Fraunhofer Einrichtung Systeme der Kommunikationstechnik

MoTeF – A toolchain for model-based test generation

Embedded World Conference

Dipl.-Ing. Mike Heidrich

Nuremberg, 05. March 2009

www.esk.fraunhofer.de

Fraunhofer ESK - Facts & Figures

Prof. Dr. Rudi Knorr
Director

Chair for Communication Technology,
Augsburg University

Fraunhofer ESK
Hansastr. 32
80686 Munich
Phone.: +49 89 547088-0
Fax: +49 89 547088-220
info@esk.fraunhofer.de

Fraunhofer Institute for Communication Systems ESK

- 55 employees
- Research budget 4.87 million Euros

Areas of Expertise

- **Adaptive Communication Systems**: Self-organization networks and methods, embedded platforms
- **Software Methodology**: Model-based design, software quality, software product lines

Business Units

- Enterprise and Carrier Communication
- Automotive
- Industrial Communication

Fraunhofer Einrichtung Systeme der Kommunikationstechnik

www.esk.fraunhofer.de

Area of Expertise - Software Methodology

Model-based design
- Model-based design of distributed and self-organizing software
- Software design for mechatronics systems

Software quality
- Virtual integration
- Model-based test specifications, test scenario generation and selection
- Testing of distributed systems and distributed test systems

Software product lines
- Implementation of software product lines
- Software product line interoperability

Mike Heidrich
Expert Group Manager

Agenda

Introduction

MoTeF - Model based test framework

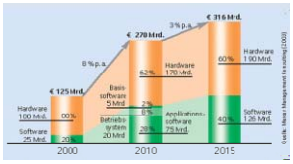
XTR – XML based test representation

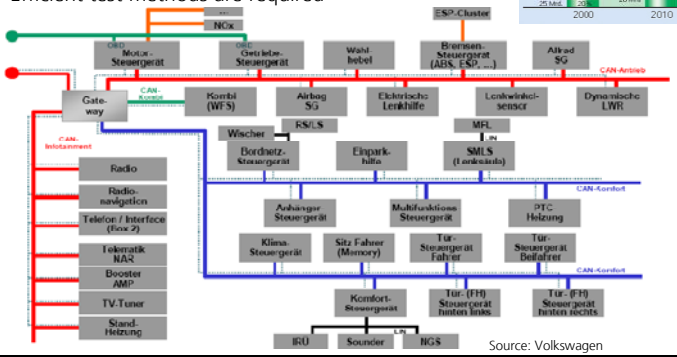
Future research directions

Summary

Problem Statement - Automotive Example

- Up to 70 embedded electronic control units (ECU)
- Rapidly growing percentage of software functions
- High quality demands at cost constraints
- Efficient test methods are required



