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Corporate Technology

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
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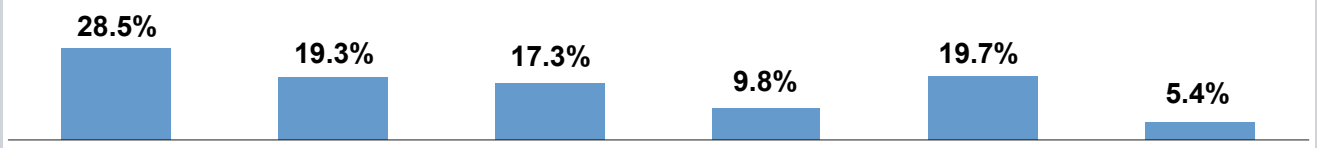
Siemens Six Business Areas

Automation and Control	Power	Transportation	Medical	Information and Communications	Lighting
					
Automation and Drives	Power Generation	Transportation Systems	Medical Solutions	Communications [1]	OSRAM
Industrial Solutions and Services	Power Transmission and Distribution	Siemens VDO Automotive		Siemens IT Solutions and Services [2]	
Siemens Building Technologies					

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

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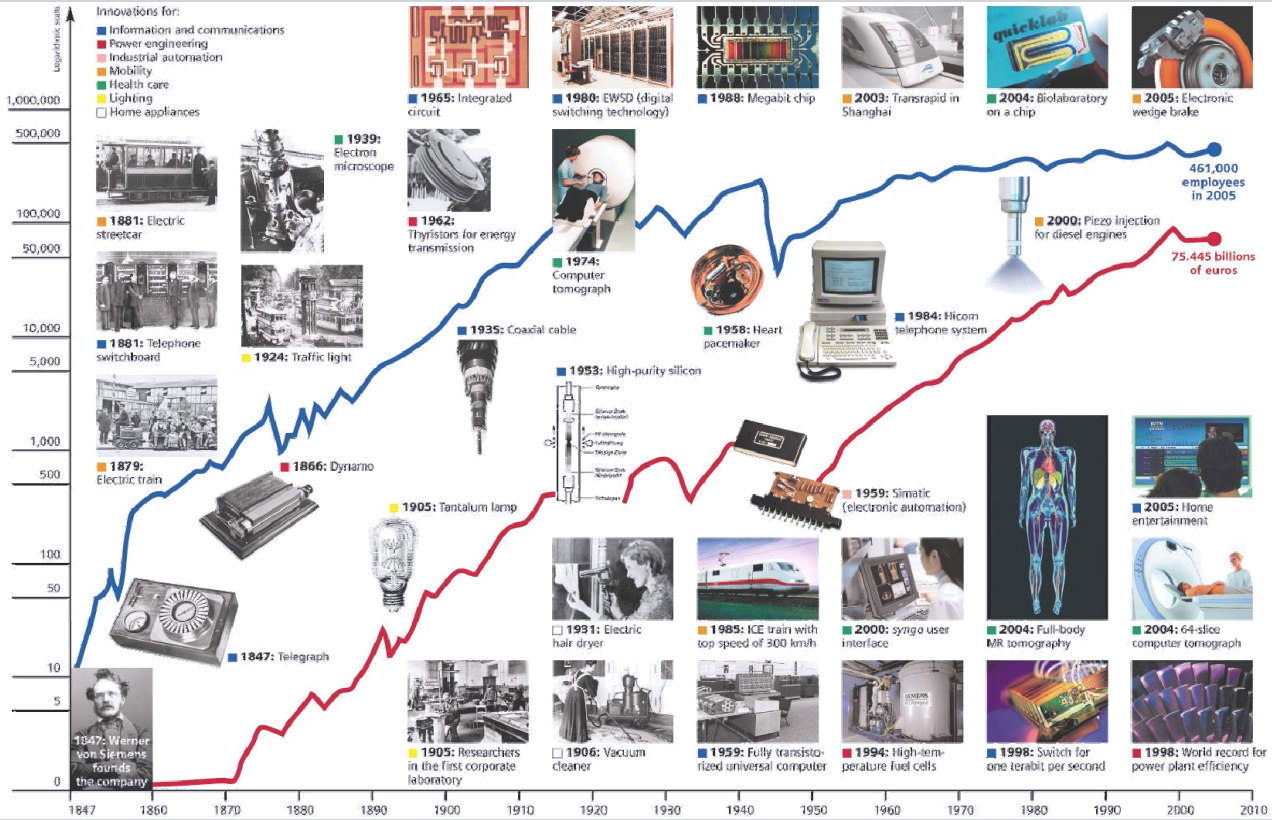

