Version Management and Conflict Detection across Tools in a (Software+) Engineering Environment

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Context and Motivation

- Automation systems engineering projects
  - Contributions from several engineering disciplines.
  - Complex artifacts like mechanical, electrical, and software components and plans, which get updated concurrently.

- Version Management
  - Available for each individual engineering discipline.
  - Very little work on version management across semantically heterogeneous data models in engineering tools and projects.

- Quality Assurance (Change & Conflict Detection)
  - Selective QA activities in individual disciplines.
  - Challenge is to integrate quality assurance activities across disciplines and systems borders.
Goal: Approaches for the integration of software tools in automation engineering.

- Semantic Integration: Engineering Database (3).
- Flexible integration of SCADA (4) with data analysis/simulation (5).
- Defect detection approaches for design time (6) and run time (7).
Signal Engineering

Foundation

- The signal is a 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 (1) and (2).
- Version management of signal changes across engineering disciplines.
- Common concept based on semantic integration (3).

Virtual common data model

Tool A Data Model

- Electrical Plan
- Tool Data
- Cust_Signal
  - Address
  - Description
  - Value Range
  - Voltage
  - Digit/Analogue

Tool B Data Model

- Function Plan
- Tool Data
- FB_Signal
  - Location
  - FB_Info
  - Value Defs
  - Input
  - Datatype

Tool A Data Extract

- Electrical Signal
- X
- Y
- +...

Tool B Data Extract

- Software Variable
- FA
- +...
- FZ
- +...

Engineering Data Base

- Signal
- Electrical Signal
- Software Variable
Virtual Common Data Model: Version Management across Tools

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

Engineering Data Base

Virtual Common Data Model

Mapping of Tool A data model to Virtual Common Data model

Mapping of Tool B data model to Virtual Common Data model

Domain/Project Ontology
- Requirement
- Engineering Trace Link
- Engineering Ticket

Common_Signal
- + Address
- + Description
- + Value Range
- + Voltage
- + ...

Support Point
- + location
- + Id
- + ...

Numbered Circles:
1. Checkin, Checkout, 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
Use Case – Signal Engineering of Hydro Power Plant Systems Integrators

[Diagram showing the workflow and tools involved in signal engineering, including Engineering Service Bus, Tool Data, Issue Tracker, Tool X, and Notification Tool.]
Basic Signal Check-In Workflow

- Check-In of new signal list.
- Signal comparison with EDB.
- Pass new signals / unchanged signals to EDB.
- Manual confirmation of changed signals and override signal in EDB.

Virtual common data model:

<table>
<thead>
<tr>
<th>Tool A Data Extract</th>
<th>Tool B Data Extract</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer</td>
<td>Transformer</td>
</tr>
<tr>
<td>Engineering Data Base</td>
<td></td>
</tr>
</tbody>
</table>

1. Engineering Data Base
2. Transformer

EDB

Start

Checkin

Signal List

Signal comparison

similar

No Change

Change Identified

Override

Next Signal

yes

no

EDB

End
Signal Changes Across Tools and Disciplines

- **Challenges and Goals**
  - Merge changes between signals coming from different disciplines.

- **Conceptual Approach**
  1. Execute Changes.
  2. Check-In and merge changes with Engineering Database
     - Conflicts can be changes semi-automatically.
     - Engineering tickets and notification in case of critical changes and conflicts (e.g., removed signals).
  3. Check-Out merged signal lists.
Pilot Application: Conflict Resolution

- **Check in: Status of Imported Signals**

```
Merge Signals (Signals are replaced on default)

| view new signals (0) | view unchanged signals (30) | view conflicts (12) |
```

Tick checkboxes to the left of the new value in order to update a property. Show only conflicts.

- **Different Views**
  - New Signals
  - Unchanged Signals
  - Changes / Conflicts

- **Highlight & Resolve Differences**

<table>
<thead>
<tr>
<th>Signal</th>
<th>Update whole row</th>
<th>channel/Name</th>
<th>InputOutputModule</th>
<th>functionTextOne</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>keep all</td>
<td>old value:</td>
<td>6</td>
<td>H_U#p 110VDC High oil pres pump feeder (Q12 F71 F72) ready</td>
</tr>
<tr>
<td></td>
<td></td>
<td>new value:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>keep all</td>
<td>old value:</td>
<td>10</td>
<td>H_U#p St Service MV cubicle HV fuse fault</td>
</tr>
<tr>
<td></td>
<td></td>
<td>new value:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Conflicts**
- Old & New values
- Selection and Notification
- Confirmation / Change & Conflict Resolution
Pilot Application: Signal Browser

- View signals in system topology.
- Identify and view of signal information.
- Export of result set and rework in spreadsheets.
- Candidate use case for next steps: Navigation to source data of signals in various tools (cross references).

Queries for subsystem selection

Show/hide individual data fields
Pilot Application: Signal Browser

- View signals in system topology.
- Identify and view of signal information.
- Export of result set and rework in spreadsheets.
- Candidate use case for next steps: Navigation to source data of signals in various tools (cross references).

