The Testing and Test Control Notation

TTCN-3

Curriculum

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1 Document Information

Version	Date	Editors	Remarks
0.1	03/2004	Ina Schieferdecker, Fraunhofer FOKUS Andrej Pietschker, Siemens	First Draft
0.2	05/2005	Ina Schieferdecker, Fraunhofer FOKUS Andrej Pietschker, Siemens	Completed Draft
1.0	08/2006	Ina Schieferdecker, Fraunhofer FOKUS	Revision for TTCN-3 v3 ETSI inclusion
1.1	12/2006	Ina Schieferdecker, Fraunhofer FOKUS	Copyright transfer to GTB in preparation of the contract with iSQI

2 Keynote

The Testing and Test Control Notation (TTCN-3) is a new test specification and test implementation language that supports all kinds of black-box testing. In particular it is well suited for reactive systems covering testing of local sequential or concurrent systems up to the testing of distributed systems.

TTCN's traditional stronghold is in testing communication protocols however with the release of version 3 it became a universal and adaptable testing language suited for a large variety of application domains. Today TTCN-3 is for example also used to test applications in the automotive industry through CAN and MOST busses. With the ever growing need to test e.g. Web services from a user's point of view, TTCN-3 delivers the concepts and tools to master these challenges. Not all possible applications of TTCN-3 have been evaluated; however industry and research start to focus on TTCN-3 and its applications in testing as recent test conferences illustrate.

TTCN-3 was developed at the European Telecommunications Standards Institute (ETSI) and is the only standardized test specification language (being also adopted at ITU). It therefore has all the benefits a standardized language possesses. Already 4 vendors support this language with compilers, even more support TTCN-3 with supplementary tools and services making the claim for vendor independence come true. With TTCN-3, test systems move from being expensive proprietary solutions designed for a single purpose to highly adaptive software test platforms supporting a variety of tests being used throughout system development and for system approval and acceptance kind of tests.

Consequences for training
TTCN-3 as such requires a deep understanding and good knowledge to be used efficiently. This calls for well trained, high qualified testing specialists.

Aim of training as a TTCN-3-CERTIFICATE.
It aims at making TTCN-3-Certificate holders to be knowledgeable in TTCN-3 concepts, the practical application of TTCN-3 and the integration of a TTCN-3 based test process into the system development. The curriculum covers the concepts, presentation formats, guidelines of use and concrete application examples of TTCN-3.

Training for a TTCN-3-CERTIFICATE is aimed at all people involved in software testing, who wish to base their knowledge and experience on TTCN-3 on a sound foundation or extend it. The training is suitable for quality and test professionals, programmers, developers, specialists and (project-) managers who are responsible for the execution, planning or control of testing.

- TTCN-3-CERTIFICATE holders are capable of designing and planning the project-specific tests and formalize them in TTCN-3. They are capable of defining adequate test strategies including test objectives, test purposes, test configurations, test suites and the realization of tests on target test platforms.

- TTCN-3-CERTIFICATE holders are capable of developing functional, conformance, interoperability, robustness, scalability, load, stress, etc. tests in TTCN-3
- TTCN-3-CERTIFICATE holders are aware that TTCN-3 is a powerful test technology but not the only one. They are capable of identifying those test targets which gain most from a systematic, formalized test approach with TTCN-3. They are capable of developing mixed test strategies (choosing from a set of test technologies) to have optimized test efficiency.
- TTCN-3-CERTIFICATE holders put into practice the TTCN-3 tests. They are capable of setting up automated tool chains for the execution of tests, creation of corresponding test reports and the interaction with the system developers.
- TTCN-3-CERTIFICATE holders are able to develop a TTCN-3 based testing process and to integrate the testing process with the system development process.

3 Notes on Curriculum and Examination

The curriculum defines:

- the examination-relevant material in its contents,

- the minimum time in which the material must be taught in accredited training courses. The material is to be illustrated and taught using suitable examples and exercises.

The curriculum does not define:

- the details of the TTCN-3 technology, concepts, language features, etc. as the TTCN-3 standard is the main source for the definitions,
- the (chapter-)sequence in which the material has to be taught, or
- the timescales for examples and exercises in accredited training courses.

The examination is a multiple-choice test:

- Word definitions, coherence as well as knowledge and understanding of test techniques defined by the TTCN-3 standard series and referenced in the curriculum are tested.