Corporate Technology International Network of Competencies – Worldwide Partner for Innovations

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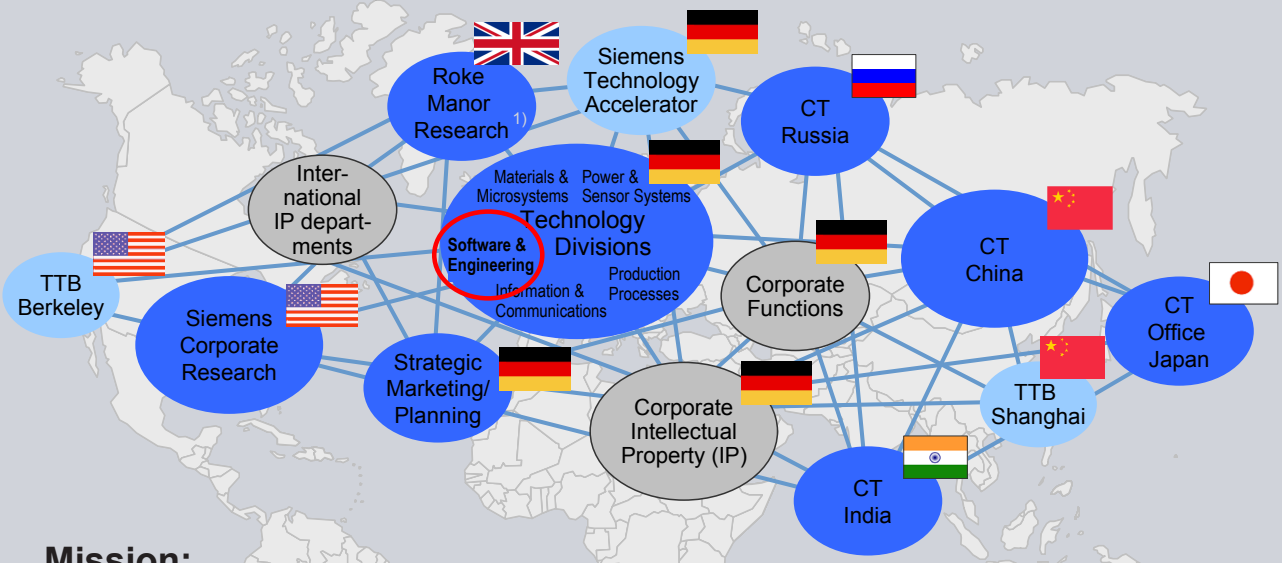
More than 2,500 employees at 31 locations worldwide



Mission:

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

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

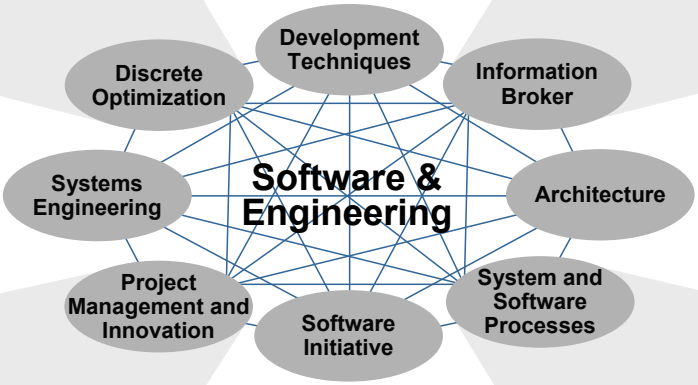
1) functional reporting to Corporate Technology