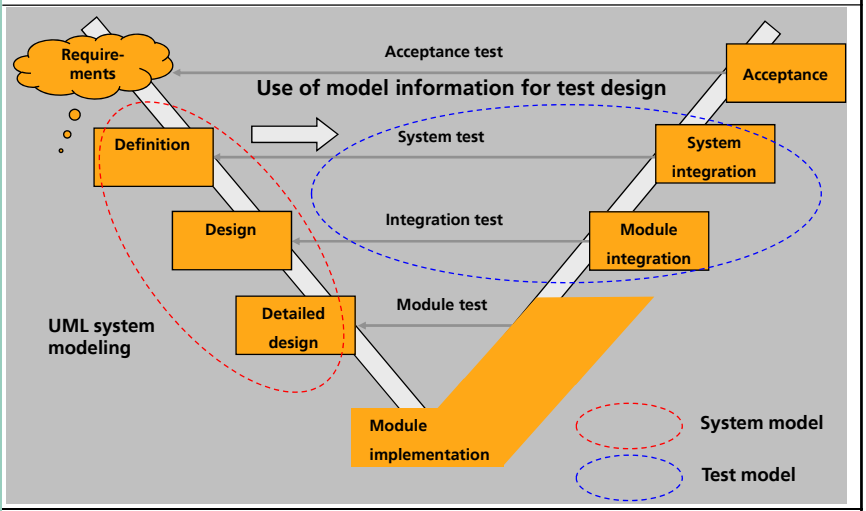


Source: Volkswagen

Fraunhofer ESK Einrichtung Systeme der Kommunikationstechnik

www.esk.fraunhofer.de

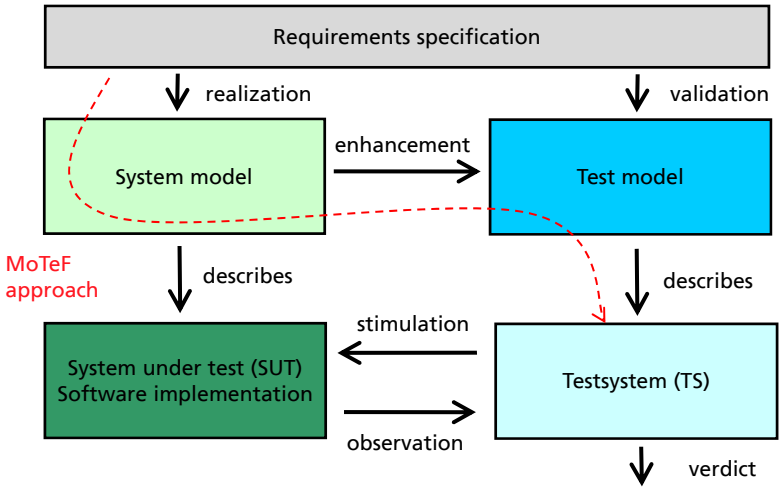
Model-based Testing



Fraunhofer ESK Einrichtung Systeme der Kommunikationstechnik

www.esk.fraunhofer.de

Definitions and Approaches for Model Based Testing



Folie 7

Fraunhofer Einrichtung Systeme der Kommunikationstechnik

Source: Volkswagen

www.esk.fraunhofer.de

Agenda

Introduction

MoTeF - Model based test framework

XTR – XML based test representation

Future research directions

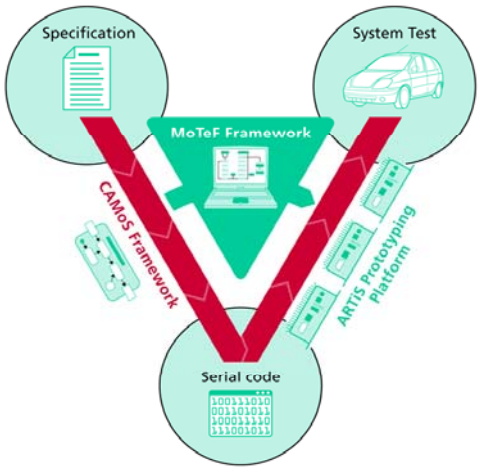
Summary

Folie 8

Fraunhofer Einrichtung Systeme der Kommunikationstechnik

www.esk.fraunhofer.de

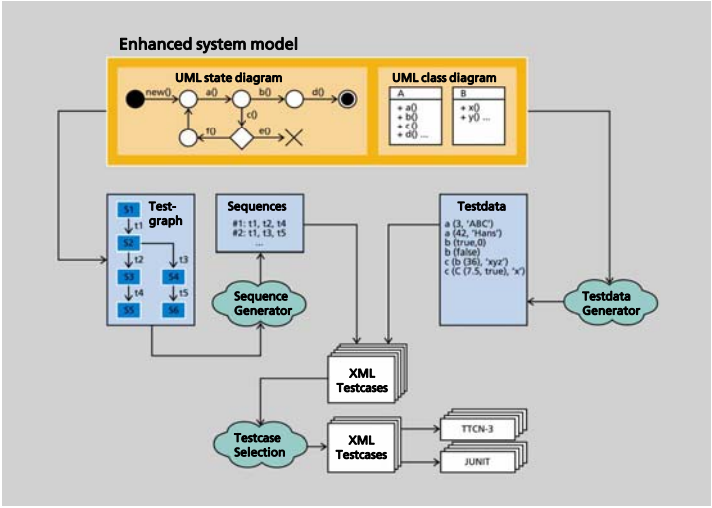
Fraunhofer ESK Solutions



Fraunhofer Einrichtung Systeme der Kommunikationstechnik

www.esk.fraunhofer.de

MoTeF Overview



www.esk.fraunhofer.de

MoTeF Framework - Test Sequence / Test Generation

Generation and selection of test sequences:

- Compilation of the model states and creation of a test tree
- Compilation of all test flows in the test tree (breadth-first and depth-first searches)
- Selection of relevant test scenarios using annotations in the model in order to implement test strategies (e.g. coverage, risk-based testing)

