TTCN-3 @ Siemens

Leveraging TTCN-3 in Software Development Projects

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- Overview of Siemens Corporate Technology
- How to Introduce TTCN-3 at Siemens
- Lessons Learned
- New Challenges
- Conclusions
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Siemens Six Business Areas

External sales of Operations Groups excluding Other Operations (as of September 30, 2006)

1) Represented by Siemens Networks GmbH & Co. KG and Siemens Enterprise Communications GmbH & Co. KG as of October 1, 2006.
2) Siemens Business Services (SBS) Group until January 15, 2007
Innovations keep us strong – Milestones across the centuries

Corporate Technology
International Network of Competencies – Worldwide Partner for Innovations

More than 2,500 employees at 31 locations worldwide

Mission:
- To increase the competitiveness and
- to secure the technological future

of the Company in cooperation with the Operating Groups and the Regional Companies

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**Corporate Technology – Research and Technologies**

**Software & Engineering Technology Division**

- System and software processes
- Software architecture for distributed, mobile and embedded systems
- Information brokers and technical liaison managers
- Software architecture for distributed, mobile and embedded systems
- Analysis and engineering of complex systems
- Project management and innovation
- Siemens Software Initiative

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**Innovation strategies and their positioning along the technology lifecycle**

- **First Mover**
  - "The early bird catches the worm" (American saying)
- **Fast Follower**
  - "The early bird catches the worm but the second mouse gets the cheese"
  - (G. Keillor)
- **Basic Technologies**: Basic competence for today’s business
  - Key Technologies: Determine today’s competitiveness
- **Pace-setting Technologies**: Determine tomorrow’s competitiveness
- **Trendsetter**
  - "If you’re in control of wormholes and mouse-traps, you get both – the worms and the cheese"

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**Siemens’ innovation strategy**: Be a trendsetter in our business!
How to Introduce TTCN-3 at Siemens: Approach Chosen by Corporate Technology

Corporate Technology is committed to promote the benefits of TTCN-3 to Siemens business units!

- Analyze the relevance of TTCN-3 for Siemens
- Contributions to the standardization
- Raising awareness within Siemens
- Getting tool support
- Trainings
- External visibility

From a Fast Follower to a Trendsetter in TTCN-3
Analyzing the Relevance of TTCN-3 to Siemens Business Units

TTCN-3 is standardized
- Test notation is independent from tool providers
- Test notation keeps pace with arising new technology trends
- Growing TTCN-3 user community
- Test suites for standard telecom protocols become available

Standardized TTCN-3 interfaces
- Provides quick adaptation to a large variety of systems with predictable costs
- Facilitates reuse of TTCN-3 test suites

TTCN-3 as a universal test notation
- Carries high potential for cost reductions
- Test suite design
- Automation of test execution
- Adaptation to different SUTs
- Test tool and test suite maintenance
- Supersedes any proprietary ad-hoc solution

TTCN-3 is a test methodology that is beneficial to SBUs

Promote the Benefits of TTCN-3: Contributions to the Standardization

- Contribution to the TTCN-3 standardization process at ETSI
  - ETSI: European Telecommunications Standards Institute
  - Starting in 2003 – at that time Edition 2 of the standard was already available
  - Incorporation of change requests into the standard
  - Elaboration of new language features

Gain expertise in the technology by ourselves

http://www.ttcn-3.org/
Promote the Benefits of TTCN-3: Raising Awareness within Siemens

- Siemens internal TTCN-3 workshops via the Siemens Software Initiative (SWI)
  - 1st workshop in May 2003
  - 2nd workshop in June 2006
  - 3rd workshop in Sept. 2007 (planned)

- Central platform for all business units
  - Information broker and forum
  - Tool evaluations
  - Joint projects with SBUs

→ Corporate Technology as a test expertise center

Promote the Benefits of TTCN-3: Getting Tool Support

- Success of TTCN-3 depends on appropriate tooling
  - TTCN-3 compiler
  - Test execution tool

- At the beginning in 2003, available tools were not appropriate for industrial projects!
  - Invest in an own in-house tool?
  - Upcoming market for commercial tools was foreseeable

- Collaboration with TTCN-3 tool providers
  - Tool providers currently used
    - Testing Technologies, Telelogic, Danet
  - Arrangement of special licensing conditions
  - About 200 licenses sold within Siemens up to now
Promote the Benefits of TTCN-3: Trainings

- Internal trainings for Siemens business units
  - Offered in-house trainings
    - Introductory course
    - Extended training over 1 week
  - Collaboration with the German Testing Board of ISTQB on tester certification
    - ISTQB ® Certified Tester
    - TTCN-3 Certificate ®
    - Qualify test engineers in TTCN-3 technology and general software testing (Foundation – Advanced – Expert Level)

Promote the Benefits of TTCN-3: External Visibility

Active participation at the International TTCN-3 User Conferences together with project partners from SBUs

