Process-based Collaboration in Global Software Engineering

Harald Klein:
Siemens AG, Corporate Technology
Software & Engineering Processes, 91051 Erlangen

Andreas Rausch, Edward Fischer:
Technische Universität Clausthal Zellerfeld, Chair for Software Systems Engineering
Agenda

- Motivation
- Collaboration Scenarios
- Formalization
- Outlook
Motivating Example
“Extended Automated Toll-Collect”
Motivation

Software/Hardware development process of organization “A”

Common software development process of organization A and B

Software/Hardware development process of organization “B”
Assumption

Goal of this approach:

- Enabling to construct syntactical correct processes and workflows
- Provide guideline for collaboration processes

What is not considered:

- Business decision support concerning the rationality of processes
- Lack of personnel
- Hand-off failures
Collaboration Scenarios

Four collaboration scenarios have been identified:

1. Collaboration with semantically equivalent processes

2. Collaboration with semantically different processes
   a. Horizontal Integration
   b. Additive vertical integration
   c. Alternative vertical integration
1. Collaboration with semantically equivalent processes

Initial Situation

Collaborative Process
2. Semantically Different Processes

Definition of “Mediator Pattern”:

-“Function” bringing together two or more semantic different actions/workflows

- UML terminology is used for mediator definition, (however, UML rules are not fulfilled)

- Auxiliary character
1. Collaboration with semantically equivalent processes
   a. Horizontal Integration

   - Similar to "Sub-contractor relationship" in e.g. VM XT®, but...
   - organizations have different process models defined

   - "Hand Over" activities clarify e.g.:
     - coding guidelines, templates to be used
     - understanding of specification
2. Additive Vertical Integration

b. Initial Situation

- Parallelization of development activities
- “decomposition” clarifies WHAT parts a supplier should take over, not HOW (like in “hand-over” but based on specialized knowledge)
- “integration” is the integration of different domain results, e.g. software and hardware
- Alternative development paths are used → no parallelization
- Rational Analysis is used to allocate sub-product parts

c. Alternative Vertical Integration

Mediator Pattern: Alternative Vertical Integration

<Action X> → Rational Analysis

[Decision: A or B]

<Action X> → Acceptance

Software Design

Software Implementation

Software Test

System Test

Activity Organization A ("Master")

Activity Organization B ("Supplier")

Safety-Critical Software Design

Safety-Critical Software Implementation

Safety-Critical Software Test

Organization A (Master)

Organization A and B

Organization B (Supplier)

Software Design

Software Implementation

Software Test

System Test

Acceptance

Rational Analysis

Decision: A or B

© Siemens AG, Corporate Technology
Formalization

Reasoning for Formalization:

- Tool-based creation of collaboration scenarios (by directly sourcing V-Model XT®)
- Automated syntactical checks

Formalization uses a graph-based representation.
Formalization
Basic Definitions and Ideas (II)

A = ( \{(Start, y_{start}), (End, y_{end}), (SystemDes., y_{action}), 
(SystemImpl., y_{action}), (SystemTest, y_{action})
\},
\{((Start, y_{start}),(SystemDes., y_{action})),
((SystemDes., y_{action}),(SystemImpl., y_{action})),
((SystemImpl., y_{action}),(End, y_{end}))\})
Formalization
„Closed Sub-graph“

As ∈ AD is_closed_sub_graph_of A ∈ AD ⇔ 
Nd_{As} ⊆ Nd_A \land Ed_{As} ⊆ Ed_A.

