Applying TDL to describe tests of a distributed RT control system

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Robust and reliant automotive computing environment for future eCars

RACE: Project objectives

- Platform of distributed, redundant nodes for fail-operational functions
- Centralized platform core reduces complexity and requires less control units
- More functionality realized in software
- Plug & play for new features, components, nodes, e.g. Adaptive Cruise Control
- Improved approval capability of the ICT architecture

Test of safety services in hard-real-time without side-effects, early on in development

http://www.projekt-race.de/
**Approach:** Distributed system of redundant, testable nodes running time-triggered

**Time-triggered execution of nodes of the RACE platform**

- Platform core of several XCCs of 2 redundant lanes (X = 2)
- Platform services and applications run periodically in 10ms cycles
- Data flows between component functions in defined order
- 100 Mbit/s Ethernet for communication, synchronized clocks
- Use of synchronous dataflow programming and testing
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Test probes (SW/HW) seamlessly built-in in each node

- Run in an reserved time-slot at the end of each cycle
- Observe states and signals (SUT output)
- Manipulate states and signals (test stimulus)
- Seed data and inject faults (test stimulus)
- Common controlling and coordinating tester: RT-Linux
- Dedicated, fast p2p communication links (Eth)
- Interactive test HMI on separate machine
How to specify and document tests?

The need for a test description language

• Specification in a programming language, e.g. C?
  • (+) Directly executable
  • (-) Lost in details; what shall be tested?

• Specification in a graphical language, e.g. standard UML?
  • (+) Good to capture high-level overview
  • (-) Various semantics, tool dependent; mostly considered as artwork

• Reality: Mostly plain text; use of MS Word or Excel or Adobe PDF
Test descriptions in RACE – Expression of domain concepts by extending UML sequence diagrams

Example test “XCC lane boots up in max. N cycles”

1) Periodic execution in cycles
2) 9.0.0 addresses a node’s state variable
3) State 3 denotes "normal operation"
Progressing beyond illustrative UML specifications

The standardized ETSI Test Description Language (TDL)

**TDL offers**
- Separation of test specification from test implementation
- Single, concise and comprehensive language on testing
- Support of black-box testing in different application domains
- Adjustable to stakeholders; multiple syntaxes

**TDL as the latest evolutionary step in test automation**

- **Test language**, capturing all test concepts in one language
- **Keyword-driven testing**, keywords embedded in (natural) language
- **Data-driven testing**, separation of test scripts and data
- **Functional decomposition**, test frameworks

**Test automation**

TDL abstract syntax, ES 203119-1
TDL graphical syntax, ES 203119-2
TDL exchange format, ES 203119-3
Finding abstractions to capture domain concepts is key for designing a good test description language

Abstractions for the time-triggered system in RACE and mapping to TDL concepts

- **Cycle** == behavior, in which signals are processed (in any order) → TDL compound behavior
  - **Interval** == behavior, which covers more than one cycle, bound to trigger signals
  - **Step** == structural element of a test description, contains cycles, intervals

- Not all abstractions in RACE have fitting TDL representations → use of TDL annotations

• **In/out signals** of the SUT == data exchanged with the environment → TDL interactions
  - **Trigger** signal == an expected signal is eventually output

Diagram:

- Cycle
- Interval
- **TRIGGER**
Building the RACE test language from TDL

Tooling for TDL – From abstract syntax to concrete syntax

- EMFText Eclipse Plug-In (http://www.emftext.org)

- Starting point: existing TDL abstract syntax (from ETSI website)
- Generation of a first concrete syntax (in EBNF) from the TDL abstract syntax using EMFText
- Adaptation of generated concrete syntax according to domain requirements
  - Deletion of unneeded features
  - Introduction of domain concepts as keywords
    e.g. RACE signal → TDL interaction, RACE cycle → TDL compound behavior
  - Further simplification of syntax, optimization
    - Decide about the general language design
      e.g. use special symbols such as {, }, ;

- EMFText supports the generation of an Eclipse-integrated editor
  - Fully fledged editor with syntax-highlighting, code completion etc.
The textual RACE test language derived from TDL and supported by an Eclipse built-in editor

Example test “Continue execution after T2 stop cycles”

```plaintext
TestDescription:
  name "Test1.d";
  Annotation: value "Node is in state S1", key Precondition, annotatedEl
  owningPackage RaceTestSuite;
  testObjective Test1.d;
  Parameter: ValidNodeState "S1";
  Parameter: Integer "T2";
  testConfiguration Config1_d;
  BehaviourDescription:

  STEP:
    TestDescriptionReference: Test1.d.Precondition;

  STEP:
    Cycle
    signal from t to state : stop;
    signal from output to t : var_data = any anyData;

  STEP:
    BoundedLoop: ( startValue: 1; endValue: add(var T2, -1); )
    Cycle
    signal from state to t : stop;
    signal from output to t : var var_data;
    signal from t to state : stop;

  STEP:
    Cycle
    signal from t to state : stop;
```

Graphical illustration of the test
Conclusions – TDL enables design of domain-specific test languages

**TDL is a tool-independent approach to provide means for testing**

- Design, implementation of textual domain-specific (test) languages
  - Well supported by existing technologies (EMFText, Xtext)
  - Within Eclipse
- Graphical test languages
  - Highly desirable by testers and non-testers for easy visualization
  - Much harder to get tool support

**Recommendations on improving user acceptance for TDL**

- Enable a quick start – Provide a TDL reference syntax and implementation
- Tap the potentials of UML editors → UML profile for TDL?
  - Support for graphical notations
  - Easier integration into the development lifecycle process
- Creation of a TDL user group?
  - Exchange forum
  - Social platform
Outlook: A scalable TDL-based tool architecture

Exchangeable and reusable tool components; adjusted to specific demands

- Textual Editor
- Graphical Editor
- TDL Model Analyzer
- TDL Test Generator
- Report
- Document Generator
- Test Plan
- C-code
- Test Code Generator

TDL Exchange Format (ETSI ES 203119-3)
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