Optimization of planning, decision and production processes

Quality and efficiency in software development

Information brokers and technical liaison managers

Analysis and engineering of complex systems



Software architecture for distributed, mobile and embedded systems

Project management and innovation

Siemens Software Initiative

System and software processes

Innovation strategies and their positioning along the technology lifecycle

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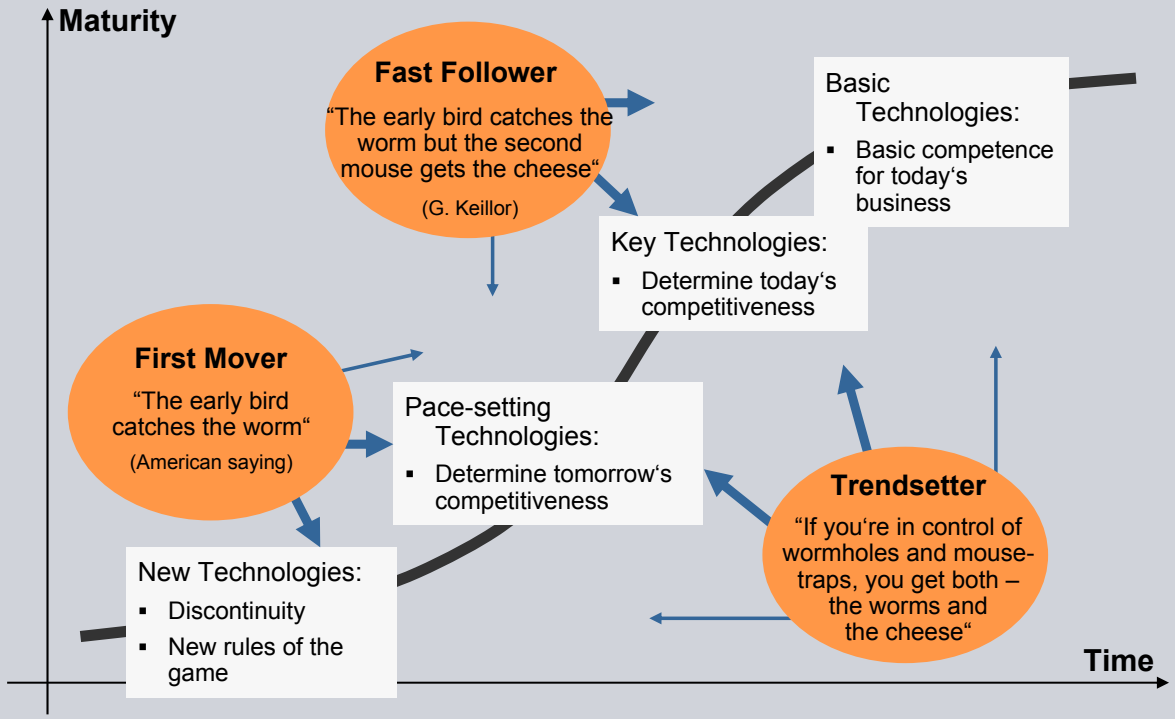

Siemens' innovation strategy: Be a trendsetter in our business!

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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

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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

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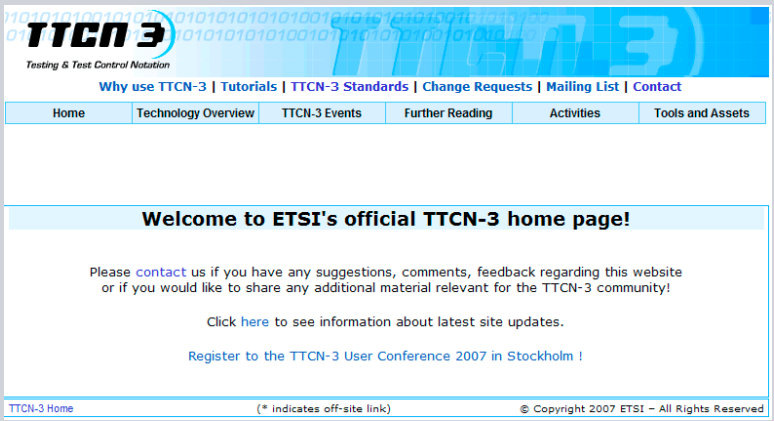
- Contribution to the TTCN-3 standardization process at ETSI
  - ETSI: European Telecommunications Standards Institute
  - Starting in 2003 – at that time Edition 2 of the standard was already available
  - Incorporation of change requests into the standard
  - Elaboration of new language features

➔ **Gain expertise in the technology by ourselves**



ETSI

http://www.ttcn-3.org/

Promote the Benefits of TTCN-3: Raising Awareness within Siemens

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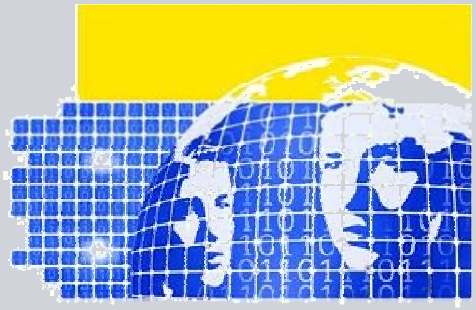
- Siemens internal TTCN-3 workshops via the Siemens Software Initiative (SWI)
  - 1st workshop in May 2003
  - 2nd workshop in June 2006
  - 3rd workshop in Sept. 2007 (planned)