- 2004: 1st T3UC, ETSI, Sophia Antipolis, France
  → 1 presentation
- 2005: 2nd T3UC, ETSI, Sophia Antipolis, France
  → 1 presentation
- 2006: 3rd T3UC, Siemens, Berlin, Germany
  → 2 presentations
- 2007: 4th T3UC, Ericsson, Stockholm
  → 4 presentations

Publications and presentations at other conferences, e.g. ISSRE
TTCN-3 Projects at Siemens

2003
- Communication: UMTS Node B development (TTCN-3 evaluation)
- Automotive: Test of infotainment devices over MOST bus

2004
- Communication: IMS testing
- Automotive: Test automation of HiL tests (TTCN-3/U2TP evaluation)

2005
- Communication: Test of HiPath PBX

2006
- Medical Solutions: Test of X-ray collimators
- Power Engineering: Test of distributed power protection systems

2007
- Communication: UMTS RNC development

Project Example: Testing for X-ray Collimators over CAN-bus

Customer: Medical Solutions
Customer challenge:
- Regression testing of controller software for X-ray collimators over the CAN bus
- Stringent real-time requirements of the software had to be met by the regression test tool

Task for Corporate Technology:
- Design and implementation of a TTCN-3 test architecture
- Evaluation and adoption of TTCN-3 test tools

Contribution of Corporate Technology:
- Design of a test architecture that meets the testing needs of the client in terms of abstraction, concurrency, and real-time performance of test cases
- Implementation of the design in cooperation with the client
- Coaching of employees

Benefits to the customer:
- Automation of manual tests
- Testing of previously untestable scenarios, e.g. concurrent access
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Findings from TTCN-3 Test Projects (1)

**Success stories!**
- Use of TTCN-3 in projects shows the expected productivity gain
  - E.g. Medical Solutions: About 3 times more efforts at beginning, but 3 times less efforts at subsequent regression tests + higher test coverage!

**Training**
- Requires sufficient training of staff
- TTCN-3 experts are still rare on the job market

**TTCN-3 project must be managed like a SW development project**
- Configuration management and version control
- Tooling for test case management
- Different project roles
### Required Roles in a TTCN-3 Test Project

<table>
<thead>
<tr>
<th>Role</th>
<th>Responsibilities</th>
<th>Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test designer (programmer)</td>
<td>Designs test suites</td>
<td>TTCN-3 tool, test design tool, configuration management</td>
</tr>
<tr>
<td>Test designer (specifier)</td>
<td>Designs test suites graphically</td>
<td>Test design tool, configuration management</td>
</tr>
<tr>
<td>Test system architect</td>
<td>Designs the test system architecture</td>
<td>TTCN-3 tool, general SW design tools, configuration management</td>
</tr>
<tr>
<td>Test platform programmer</td>
<td>Implements adaptors for integration with SUT</td>
<td>Java/C/C++ IDE, configuration management</td>
</tr>
<tr>
<td>Test manager</td>
<td>Needs test reports and additional metrics</td>
<td>Test management tool, Web browser</td>
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### Findings from TTCN-3 Test Projects (2)

**Integration with SUT**
- Adaptable interfaces via TRI and TCI-CD
- Flexible data support, e.g. mixture of ASN.1, XML, others
- Mainly message-based interfaces tested, only little API

**Test language**
- Allows adequate abstraction level for most types of tests
- Modularity of TTCN-3 test suites
  - Allows design of a library of re-usable TTCN-3 code
  - Supports team work
  - Eases incremental development and configuration management
- Human readable test language
  - Simple text editor, e.g. Emacs, is sufficient
  - Version control is easy because of text files
  - Graphical format of TTCN-3 has no/little benefits over textual format
Findings from TTCN-3 Test Projects (3)

More emphasis on development of TTCN-3 test frameworks is required

- Answer to question: How do I implement a test purpose, e.g. an MSC, as a TTCN-3 test case?
  - Provides basic functionality to specify test cases (libraries)
  - Starting test design each time from scratch is not an option!

→ Development of adaptable test frameworks for different domains encouraged!

Findings from TTCN-3 Test Projects (4)

Efforts to introduce TTCN-3 are justified if …

- A separate test team exists
  - Usually in later test phases such as integration and system tests
  - No option for module tests because of high integration costs
  - SUT has stable (enough) interfaces
  - Efforts to develop adaptors for SUT integration can be kept low

Staff motivation

- Using newest technology provides extra motivation
Evolution of Testing: 
Raising the Level of Abstraction

<table>
<thead>
<tr>
<th>Model-Based Approaches</th>
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</thead>
<tbody>
<tr>
<td>Model design and test generation, e.g. using state charts (Rhapsody), Matlab/Simulink (Reactis), UML 2.0 Testing Profile</td>
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</table>

<table>
<thead>
<tr>
<th>Test Specification Techniques</th>
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<tr>
<td>Abstract test design with, e.g., TTCN-3, test scenario specifications with UML, etc.</td>
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<tr>
<th>Test Frameworks</th>
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<tr>
<td>Application/domain-oriented solutions, data-driven approaches, tool-based (e.g. WinRunner etc.)</td>
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<table>
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<tr>
<th>Test Scripting</th>
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<tr>
<td>VBasic, C/C++, Tcl/Tk, Expect, Pearl, Python etc.</td>
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<table>
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<tr>
<th>Test Execution Platform</th>
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<tr>
<td>Generation</td>
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Abstraction
Challenge (1): TTCN-3 and Model-Based Testing

- TTCN-3 becomes more of a test execution language and less of a test specification language

Why to detour to TTCN-3 to produce executable test scripts?
- Adds additional layer of complexity in the test architecture

TTCN-3 is justified if …
- A TTCN-3 test system already exists
- Used for certification → Standardized tests
- Templates of test data are rather complex due to nested type def.