Generation of test data

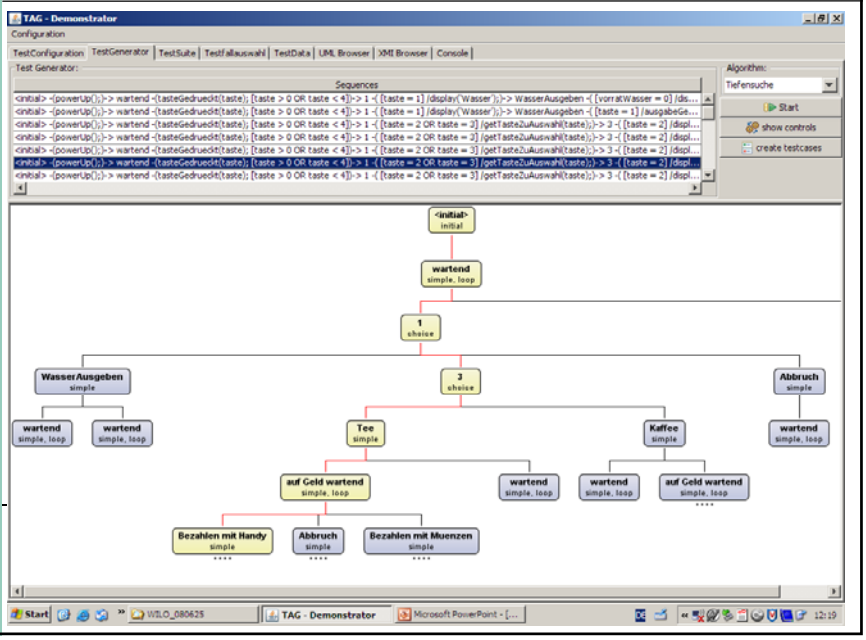
- Random-based
- Equivalence class creation and threshold analysis
- Numerical methods
- Genetic algorithms

Test scenario selection

- Modeling methodology for selection criteria based on annotations

Fraunhofer Einrichtung Systeme der Kommunikationstechnik
www.esk.fraunhofer.de

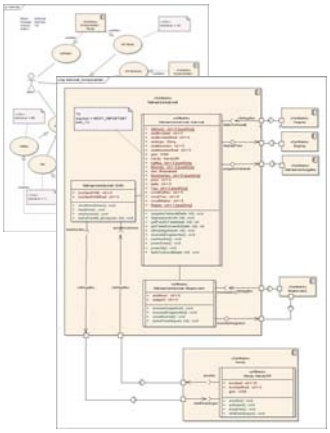
MoTeF Framework – Tool Prototype



www.esk.fraunhofer.de

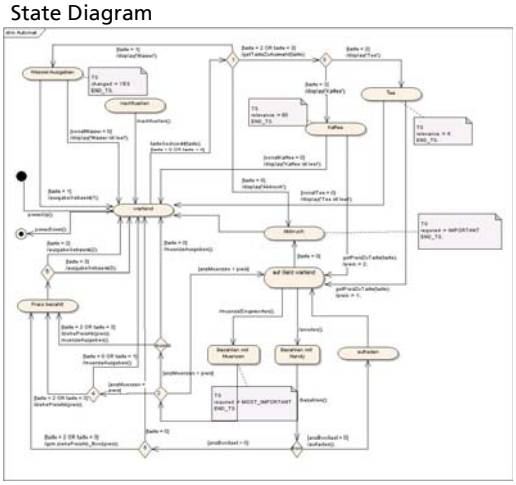
MoTeF Framework – Example: Vending Machine

Use-Cases



Components

State Diagram



Fraunhofer ESK Einrichtung Systeme der Kommunikationstechnik

MoTeF Framework – Example: Vending Machine

Temp Format XTR

```
- <ts:testCase name="TC1">
  - <ts:xmiIDs>
      <ts:id>EAID_0FB8914B_B2DC_4a79_B09B_9D978CB30D9B</ts:id>
      <ts:id>EAID_813FBE98_3C43_404a_B807_472E46509D0C</ts:id>
      <ts:id>EAID_874B1893_6505_413e_8368_C6A27327B8EA</ts:id>
      <ts:id>EAID_55683C14_1286_447e_8D0F_7B3566EBEB4D</ts:id>
      <ts:id>EAID_3D7444D0_60E8_4b2d_B586_ED42F5E306EA</ts:id>
      <ts:id>EAID_B0FF8AFF_BA08_46e6_B75D_46F44C6CB27E</ts:id>
      <ts:id>EAID_7F67F2BE_37E3_474a_B910_6825D969402B</ts:id>
      <ts:id>EAID_EE349353_6AFD_427c_8575_FE3C8217A747</ts:id>
      <ts:id>EAID_874B1893_6505_413e_8368_C6A27327B8EA</ts:id>
    </ts:xmiIDs>
  - <ts:testBehaviour testComponent="TComp1">
    - <ts:variables>
        <ts:object name="taste" type="int" complex_type="false" />
      </ts:variables>
      <ts:testInteraction type="call" object="test" method="powerUp" />
    - <ts:testInteraction type="call" object="test" method="tasteGedrueckt">
        <ts:value type="variable">taste</ts:value>
      </ts:testInteraction>
    - <ts:verify type="assurance" verdict="pass">
      - <ts:condition type="eq">
```