- 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

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- 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

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- 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

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

TTCN 3
Testing & Test Control Notation

- 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

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TTCN-3 Projects at Siemens

2003 | 2004 | 2005 | 2006 | 2007

Communication
UMTS Node B development (TTCN-3 evaluation)

Communication
Integration of existing test automation solutions

Automotive
Test of infotainment devices over MOST bus

Automotive
Test of AUTOSAR basic software

Communication
Test of HiPath PBX

Communication
IMS testing

Automotive
Test automation of HiL tests (TTCN-3/U2TP evaluation)

Medical Solutions
Test of X-ray collimators

Power Engineering
Test of distributed power protection systems

Communication
UMTS RNC development

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

The Sireskop SX uses collimators from MED to control the shape and density of X-rays

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

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Required Roles in a TTCN-3 Test Project

Test designer (programmer)	*Designs test suites*	TTCN-3 tool, test design tool, configuration management
Test designer (specifier)	*Designs test suites graphically*	Test design tool, configuration management
Test system architect	*Designs the test system architecture*	TTCN-3 tool, general SW design tools, configuration management
Test platform programmer	*Implements adaptors for integration with SUT*	Java/C/C++ IDE, configuration management
Test manager	*Needs test reports and additional metrics*	Test management tool, Web browser

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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

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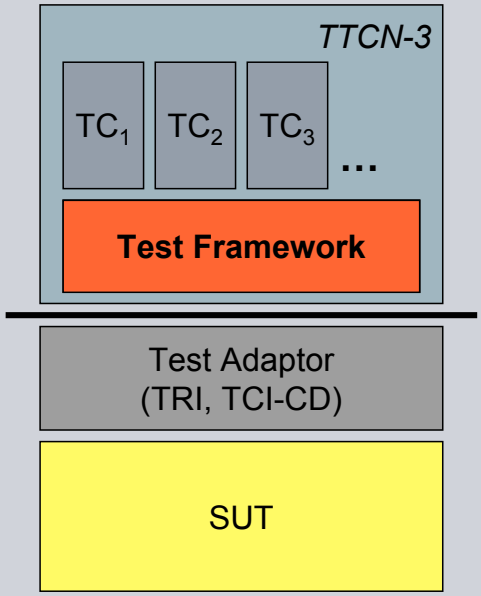
Findings from TTCN-3 Test Projects (3)

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!**



Example: Mapping of Test MSCs to TTCN-3 functions based on a specifically developed test framework

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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

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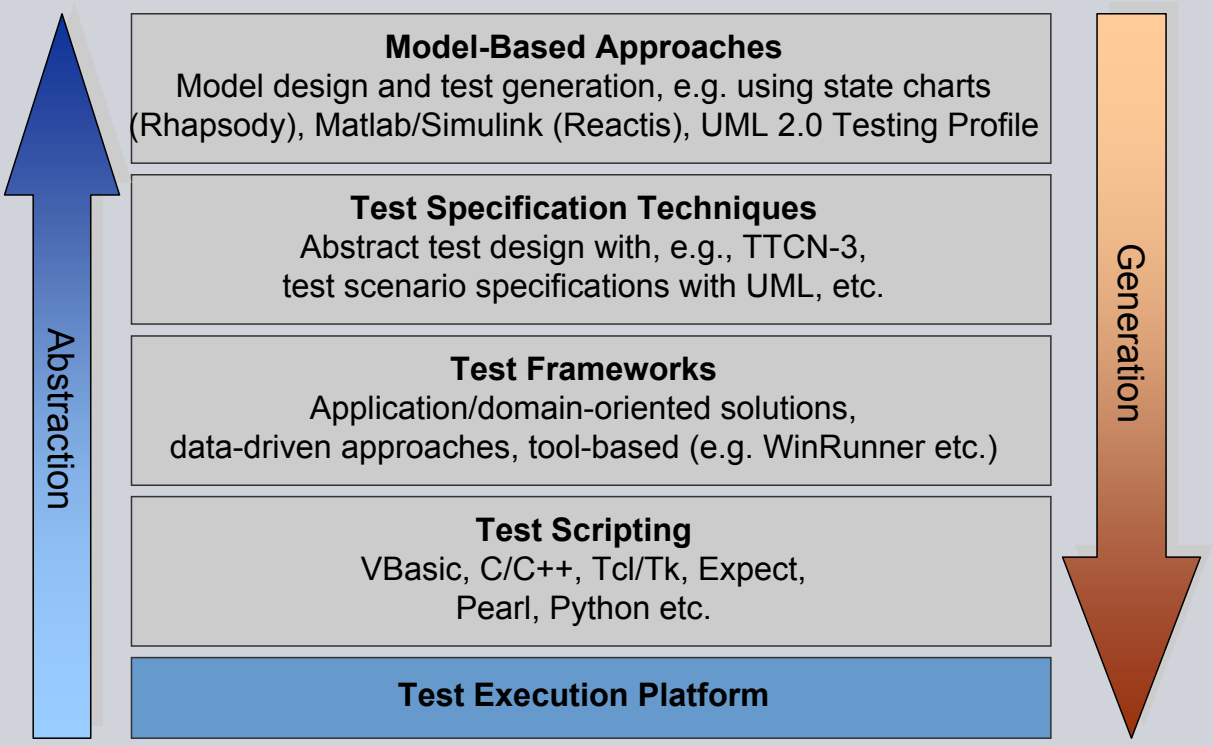
Evolution of Testing: Raising the Level of Abstraction



