Process Automation and Quality Management in Multi-Disciplinary Engineering Environments

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Motivation

Background

- Software+ Engineering Process Analysis and Improvement.

Challenges in Multi-Disciplinary Engineering Team Processes

- Change Management in concurrent engineering processes across disciplines.
- **Risk-based process analysis** as foundation for quality management and process automation
- **Measurement** required to assess project and product characteristics and initiate project and product improvement.
- **Comprehensive project and process** view across disciplines
- Standardization and benchmarking.

Engineering Process Automation & Quality Management

- Builds up on technical and semantic integration platforms.
- Supports process automation on **Engineering Team Level**.
- Supports quality measurement and analysis as foundation for (a) **engineering process improvement** and (b) **project monitoring and control**.
Scope of Research
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.
State of the Art

Defect Detection and Quality Assurance in the Engineering Process

- Methods for defect detection in software engineering:
  Artifacts inspection, model checking, testing, test-first development.
- In automation systems engineering: focus on integration and acceptance testing.
- Verification of system behavior, e.g., state charts.
- Automated test case generation, execution and reporting based on models.

Our previous work

- Software defect detection and prediction methods and models.
- Value- and risk-based software test planning.
- Test-first software development for automation systems.
- Test management & simulation for production automation system.
- Integrating constructive and analytical software engineering approaches, i.e., Pair programming and best-practice inspection.
- Various empirical studies on software inspection, architecture evaluation, and agile development practices.
Research Methods

- V-Model of Empirical Research

Planned Research Work
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
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.
UC: 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).

**Expected CI&T process**

**Process analysis based on sample engineering logs.**

- Low waiting time
- Medium waiting time
- High waiting time
Planned Research

- **Process and project management in heterogeneous engineering environments**
  - Process automation and analysis based on event data and measurement.
  - Systems Testing for EngSB Applications
    - Support of OpenEngSB development
      (code coverage, unit- integration and systems test level)
    - Runtime-test coverage.

- **Quality Assurance and Quality Management**
  - Process, project and product improvement
  - Static and dynamic QA approaches,
    e.g., inspection and testing
  - Defect detection across disciplines
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.

- **End-to-End Quality Assurance examples:**
  - Difference analysis between signal versions
  - Defect detection in data models across tools and engineering disciplines

- **Process automation examples**
  - Change management with tickets and notification.
  - Continuous integration and test (CI&T)
  - Engineering process design and analysis.
Backup Slides
Product Development Processes on Team Level

- Process approaches have been proven in Business IT Software development, e.g., V-Modell XT, RUP, Scrum.
- Challenges for Systems Engineering Processes
  - Various disciplines, e.g., mechanical, electrical, and software engineering.
  - Heterogeneous software tools for individual engineering disciplines.
  - Wide range of stakeholder roles in multi-disciplinary engineering teams.
  - Focus on risks in overlaps between engineering disciplines (common concepts).
UC: Change Management for Signal Engineering

- Basic workflow for Change Management (research prototype at Andritz Hydro).
- Works with EPlan, OPM, and customer-specific signal lists.

Example:
- Change management has to address signal changes with overlapping attributes between tools from several engineering disciplines.
- Electrical engineer needs to change a signal (after Milestone B = status approved)
- Change reason: sensors of alternative types require modified signal attributes:
  - Changes are driven by engineering rules.
  - Ticketing and notification in engineering team if process automation is incomplete.
UC: Engineering Process Monitoring and Analysis

- Project monitoring, analysis, and improvement based on quantitative data.
- Process-driven approach enables traceability, repeatability, measurement, and improvement of processes and products.
- Engineering process status reporting:
  - Identification and inspection of all deliverables at a defined milestone for approval.
  - Traceability of project progress.
  - Quantitative data, e.g., sequence of steps for process assessment, duration, and number of iterations.

### Development phases

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<th>Milestones</th>
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<td>Requirements</td>
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<tr>
<td>Systems Design</td>
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<td>Software Design &amp; Implementation</td>
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<td>Test</td>
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- **Finished and approved**
- **In progress / changed / not approved**
- **Not started / failed / not approved**

Current status
Dipl.-Ing. Dietmar Winkler

- Institute of Software Technology and Interactive Systems
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- Research Interests and Application Areas
  - Software Engineering and Project Management
  - Software Product and Process Improvement
  - Software Quality Assurance and Quality Management
  - Empirical Software Engineering
  - Software Processes
  - Scenario-based Software Architecture Evaluation

- Selected Past & Present Cooperations:
  - Continental Automotive Switzerland AG (Quality Management Consulting)
  - Austrian Computer Society (OCG Arbeitsgruppe “Software Prozesse”)
  - Bundesrechenzentrum GmbH (Quality Assurance and Knowledge Management)
  - Continental Automotive Switzerland AG (Process and QM Consulting)
  - Czech Technical University (SE and QA Consulting)
  - Fraunhofer Institute for Experimental SE (Strategic Quality Planning)
Selected Projects and Publications (1/3)

General Software Engineering


Complex and heterogeneous systems


Test-Driven Automation

Selected Projects and Publications (2/3)

Quality Assurance

Architecture Evaluation
Selected Projects and Publications (3/3)

Agile Software Development and Quality Assurance