Result Set

<table>
<thead>
<tr>
<th>line</th>
<th>region</th>
<th>cpuNumber</th>
<th>channelName</th>
<th>functionTextOne</th>
<th>projectId</th>
<th>componentNumber</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>02</td>
<td>10</td>
<td></td>
<td>Drainage pit 1 - drainage pump 2 temperature</td>
<td>project1</td>
<td>040</td>
</tr>
<tr>
<td>2</td>
<td>02</td>
<td>11</td>
<td></td>
<td>Drainage pit 1 - jet pump control valve - open</td>
<td>project1</td>
<td>040</td>
</tr>
<tr>
<td>3</td>
<td>02</td>
<td>10</td>
<td></td>
<td>Drainage pit 2 - drainage pump 2 temperature</td>
<td>project1</td>
<td>040</td>
</tr>
<tr>
<td>4</td>
<td>02</td>
<td>11</td>
<td></td>
<td>Drainage pit 2 - jet pump control valve - open</td>
<td>project1</td>
<td>040</td>
</tr>
<tr>
<td>5</td>
<td>02</td>
<td>12</td>
<td></td>
<td>Drainage pit 1 - jet pump control valve - closed</td>
<td>project1</td>
<td>040</td>
</tr>
</tbody>
</table>
Pilot Application: History of Signal Data Check-Ins

Five most modified signals

- Customer/project1/turbine/Auxiliary_Rack/CPU_2/Channel_1/Pin_3
- Customer/project1/control_board/Main_Rack/CPU_1/Channel_2/Pin_1
- Customer/project1/turbine/Auxiliary_Rack/CPU_1/Channel_6/Pin_2
- Customer/project1/cooler/Main_Rack/CPU_3/Channel_1/Pin_3
- Customer/project1/turbine/Auxiliary_Rack/CPU_1/Channel_5/Pin_3

Basic statistics on most frequently changed signals

Revision 127
Commit via Hydro-EDB API
draft for new turbine fallback wiring <admin@ahy.com>
25 added, 2 modified, 0 deleted
more...

Revision 126
Commit via Hydro-EDB API
Stress Test feedback <admin@ahy.com>
3 added, 2 modified, 5 deleted
more...

Detailed Check-In Information

Committer: admin <admin@ahy.com>
Author: admin <admin@ahy.com>
Time: Tue., 19. Oct. '10 - 3:16
Message:
Commit via Hydro-EDB API
Previous Checkins

- 0f23ff9d702b48a8dfdd2a31a7b2407ab498c15

Summary: 2 added, 15 modified, 0 deleted
Added
- customer/project1/B/010/01/01/02/6f730a33-a49f-4a3e-a7c3-8f908831ee1a
- customer/project1/B/010/02/01/02/fb8a688a-ac30-4c2f-8eb3-07cf1d3ed621

Modified
- customer/project1/B/010/01/01/2/01/eb9a636c-6bd6-47e4-bddf-f4e3e693d3c4
- customer/project1/B/010/01/01/3/00/9723b660-0a9b-4914-a715-1389663fc0cd
- customer/project1/B/010/01/01/3/01/147a6618-2eef-4b13-9d63-57e0337790fc
UC: Signal Deletion with Engineering Tickets

- **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
Prototype: Engineering Ticket Overview

- **Challenges and Goals:**
  - Notification of stakeholders (e.g., warning on deleted signals)
  - Ensure the correct process steps to deal with “deleted signals”:
    Clear status of process

- **Approach**
  - Engineering Ticket: “Change Request” that holds all relevant information for the roles involved.
  - Allows tracking the process status
  - Minimizes searching in documents