Challenge (1): TTCN-3 and Model-Based Testing

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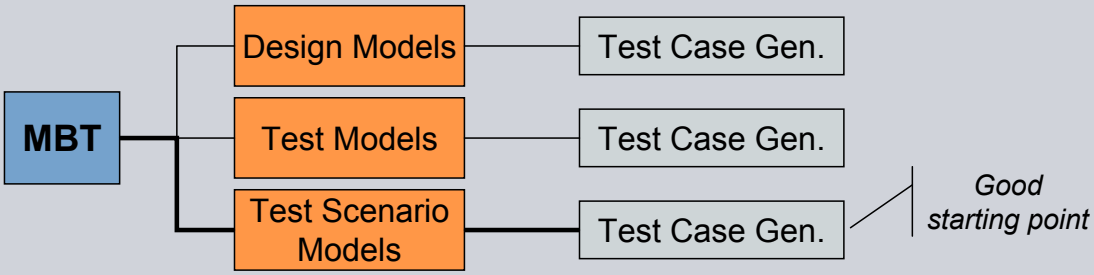

- TTCN-3 becomes more of a test execution language and less of a test specification language

➔ **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.

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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

Source: http://www.mooseproject.org/

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

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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	**Case 2**: Two timeouts occur at a similar time

`p.send(outMsg);`
`T.start(0.002);`
`alt {`
`[] T.timeout {}`
`[] p.receive(inMsg)`
`{ T.stop; }`
`}`
	`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

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2) Memory footprint of generated tester code

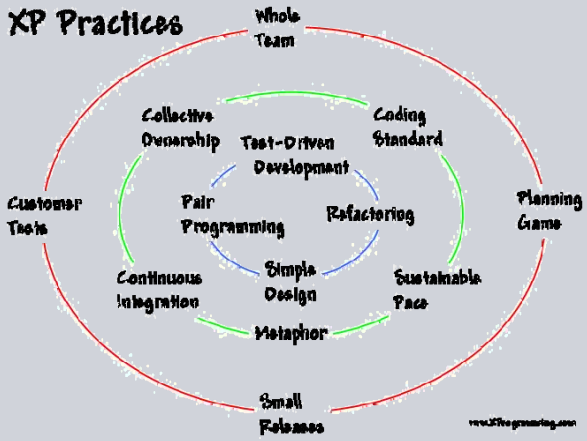
- Executable tester should be capable to run on target hardware
- Only code that is used to run a test case shall be generated
- Optimized and adaptable runtime library to produce executable tester
  → Reduce overhead of TCI implementation
  - Provision of optimized codecs
  - Flexible logging of a test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

Write a test	Write the code	Refactor



- 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

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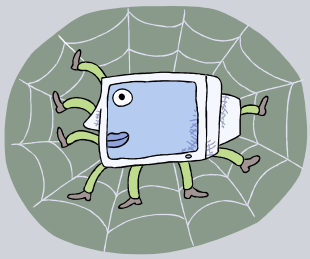
- *Multi-site development projects, ca. 30% of our software staff work in "low-cost" countries (source: Siemens Software Initiative, 2005)*

- 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

QUALITY



➔ **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

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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

