Engineering Environment Integration Across Disciplines with the Engineering Service Bus

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End-to-End Test Across Engineering Models

Use of common concepts in models across engineering disciplines

Sensor
- S1
- S2
- S3
- S4
- S5

System Interface

Software Interface
- V_A
- V_B
- V_C
- V_D

Wiring

Configuration

Use of Data

Electrical Engineer

Configurator

Software Engineer

End-to-End Analysis

- List of sensor name/description/type with Variable name/description/type
- Warnings for incomplete chains between variables and sensors
Motivation and Overview

- Software-intensive systems.
- Several disciplines cooperate in an industry environment.
- Engineering models (e.g., mechanics and electronics) contain requirements and design constraints for software engineers.
- Existing models and tools focus on supporting engineers in specific disciplines.
- Human experts bridge technical and semantic gaps between models and tools of different engineering disciplines.
Scope of Research

- What hinders effective collaboration across disciplines?
  - Domain- and vendor-specific solutions (e.g., point-to-point integration).
  - Heterogeneous models in various disciplines.
  - Different stakeholders and different “languages”.
  - Limited connection between development and operation.

- Concept evaluation based on real-world use cases and prototypes
  - Technical Integration of Tools.
  - Semantic Integration of Data.
  - Quality Assurance across Engineering Disciplines.

- Christian Doppler Laboratory started on January 2010.
Software Engineering Integration for Flexible Automation Systems

Basic research challenges
- Early defect detection across engineering discipline and tool boundaries.
- Engineering process analysis using design- and run-time data sources.

Research applications in the industry partners’ domains
- Platform to build integrated tools for automation systems development & QA.
- SCADA systems with data analysis for monitoring automation systems.
Challenges and Requirements

Challenges from weak integration of software tools for engineering

1. **Engineering process** on event level is hard to track and analyze.
2. **Integration of software tools** is often vendor-specific and/or fragile.
3. **Sharing of data models** across software tools is inefficient and risky.
4. **Run-time defect detection** cannot easily access design knowledge.
5. **Integration of run-time environments** is hard to observe for analysis.
Goal: Approaches for the integration of software tools in automation engineering.

- Semantic Integration: Engineering Knowledge Base (3).
- Flexible integration of SCADA (4) with data analysis/simulation (5).
- Defect detection approaches for design time (6) and run time (7).
Example: Technical Systems Integration and Interoperability

Approach for integrating available automation engineering tools

- 3 heterogeneous engineering tools.
- Defined Workflow.
Collaboration Across Disciplines: Semantics?

Virtual common data model

Data integration and transformation?

Data model QA and use?
Semantic Integration of Engineering Knowledge

Identification of common concepts across engineering disciplines.

- **Mechanical equipment properties**
- **Transmission lines**
- **Terminal points**
- **Signals (I/O)**
- **Location IDs**
- **Components**
- **Interfaces**

**Model Mapping**

- **Tool A – Domain**
- **Tool A – Tool B**
- **Tool C Data Model**

**Derived Mapping**

- **Tool A – Tool B Models**

**Information**

- Analog
  - 0 to 10 V
  - X.22.2.1
- "Pump flow"
  - Real (l/min)
  - 0 to 1,200
  - %I20.5.3
Defect Detection Across Tool Boundaries and Disciplines

Use of common concepts in models across engineering disciplines
End-to-End Quality Assurance

- **Challenge:** Defect Detection across engineering disciplines

- **Identification of various defect types:**
  - Missing, wrong, inconsistent model elements or relationships.
  - Conflicts from changes to overlapping model elements.
  - Run-time violation of model constraints.

- **Quality Assurance approaches**
  - Review of overlapping model parts, e.g., with inspections.
  - Automated check of model assertions (syntactic and semantic).
  - Change conflict detection and resolution.
Engineering Process Analysis (CI&T)

- **Process automation, analysis and assessment** based on (EngSB) event logs
  - Visualization of the expected engineering process.
  - Comparison of expected with traces of actual engineering processes.
  - Analysis of actual engineering process variants (frequency of paths taken).
  - Measurement of engineering process duration, waiting and execution times.
- **Example: Continuous Integration and Test (CI&T).**

![Diagram of Expected CI&T process]

Expected CI&T process

![Diagram of Process analysis based on sample engineering logs.]

Process analysis based on sample engineering logs.
Summary

- Multi-disciplinary engineering projects are prone to risks from defects and delays due to technical gaps between tools and semantic gaps between data models.
- Technical and semantic integration provide the foundation for engineering process automation and quality management to lower these project risks.

**The Engineering Service Bus (EngSB) environment provides:**
- Semantic Integration: Data Models across disciplines.

**Industry Use Cases**
- End-to-End Quality Assurance.
- Difference analysis between signal versions.
- Defect detection in data models across tools and engineering disciplines.
- Engineering Process Automation, Analysis and Improvement.
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