Embedded Software Development

- MOOSE ITEA project: analysis of about 80 embedded SW development projects → What is state of practice?
  - System engineering is mainly hardware driven
    - System architecture decisions constraint SW architecture
  - Cost pressure mainly on HW
  - Product characteristics
    - 50% of products have hard real-time constraints
    - 35% of products have memory boundaries below 1 MByte
  - Increasing use of MDD techniques

Findings coincide with our own observations
- Non-functional SW requirements are important for our businesses, e.g. real-time performance (50%), restricted hardware resources (ca. 40%), safety (source: Siemens Software Survey, 2002)
Challenge (2.1):
TTCN-3 and Testing of Embedded Software

Today's TTCN-3 implementations have limited real-time capabilities
1) Handling of real-time constraints
   ▪ Fast and deterministic response time of tester
     (time between reception of a system output and a new input)
   ▪ Robustness of timer operations
     ▪ High number of timer invocations and timeouts during runtime
     ▪ Short timer durations lead to non-deterministic tester behavior

| Case 1: Timeout might occur after system output has been received and during the timer stop operation |
| p.send(outMsg); |
| T.start(0.002); |
| alt { |
| } T.timeout {} |
| [ ] p.receive(inMsg) |
| } T.stop; |
| Case 2: Two timeouts occur at a similar time |
| T1.start(0.003); |
| T2.start(0.002); |
| alt { |
| } p.receive(inMsg) {} |
| } T1.timeout {} |
| [ ] T2.timeout {} |

Challenge (2.2):
TTCN-3 and Testing of Embedded Software

2) Memory footprint of generated tester code
   ▪ Executable tester should be capable to run on target hardware
   ▪ Only code that is used to run a test case shall be generated
   ▪ Optimized and adaptable runtime library to produce executable tester
     → Reduce overhead of TCI implementation
     ▪ Provision of optimized codecs
     ▪ Flexible logging of a test run

→ Improvements on TTCN-3 compilers required!
Agile Software Development

- Agile development replaces more and more waterfall processes
- Extreme programming as key technology offering a set of core practices
  → Test driven development
  - Test driven development
  - Strong focus on
  - Unit tests, acceptance tests
  - Continuous integration and test

Siemens products
- More “enhancements, customizing, maintenance” (ca. 60%) than “new” (40%) development (source: Siemens Software Survey, 2002)

Challenge (3): TTCN-3 and Agile Software Development

- Unit tests are not in the domain of TTCN-3
  - High integration efforts
  - Different programming paradigms used in coding and testing
  - Different test methods: white-box (unit test) vs. black-box (TTCN-3)
- Focus on acceptance tests with TTCN-3
  → Concentrate on elaboration of stable system interfaces first!
- Advanced support from TTCN-3 tools required
  - Reduced efforts to build an executable test system, in particular better codec support for testing of APIs
  - Support for refactoring of tests
    - Evolving and changing system interface specifications → Templates
    - Changed system use cases → Reuse of test functions
Challenge (4):
TTCN-3 and Multi-Site Software Development

- Multi-site development projects, ca. 30% of our software staff work in “low-cost” countries (source: Siemens Software Initiative, 2005)

- Consequences from the perspective of testing:
  All testing activities could be distributed!
  - Test specification
  - TTCN-3 scripting
  - Setup of test environment
  - Test execution
  - Test tool maintenance

→ How to ensure the quality of TTCN-3 tests if test scripting and test execution are performed at different sites?

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Hurdles to Overcome when Introducing TTCN-3

- Complexity of the whole test automation solution → No out-of-the-box solution!
- Maturity of TTCN-3 tools (stability, real-time, Edition 3 support)
- Investment in existing test automation solutions must be protected → TTCN-3 as umbrella technology
- Solutions need to be worked out and improved tooling is required to cope with new challenges
  - Model-based testing
  - Testing of embedded real-time systems
  - Agile development processes
  - Multi-site software development

Conclusions

- TTCN-3 could be successfully introduced across different business areas of Siemens
- TTCN-3 is a good example how a new technology was embraced by Corporate Technology and then disseminated within Siemens
- TTCN-3 is a flexible solution for test automation projects
  - Good choice for black-box tests of reactive systems
  - Suitable for integration and system tests incl. end-to-end tests
  - No solution for testing of fast changing interfaces, e.g. GUIs!
- TTCN-3 tools reached industrial strength, but room for improvements
- Continued maintenance of TTCN-3 ensures a language that keeps pace with technological changes → Important factor for its success