Language JUnit

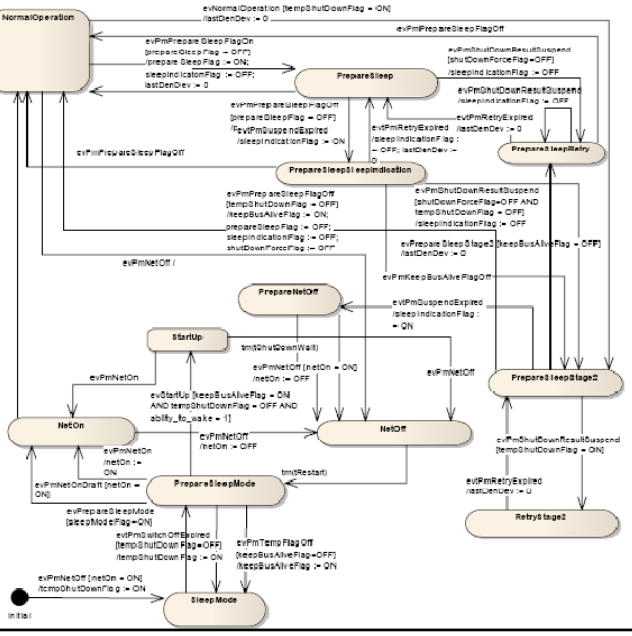
```
public void testTC1() {
    try {
        int taste = 1;

        tcomp0.powerUp();
        tcomp0.tasteGedrueckt(taste);
        if(!( tcomp0.getTaste() == 1 )) return;
        if(!( tcomp0.getVorratWasser() == 0 )) return;
    } catch (Exception ex) {
        fail("excpection was not expected");
    }
}

public void testTC2() {
    try {
        int taste = 1;

        tcomp0.powerUp();
        tcomp0.tasteGedrueckt(taste);
        if(!( tcomp0.getTaste() == 1 )) return;
        if(!( tcomp0.getTaste() == 1 )) return;
    } catch (Exception ex) {
        fail("excpection was not expected");
    }
}
```


Fraunhofer ESK Einrichtung Systeme der Kommunikationstechnik

www.esk.fraunhofer.de

Fraunhofer ESK Jan 2008

MoTeF Framework – Example: MOST Powermaster



Agenda

Introduction

MoTeF - Model based test framework

XTR – XML based test representation

Future research directions

Summary

Fraunhofer ESK Einrichtung Systeme der Kommunikationstechnik

www.esk.fraunhofer.de

Motivation

Reasons for using a XML-based representation format

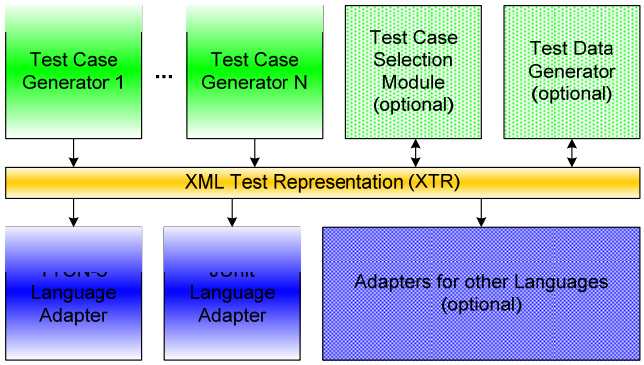
- Many commercial and academic tools for the model-based test generation
- Different solutions for test case specification:
  - Using the same language for programming the SUT and writing test cases
  - Specification of test cases with scripting languages, e.g. TCL
  - Utilization of specialized testing languages, for example TTCN-3
- Only a small number of test generation tools support several target languages
- A test representation format facilitates:
  - The exchange of test cases between different tools
  - The implementation of adapters for different target languages
- Advantages of using XML for test case representation:
  - XML documents can be formalized by XML Schemata (XSD)
  - XML is processable with commercial tools

Fraunhofer Einrichtung Systeme der Kommunikationstechnik
www.esk.fraunhofer.de

Toolchain Architecture

Architecture of a tool chain which utilizes the XTR format

- Different test case generators and other optional modules
- Adaptors for different target languages

