MDSD for Railway Control Centers

Workshop: Model-driven Software Development in the Real World 2010

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Goals



4 Solution Approaches

- DSL Partitions
- Testing

5 Processes

6 Literature

Modellbasierte Enfwurfsmethoden für eine neue Generation elektronischer Stellwerke (MENGES)

Domain Electronic Railway Control Systems

Use Case Project Lindaunis, light railway route Kiel-Flensburg

Topics Visualization, documentation, verification, early testing, simulation, and (meta-)model changes

- Industry b+m Informatik AG Funkwerk IT
- University Software Engineering Group Embedded and Real-time Systems Group















Use Case

Introduction



- Control Center in Eckernförde
- Single-track railway with five Stations
- ∀ Stations: 4 switches, 12 signals, ...
- Specials: Flap bridge over the Schlei



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Application Domain

Track System

- Tracks, Switches, Signals
- Railroad Crossings, Stations
- Neighbor Railway Control Systems

PLC Programming

- PLC programming standards [IEC, 61131-3]
- Limited Hardware 1-4 MB RAM
- Safety Constraints (SIL 4)
- Real-time requirements

Safety

- CENELEC certification documents
- Certification of resulting PLC programs



Goals

- DSLs for different aspects of the domain
- Specification schemes for future changes in the DSL
- Analytical and simulation-based testing methods
- Pragmatics for the graphical DSL
- Automated generation of required documentation



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- Topology, attached components and constraints
- Behavior of physical and logical components
- Communication
- Sensors and actors
- Handling of failures and errors (safety)
- Distribution/Deployment

Challenges



Complexity of the application domain

- Family of domains with some common elements and semantics
- State and company policies
- Wide range of usage scenarios

Model and meta-model changes

- Evolving state and customer policies
- New technologies (like signals or safety concepts e.g. ETCS)

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DSL Solutions

- Separation of different aspects of the domain with different partitions in the DSL
- Design of the DSL partitions as reusable packages
- Automated layout of graphical DSLs using rule based layout

Simulation and Testing

- Simulation based on different levels of abstraction
- (Semi-)Automatic instrumentation of the simulation models
- Coupling simulation with inputs from environment simulations

DSL Partitions







Topology DSL





Topologie: Einbruchsstelle E1 Weiche W1 abzweig links grenzzeichen G1 verbinde spitze mit E1.ende Weiche W2 abzweig rechts grenzzeichen G2 verbinde spitze mit W1.rechts Weiche W3 abzweig rechts grenzzeichen G3 verbinde rechts mit W2.links verbinde links mit W1.links Stumpfgleis S1 verbinde ende mit W1.links Einbruchsstelle E2 verbinde ende mit W2.spitze

Topology Meta-Model

Solution Approaches > DSL Partitions



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Field Element Behavior

Deterministic Automata

- Describe valid states and transitions
- Triggered by user or field element events

Rule Graphs Start node: Command WU End node: Action go left, go right





- Configuration of running tracks match configuration of switches and signals
- Track graph is valid
- Identification of missing safety components (e.g. signals)
- Check of rule graphs (unreachable sections)
- Detection of unreachable states
- Some timing constraints (upper bounds)



Different abstraction level

- Simulation of model code
- Simulation of PLC code (Software PLC)
- Simulation with real PLC

Different simulation parts/sections/subdomains

- User simulation
- Environment simulation (tracks, trains and their failures)
- Simulation of the control system

Instrumentation of Simulations

Benefits of Instrumentation

- Minimizing monitoring data (less data garbage)
- Defining complex measurements in code

Use Cases for Instrumentation

- Detection of unused code
- Testing time constraints
- Identifying slow processes







- Agile DSL development, adding language and model features over time
- Direct involvement of domain experts through meetings and use of the language

Literature I

Literature

[IEC] Programmable controllers - part 3: Programming languages (iec 61131-3:2003).