4 Summary of the Curriculum

Topic	Duration (min)	Content
Introduction	30	The Certified Tester Program
Basics of TTCN-3	60	Motivation History Main Concepts Basic Syntax
Language Features: Data Types and Templates	60	Basic and structured types Send templates, receive templates, inline templates
Language Features: Communication	60	Message-based and signature-based communication Port types and handling
Language Features: Test Configurations	60	Component types Component handling
Language Features: Behaviour	180	Functions, altsteps, test cases, external functions Statements Operations Timing
Language Features: Modules	90	Modules Module control Import Scoping Grouping Parameterization Attributes
Other Presentation Formats	45	Graphical Format Tabular Format
Test Execution	90	Test system components TRI TCI
TTCN-3 Standard	30	Standardization process around TTCN-3 Maintenance of TTCN-3
Test Design and Development	105	Test purposes and test cases Functional, conformance, interoperability test aspects Performance, load and scalability aspects
Open Data Interface	60	ASN.1, XML, IDL within TTCN-3
Test Tools	30	Tool support for TTCN-3 based testing
Overall	900	Corresponds to 20 lectures à 45min and to 3 tutorial days à appr. 7 lectures a day

5   Details of the Curriculum

Subject	Description	Time (min)

Introduction		**30**

Introduce the
- Concept of the TTCN-3-Certificate,
- Coherence curriculum,
- Training,
- Examination and certification,
- Associated institutions and international connections (certification body ISQI, training providers, ETSI).

Basics of TTCN-3   60

Introduce the background, history, objectives, and main concepts of TTCN-3.

Motivation, History   15

Explain that TTCN-3
- Supports
  - Testing current system technologies
  - Different kinds of tests
    - functional, integration, interoperability, scalability, load, …
  - Platform-independent testing
  - Integrated graphical test development, -documentation und -analysis
  - Adaptable, open test environments
  - Local and distributed test setups
- Avoids heterogeneous test environments that are hard to maintain and proprietary solutions which are expensive to develop and maintain
- Is
  - The Testing and Test Control Notation
  - The standardised test specification and test implementation language
  - Developed based on the experiences from previous TTCN versions
  - Applicable for all kinds of black-box testing for reactive and distributed systems
- Was developed to
  - Enable testing of current and upcoming technologies
  - Consolidate test concepts
  - Widen the scope of application
- Is historically based on
  - The ISO/IEC Conformance Testing Methodology and Framework
  - With the TTCN: Tree and Tabular Combined Notation (version 1,2)
  - Version 2++ developed by ETSI MTS
  - Version 3 (TTCN-3) developed by ETSI MTS
  - And currently continuously maintained by ETSI

Main Concepts   45

Introduce the main aspects of TTCN-3.
Being:
- Configuration: Dynamic concurrent test configurations with test components
- Communication with various communication mechanisms (synchronous and asynchronous)
- Control: Test case execution and selection mechanisms
- Improved
  - Module concept
  - Harmonisation with ASN.1
- Extendibility through attributes, external functions, and external data

- Well-defined syntax, static and operational semantics
- Different presentation formats (Text, tabular, graphical)

Mention the principal structure of the TTCN-3 standard consisting of
- The textual core language covering all the language features (types, data, behaviour, etc.)
- Other presentation formats including the graphical and the tabular format
- Open data interface including ASN.1, IDL and XML

Introduce the basic concepts of TTCN-3 including
- Black-box testing (giving stimuli to the SUT via well-defined interfaces, observing and evaluating the response)
- Test configurations (covering TSI, MTC; PTC and the port and test component handling)
- Test system architecture (with the test system, SUT, TSI and real test interface)
- Message-based ports (with FIFO queue and send and receive statements)
- Procedure-based ports (with FIFO queues, roles of client and server, and with call, getcall, reply, getreply, raise and catch statements)
- Test verdicts (list all the verdicts and their precedence, explain the only-get-worse rule, explain the verdict handling within test components and the accumulation of the overall verdict result, explain the setverdict and getverdict statement)

Introduce the basic elements of a TTCN-3 module covering
- Declarations and control
- Types, and templates
- Functions, altsteps, and test cases
- Module parameters and constants

Language Features: Data Types and Templates   60

Give an overview of the data type system of TTCN-3 and discuss the different kinds of types and the definition of templates (including the matching mechanisms).

Basic and structured types   20

Mention that data type definitions are build from predefined and user-defined structured types. Explain
  • Basic types
  • Structured types
  • Any type
  • Configuration types
  • Type compatibility rules

Explain the different possibilities for sub-typing including range, list and length restrictions. Explain and discuss type compatibility rules.

Discuss the usage of different types.

Explain values and expressions and discuss the construction of expressions. Explain the TTCN-3 operators including
  • Arithmetic operators
  • String operators
  • Relational operators
  • Logical operators
  • Bitwise operators
  • Shift operators
  • Rotate operators

Send templates, receive templates, inline templates   40

Explain that
  • templates define test data
  • they either transmit a set of distinct values or are used to test whether a set of received values matches a template specification
  • they have the following possibilities
    • they are a way to organize and to re-use test data, including a simple form of inheritance;
    • they can be parameterized;
    • they incorporate matching;
    • they can be used with either message-based or procedure-based communication
  • send templates contain only concrete values and no matching operations
  • Receive templates can contain wildcards or matching operations

Explain that templates
- Have global scope
- Can be parameterized
- Can be modified (achieving a simple form of inheritance)
- Can be unnamed (so called in-lined templates)

Explain the different matching mechanisms including
- Matching for specific values
- Matching instead of values
- Special matching symbols inside values
- Matching attributes

Discuss the purpose of different template features.