\[ \begin{align*}
\text{Ed}_{A-\text{OUT-As}} & := \text{DEF} \{ (s,t) \in Ed_A \mid s \notin Ed_{As} \land t \notin Ed_{As} \} \\
\text{Ed}_{A-\text{TO-As}} & := \text{DEF} \{ (s,t) \in Ed_A \mid s \notin Ed_{As} \land t \in Ed_{As} \} \\
\text{Ed}_{A-\text{IN-As}} & := \text{DEF} \{ (s,t) \in Ed_A \mid s \in Ed_{As} \land t \in Ed_{As} \} \\
\text{Ed}_{A-\text{FROM-As}} & := \text{DEF} \{ (s,t) \in Ed_A \mid s \in Ed_{As} \land t \notin Ed_{As} \}
\end{align*} \]
**Formalization**  
„Mapping Operation“

\[
\text{MAP}_{\text{As-Bs}} := \text{DEF} \{ \text{Map}_{\text{As-Bs}} \subseteq \text{Nd}_{\text{As}} \times \text{Nd}_{\text{Bs}} \mid \\
\forall (s,n) \in \text{Ed}_{\text{A-TO-As}} \Rightarrow \exists (n,n') \in \text{Map}_{\text{As-Bs}}, \\\n\forall (n,t) \in \text{Ed}_{\text{A-FROM-As}} \Rightarrow \exists (n,n') \in \text{Map}_{\text{As-Bs}} \} 
\]
**Formalization**

**Function: “Integration Operation”**

\[ \text{integrate}_\text{graph}(A, As, B, Bs, \text{Map}_{As-Bs}) := \text{DEF} \ AB, \]

where

- \( \text{Nd}_{AB} = ((\text{Nd}_A \cup \text{Nd}_B) \setminus \text{Nd}_{\text{Del}}) \cup \text{Nd}_{\text{Add}} \)
- \( \text{Ed}_{AB} = ((\text{Ed}_A \cup \text{Ed}_B) \setminus \text{Ed}_{\text{Del}}) \cup \text{Ed}_{\text{Add}} \)
- \( \text{Nd}_{\text{Del}} \) to be defined by concrete integration operation
- \( \text{Nd}_{\text{Add}} \) to be defined by concrete integration operation
- \( \text{Ed}_{\text{Del}} \) to be defined by concrete integration operation
- \( \text{Ed}_{\text{Add}} \) to be defined by concrete integration operation

**Example:**

\[ \text{Integrate}_\text{graph}() \]
**Formalization**

**Operation:** „Semantically equal processes“

\[
\text{integrate}_\text{SemEq extends integrate}_\text{graph}
\]

where

- \( \text{Nd}_{\text{Del}} = \text{Nd}_{\text{As}} \cup (\text{Nd}_{\text{B}} \setminus \text{Nd}_{\text{Bs}}) \)
- \( \text{Nd}_{\text{Add}} = \emptyset \)
- \( \text{Ed}_{\text{Del}} = \text{Ed}_{\text{A-TO-As}} \cup \text{Ed}_{\text{A-FROM-As}} \cup \text{Ed}_{\text{A-IN-As}} \cup \text{Ed}_{\text{B-TO-Bs}} \cup \text{Ed}_{\text{B-FROM-Bs}} \cup \text{Ed}_{\text{B-OUT-Bs}} \)
- \( \text{Ed}_{\text{Add}} = \text{Ed}_{\text{AddA2B}} \cup \text{Ed}_{\text{AddB2A}} \)
- \( \text{Ed}_{\text{AddA2B}} = \{ (s,t') \in \text{ED} \mid \exists (s,t) \in \text{Ed}_{\text{A-TO-As}}, (t,t') \in \text{Map}_{\text{As-Bs}} \} \)
- \( \text{Ed}_{\text{AddB2A}} = \{ (s',t) \in \text{ED} \mid \exists (s,t) \in \text{Ed}_{\text{A-FROM-As}}, (s,s') \in \text{Map}_{\text{As-Bs}} \} \)
Outlook and further activities

- Refinement and extension of collaboration diagrams (e.g. data flow diagrams)

- Empirical validation of this approach

- Application to development models and approaches e.g. V-Model XT®, CMMI®, RUP®
Thank you very much for your attention!

Questions?