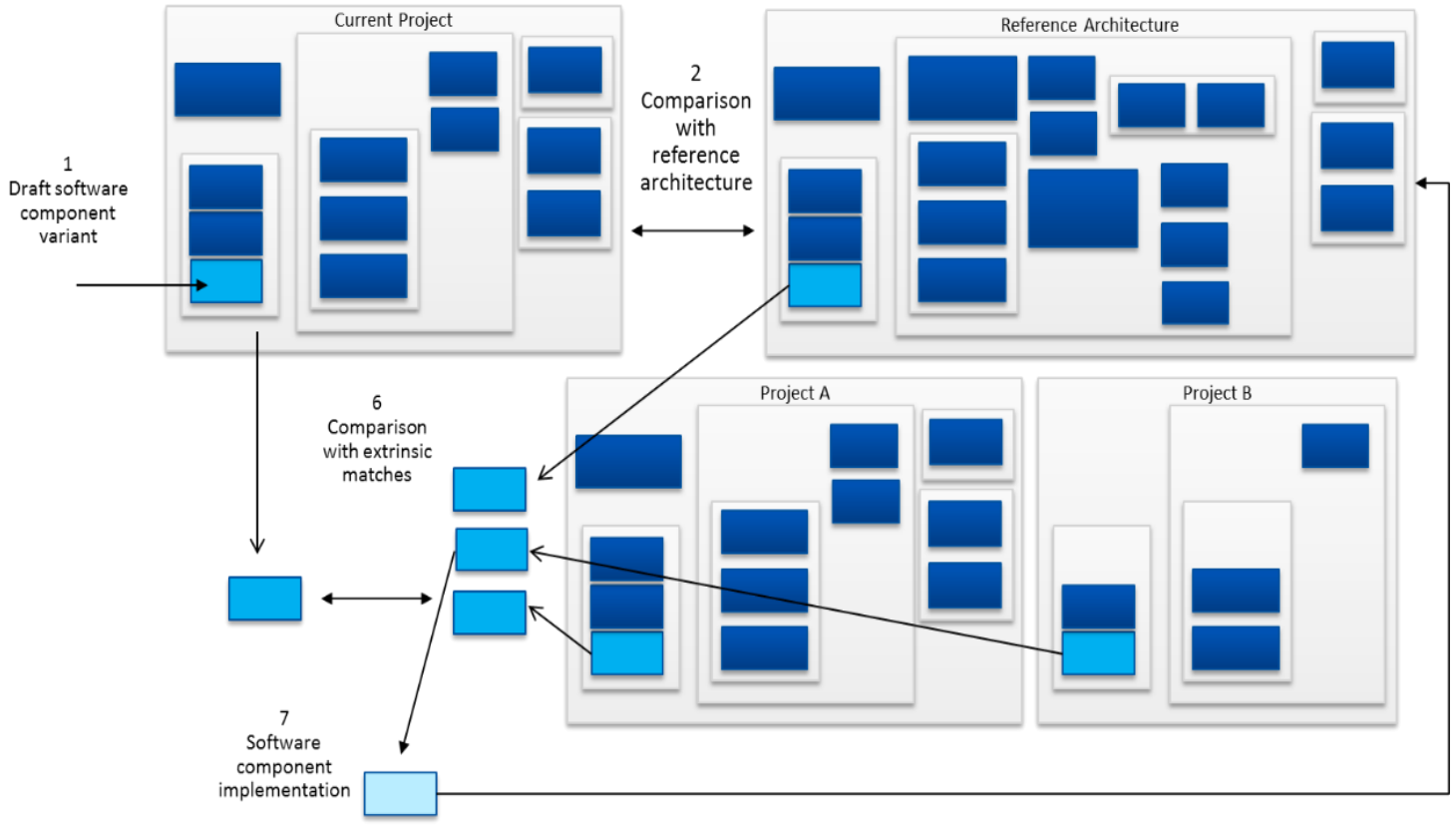




Example 2: Extracting reference architectures with product-driven software product line engineering

Exemplarily illustration of the process:

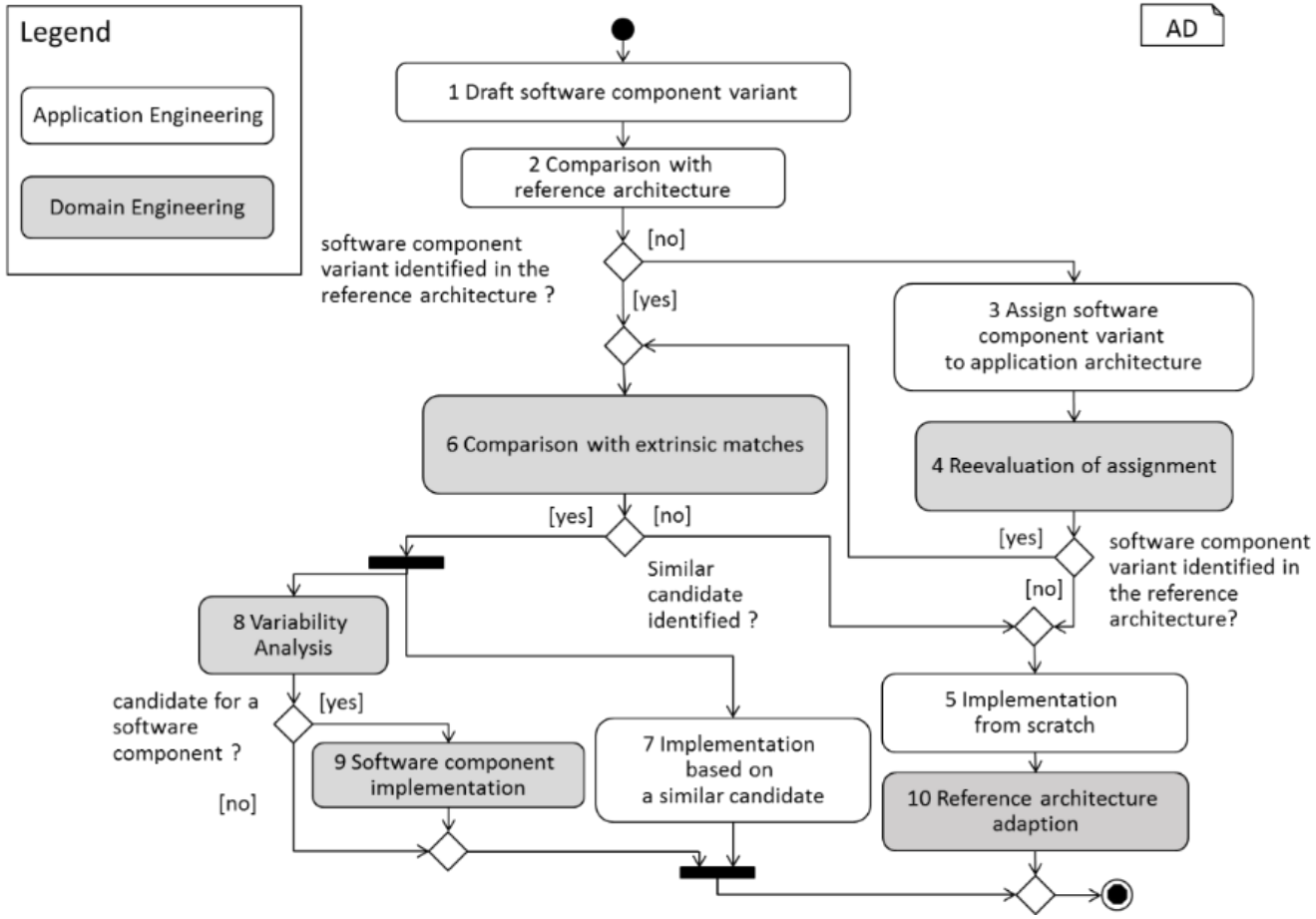
- One current ongoing project and further projects providing different software component variants.
- Finding matches for a detailed similarity analysis.
  - On component level.
- Possible actions:
  - Software component is implemented in the project,
  - The reference architecture and software platform is updated.



Example 2: Extracting reference architectures with product-driven software product line engineering

Adaption/change process:

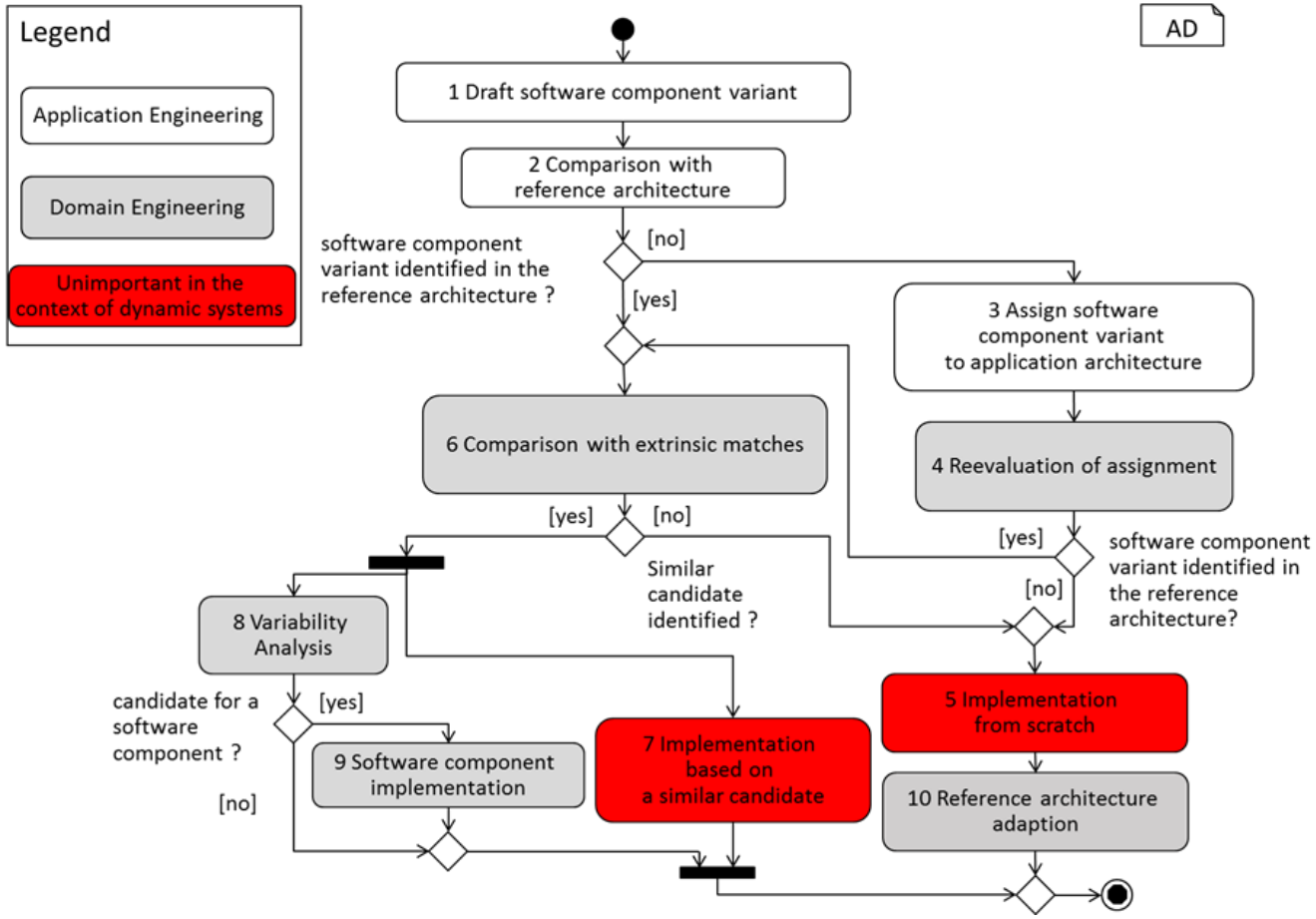
1. Extraction of information for matching.
2. Comparison between the current reference architecture and the new component.
3. Adaption in further steps, if needed.
4. Update of the reference architecture after the process is finished.



Example 2: Extracting reference architectures with product-driven software product line engineering

Influence of open systems to the process:

1. Extraction of information for matching.
2. Comparison between the current reference architecture and the new component.
3. **Implementation of changes based on a similar candidate does not happen.**
   - Higher effort to find similarities.
4. **Implementation from scratch is not possible,**
   - A core reference must exist.



Summary

- Reference architectures provide templates for concrete architectures of a class of systems
  - Supporting engineers in reusing established design solutions.
  - Help in covering relevant design goals.
- In CrESt reference architectures have been developed for the design of collaborative systems.
  - Covering different aspects and at different abstraction levels.
- Two examples have been introduced:
  - Reference architecture for adaptable and flexible factories.
  - Reference architecture extraction with product-driven software product line engineering.

DLR Projektträger

Collaborative Embedded Systems

CrESt

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Thank you very much.

Questions?

SIEMENS

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FEV