<table>
<thead>
<tr>
<th>Ticket</th>
<th>Summary</th>
<th>Component</th>
<th>Status</th>
<th>Resolution</th>
<th>Type</th>
<th>Priority</th>
<th>Owner</th>
<th>Modified</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>Signal 2345-FDCB-1241 removed</td>
<td>Generator</td>
<td>new</td>
<td></td>
<td>review (signal deleted)</td>
<td>major</td>
<td>florian.waltersdorfer</td>
<td>04/08/10</td>
</tr>
<tr>
<td>#3</td>
<td>Signal 9537-A4D2-2341 removed</td>
<td>Turbine2</td>
<td>assigned</td>
<td></td>
<td>review (signal deleted)</td>
<td>major</td>
<td>stefan.biffl</td>
<td>04/08/10</td>
</tr>
<tr>
<td>#8</td>
<td>Signal 4232-FNXX-3283 changed</td>
<td>Turbine1</td>
<td>accepted</td>
<td></td>
<td>approve (signal change)</td>
<td>major</td>
<td>peter.fruehwirt</td>
<td>04/08/10</td>
</tr>
<tr>
<td>#9</td>
<td>Signal 1232-UFEW-9231 changed</td>
<td>Generator</td>
<td>new</td>
<td></td>
<td>review (signal deleted)</td>
<td>major</td>
<td>stefan.biffl</td>
<td>04/08/10</td>
</tr>
<tr>
<td>#12</td>
<td>Signals changed (4 unapproved)</td>
<td>Schaltzentrale</td>
<td>new</td>
<td></td>
<td>approve (signal change)</td>
<td>major</td>
<td>dietmar.winkler</td>
<td>17/09/10</td>
</tr>
<tr>
<td>#11</td>
<td>Signal deletion by florian.waltersdorfer (1 signals)</td>
<td>Turbine</td>
<td>closed</td>
<td>clear for deletion</td>
<td>review (signal deleted)</td>
<td>major</td>
<td>dominik.hofer</td>
<td>24/09/10</td>
</tr>
<tr>
<td>#10</td>
<td>Signal deletion by florian.waltersdorfer (2 signals)</td>
<td>Turbine</td>
<td>closed</td>
<td>request for change</td>
<td>review (signal deleted)</td>
<td>major</td>
<td>dominik.hofer</td>
<td>24/09/10</td>
</tr>
<tr>
<td>#7</td>
<td>Signal 9324-FWDF-2312 changed</td>
<td>Generator</td>
<td>closed</td>
<td>rejected</td>
<td>review (signal deleted)</td>
<td>major</td>
<td>peter.fruehwirt</td>
<td>04/08/10</td>
</tr>
<tr>
<td>#6</td>
<td>Signal 2333-WETD-9452 changed</td>
<td>Schaltzentrale</td>
<td>closed</td>
<td>approved</td>
<td>approve (signal change)</td>
<td>major</td>
<td>peter.fruehwirt</td>
<td>04/08/10</td>
</tr>
<tr>
<td>#5</td>
<td>Signal 9122-UNDZ-2332 removed</td>
<td>Schaltzentrale</td>
<td>closed</td>
<td>clear for deletion</td>
<td>review (signal deleted)</td>
<td>major</td>
<td>florian.waltersdorfer</td>
<td>04/08/10</td>
</tr>
<tr>
<td>#4</td>
<td>Signal 2312-ZWDA-1237 removed</td>
<td>Schleuse</td>
<td>closed</td>
<td>rejected</td>
<td>review (signal deleted)</td>
<td>major</td>
<td>stefan.biffl</td>
<td>04/08/10</td>
</tr>
<tr>
<td>#2</td>
<td>Signal 2781-ADEI-1325 changed</td>
<td>Generator</td>
<td>closed</td>
<td>rejected</td>
<td>approve (signal change)</td>
<td>major</td>
<td>peter.fruehwirt</td>
<td>04/08/10</td>
</tr>
</tbody>
</table>
Prototype: “Deletion” Engineering Ticket

Pre-Defined Ticket Information

Ticket #10 (closed review (signal deleted): request for change)

Signal deletion by florian.waltersdorfer (2 signals)

Reported by: florian.waltersdorfer
Owned by: dominik.hofer
Priority: major
Component: Turbine
Keywords:
Cc: michael.pritsch

Description (last modified by hydro (diff))

Signal Main_Rack/CPU_1/Channel_4/Pin_2 (Id: 2d9e6e... has been deleted.
Type: analog
Text: U1 - TEMP . STATORWINDING/phase U/ centre
KKS: G-MKA20-CT001-B01

Further Information

- http://www.andritz.com/de/hydro/boyabat/links/eplan/2d9e6eb2-7cb6-4dac-b75b-b022b77618d7

Signal Auxillaray_Rack/CPU_2/Channel_1/Pin_3 (3894599... has been deleted.
Type: digital
Text: 400 VAC Main distribution, busbar A, undervoltage
KKS: G-MKA20-CL001-501

Further Information

- http://www.andritz.com/de/hydro/boyabat/links/eplan/38945975-a91b-46d8-81de-d3a2119d2967

Data Source:
Project Role Concept

Data source:
Engineering Database
Quality Assurance & Defect Detection in Engineering Models across Tools

Use of common concepts in models across engineering disciplines

Defect type examples

- Missing, wrong, inconsistent model elements or relationships
- **Conflicts from changes** of overlapping model elements
- Run-time violation of model constraints

Defect detection approaches

- Review of overlapping model parts
- Automated check of model assertions (syntactic and semantic)
- **Change conflict detection** and resolution
- Derivation of run-time assertions
End-to-End Test Across Engineering Models

Use of common concepts in models across engineering disciplines

End-to-End Analysis

- List of sensor name/description/type with Variable name/description/type
- Warnings for incomplete chains between variables and sensors
Engineering Process Automation Concept

Main Contractor
- Process Eng.
- Elec. Eng.

EPC Contractor
- Electrical Engineering
- PCS Programming
- PLC Programming

EPC Contractor
- Requirements Management
- Process Engineering
- Pipe & Instrumentation

Plant
- SCADA
- PLC
- Condition Monitoring

Business Processes
- Engineering, Construction, Commissioning, Operation

Logging, Auditing, Reporting
- Start
- After Milestone B
- Design Document
- Approved?
- Change & Notify
- Ticketing
- Change
- Approve
- End
Conclusion and Further Work

- Automation systems engineering projects
  - Contributions from several engineering disciplines
  - Need for version 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
  - Integrated quality assurance activities

- Further research work
  - Identify new use cases from heterogeneous application domains.
  - Identify candidate industry partners for research prototype development.
Thank you ...

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