Engineering Object Change Management Process Observation in Distributed Automation Projects

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Motivation and Background

- Context: Complex Automations Systems Engineering Projects
- Distributed Environments
- Heterogeneous Disciplines
  - Electrical Engineering
  - Mechanical Engineering
  - Software Engineering
- Heterogeneous Methods, Data Models, and Tools
- Challenges
  - Collaboration of Engineers from heterogeneous disciplines.
  - Change Management & Quality Assurance across disciplines and tool borders.
  - Process support in a distributed environment.
Concurrent changes in distributed environments require efficient change management approaches (1).

Efficient synchronization mechanisms (2) enable cross-disciplinary change management based on the Engineering Service Bus Platform.
Foundation for Semantic Integration: Common Concepts

Signals

- Signals are common concept for linking information between disciplines (e.g., mechanical interface, electrical signal (wiring), software I/O variable).

Challenges & Goals

- Consistent signal handling (e.g., up to 40,000 signals in power plants).
- Integration of signals from heterogeneous data models / tools.
- Common concept based on semantic integration.
- Elicitation of a Virtual Common Data Model (VCDM)
Virtual Common Data Model (VCDM)

Data storage for change/version management across tools

Tool A Data Model
- Electrical Plan
  - Tool Data
- Cust_Signal
  - Address
  - Description
  - Value Range
  - Voltage
  - Digit/Analog

Tool A Data Extract

Tool B Data Extract

Tool B Data Model
- Function Plan
  - Tool Data
- FB_Signal
  - Location
  - FB_Info
  - Value Dirs
  - Input
  - Datatype

Engineering Data Base

Virtual Common Data Model
- Domain/Project Ontology
  - Requirement
  - Engineering Trace
  - Link
  - Engineering Ticket
- Common_Signal
  - Address
  - Description
  - Value Range
  - Voltage
  - ...
- Support Point
  - Location
  - Id
  - ...

Mapping of Tool A data model to Virtual Common Data Model

Mapping of Tool B data model to Virtual Common Data Model

Tool A Parser

Tool B Parser

Numbered Circles:
1. Checkin,
2. Checkout
3. Version management

Numbered Squares:
1. Derive Virtual Common Data Model (VCDM)
2. Derive Mapping from a tool to VCDM
3. Configure parser with data mapping
Signal Change Management with the Automation Service Bus

- **Challenges and Goals**
  - Some conflicts cannot be resolved during check-in, e.g., removed signals
  - Notification required to minimize surprises in the engineering team

- **Conceptual Approach**
  1. Execute Changes
  2. Conduct Difference Analysis
  3. Identify “Removed Signals” → generate Engineering Ticket
  4. Notify (multiple) related stakeholders
  5. Checkout
Signal Change Management Workflow

- **Signal Changes**
  - Modified signals
  - New signals
  - Removed signals
  - Accepted / rejected signals

- Notification of changes to related stakeholders

- Events (E1 .. E10) enable process observation and project control

- Evaluation: pilot application based on historical data.
Pilot Application & Study Description

- **Goal:**
  1. Verification and validation of signal change management (process behavior)
  2. Definition of project metrics, i.e., number of change per engineering phase / check-in sequence) for project monitoring and control.

- **Measurement Data & Metrics**
  - Events.
  - Definition of Product and Project Metrics.
    
    | Metric / No. of | Metrics Description                                                      |
    |-----------------|-------------------------------------------------------------------------|
    | Check-ins      | Number of different signal lists from various sources                   |
    | Signals         | Number of signals handled during an individual check-in.                |
    | Similar Signals | Number of unchanged signals (signal list compared to EDB signals)        |
    | Accepted changes| How many changes were accepted during an individual check-in? Accepted signals include (a) new signals, (b) deleted signals, and (c) modified signals. |
    | Rejected changes| How many changes were rejected during check-in?                         |

- **Material:**
  - Real world project (hydro power plant) with three different signal lists in early phases of development (approx. 700 signals per list).

- **Process:**
  - Check-in of different signal lists
  - Capturing event data
  - Analysis of event data for process evaluation and determination of product metrics.
Goal 1: Change Management Process Evaluation

- Process Evaluation with ProM

- Goal of process evaluation with ProM:
  - Identify deviations of real and expected processes / workflows
  - Identification of bottlenecks for process improvements.
  - Measurement data for process / workflow analysis, i.e., time data, number of traces, type of traces.

- Limitations: Pilot application in controlled lab environment.

Goal 2: Project Metrics – Results of the Pilot Application

- Process Verification and Validation: Compliance of the implemented process and the expected workflow.
- Project monitoring and observation:

<table>
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<tr>
<th>Check-in Phases</th>
<th>Phase 1.1</th>
<th>Phase 1.2</th>
<th>Phase 1.3</th>
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<tr>
<td>No</td>
<td>%</td>
<td>No</td>
<td>%</td>
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<tr>
<td>Rejected Changes</td>
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<tr>
<td>Signal Comparisons</td>
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<td>100%</td>
<td>1,300</td>
<td>100%</td>
</tr>
</tbody>
</table>

Share of Signal Changes

Share of Signal Change Type
Summary & Outlook

Automation systems engineering projects
- Contributions from several engineering disciplines
- Need for change management across semantically heterogeneous data models in engineering tools and projects

Automation Service Bus (ASB) and Engineering Database (EDB) concept enables
- Version management
- Change & conflict detection and resolution

Outlook
- Engineering Cockpit
- Identify new use cases from heterogeneous application domains.
- Identify candidate industry partners for research prototype development.
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