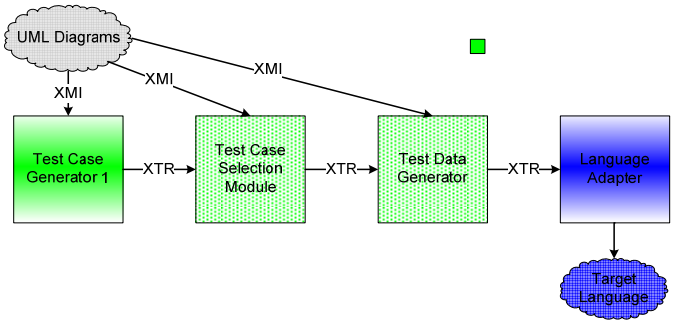


Fraunhofer Einrichtung Systeme der Kommunikationstechnik
www.esk.fraunhofer.de

Toolchain and Workflow

Workflow of test case generation with the XTR format

1. Test Case Generator produces test cases in the XTR format
2. Optional modules can be used for post-processing
3. A Language Adapter transforms XTR test cases into a target language



Fraunhofer Einrichtung Systeme der Kommunikationstechnik
www.esk.fraunhofer.de

XTR example: test case representation

Specification of a XTR test case

```
<testCase name="TC_1">
  <testBehaviour testComponent="Comp
    ...
  </testBehaviour>
  <testBehaviour testComponent="Comp
    <variables>
      <variable name="timeOutTimer"
      <variable name="waitTimer" typ
    </variables>
    <testInteraction>
      <send>  // send testInteractio
        <message>
          <value typeName="aStructur
          ...
          </value>
        </message>
      </send>
    </testInteraction>
    <timerOperation type="start" tim
    <testInteraction>
      <receive verdict="pass">   //
        <message>                //
          <template templateName="aT
        </message>
      </receive>
      <timeout timer="timeOutTimer"
    </testInteraction>
    <timerOperation type="stop" time
    <synchronize/>   // => Synchroni
  </testBehaviour>
</testCase>
```

```
function testBehaviour_2 () runs on Component_2 {
  timer timeOutTimer := 15.0;
  timer waitTimer := 15.0;
  {
    pco2.send(...)  // sending a fixed value
    timeOutTimer.start;
    alt {
      []pco2.receive(aTemplate) {
        setverdict(pass);
        timeOutTimer.stop;}
      []pco2.receive(?) {
        setverdict(fail);
        timeOutTimer.stop;}
      [] timeOutTimer.timeout{
        setverdict(fail);}
    }
  synchronize(); // Waiting for other testcomponents
}
```

www.esk.fraunhofer.de

Agenda

Introduction

MoTeF - Model based test framework

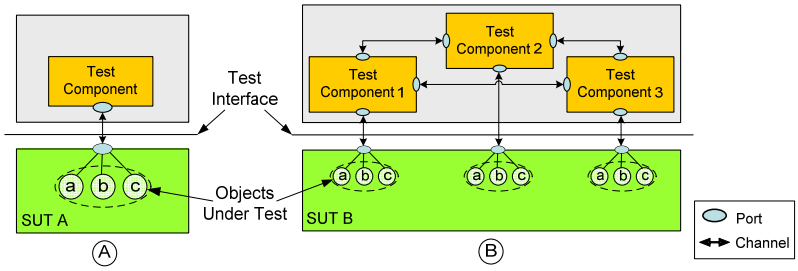
XTR – XML based test representation

Future research directions

Summary

Fraunhofer Einrichtung Systeme der Kommunikationstechnik
www.esk.fraunhofer.de

Testing distributed systems



Scenario A: Centralized test system for distributed objects

- Compilation of the model information
- Automated, integrated creation of test flows and test data

Scenario B: Distributed test systems and distributed systems under test

- Support for distributed systems (communication software)
- Support for parallel processes during testing (concurrencies)

Fraunhofer Einrichtung Systeme der Kommunikationstechnik
www.esk.fraunhofer.de

Agenda

Introduction

MoTeF - Model based test framework

XTR – XML based test representation

Future research directions

Summary

Summary

Model-based testing

- Formal specification for the software under development through models
- Automated development of test flows and test data from existing models

XML based test representation

- Adaptation to different test generators
- Mapping to different target languages

Future research directions

- Testing of distributed systems

Fraunhofer Einrichtung Systeme der Kommunikationstechnik

Thank you for your attention !

Please visit us at booth 11-101 !

Mike Heidrich
+49 89 547088 377
mike.heidrich@esk.fraunhofer.de

www.esk.fraunhofer.de