Language Feature: Communication   60

Give an overview on the available forms of communication and their purpose. Explain the differences of unicast, multicast and broadcast communication in TTCN-3.

Message-based communication   30

Explain the
- basic FIFO semantics of ports,
- message port types and their compatibility rules.

Discuss the operations available on message-based ports
- send,
- receive,
- trigger,
- check.

Signature-based communication   15

Explain the
- The logic of an operation call
- Client and server role of test components
- Procedure port types and their compatibility rules

Discuss the operations on signature-based ports
- call
- getcall
- reply
- getreply
- raise
- catch
- check
- timeout

Port handling   15

Discuss
- the initial status of ports,
- the setup of connections between ports,
- the differences between connected and mapped ports.

Explain
- one-to-one and
- one-to-many connections (incl. from/to addressing schemes)

Discuss port handling operations including
- connect
- map
- start
- stop
- clear

Language Features: Test Configurations   60

Introduce component types, the role of configurations in TTCN-3, the set-up and teardown of configurations.

Basics of configurations   20

Explain that
- a configuration consists of
    - a set of inter-connected test components
    - with well-defined communication ports and
    - an explicit test system interface which defines the border of the test system
- Within every configuration there is one and only one main test component (MTC)
    - MTC is created automatically at the start of each test case execution.
    - The behaviour defined in the body of the test case is executed on this component.
- During execution of a test case other components can be created dynamically.
    - These test components are called parallel test components (PTC's).

Explain and discuss
- Static and dynamic configurations
- Valid and invalid configurations

Component types   20

Explain how component types are defined and
- that they can have locally declared
    - variables,
    - timers,
    - ports,
    - constants.
- that functions share data when executed via these locally declared properties of a component type.

Explain the differences between normal and alive test components.

Component handling   20

Explain how components are
- created,
- started, and
- terminated including
    - stop by itself,

- external stop,
- return from test component behaviour,
- completion of test component behaviour.
- checked if they are running.
- checked if they have terminated.

Language Features: Behaviour 180

Introduce the principle behavioural elements of TTCN-3 including functions, altsteps, test cases, external functions, statements and operations. Introduce also the timing concepts.

Functions, altsteps, test cases, external functions 60

Explain that
- functions are the building-blocks of the test system behaviour.
- functions have local declarations and a program part.
- external and pre-defined functions can be used.

Discuss the different kinds of functions. Include:
- "Pure" Data functions (without component and port behaviour).
- "Behaviour" functions (with runs on).
- Test case as special "behaviour" functions (with runs on and system).
- External functions.
- Pre-defined functions.

Discuss the various predefined functions and their use.

Statements 60

Introduce basic program statements, behavioural program statements, and statements for default handling.

Explain the assignments, logging and the control structures in
- Label and Goto
- If-else
- For loop
- While loop
- Do while loop
- Stop execution
- Returning control

Explain the snapshot semantics of TTCN-3and discuss the behavioural program statements
- Alternative behaviour
- Re-evaluation of alternative behaviour
- Interleaved behaviour

Explain the default mechanism of TTCN-3, the use of altsteps in alt statements and the default handling statements
- Activate a default
- Deactivate a default

Operations   45

Give an overview on the set of TTCN-3 operations including
- Configuration operations
    - create
    - connect
    - disconnect
    - map
    - unmap
    - mtc
    - system
    - self
    - start (of a test component)
    - stop (of a test component)
    - running
    - alive
    - done
    - killed

- Communication operations
    - send
    - call
    - reply
    - raise
    - receive
    - trigger
    - getcall
    - getreply
    - catch
    - check
    - clear (a port)
    - start (a port)
    - stop (a port)
    - freeze

- Timer operations
    - start (a timer)
    - stop (a timer)
    - read (a timer)
    - running (of a timer)
    - timeout

- Verdict operations
    - setverdict
    - getverdict

- External actions

- Execution of test cases

Summarize those operations that have been explained previously, explain those that haven't. Discuss the usage of these operations.

Timing	15

Explain that
- timers are used to observe progress of time.
- timers can be declared and used within
    - control part, test cases, functions and altsteps,
    - additionally component wide within component type definition.
- timer values are represented as floats, the base unit being seconds.
- timers can be started, stopped, read, checked for their status and can time-out.
- in addition, the execution of a test case and a call operation can be time-guarded.

Language Features: Modules   90

Explain the module concept, the parts of a module definition, the means to reuse declarations from modules and the role of the control part.

Module definition and control   20

Explain that
  • Modules are the building blocks of all TTCN-3 specifications.
  • A test suite is a (set of) module(s).
  • A module may consist of a definition and a control part.
  • Modules can be parameterized.

Explain the possibilities within a module control part for
  • test case selection,
  • test case parameterization, and
  • test case execution depending on verdicts of previous test case

Import   20

Explain the
  • Main concepts of import
  • Recursive and non-recursive import

Explain the different forms of imports used for inclusion of
  • A single definition
  • All definitions
  • Groups
  • A number of definitions of the same kind

Scoping, Grouping   15

Explain the scope rules of
  • a module definition part
  • a control part of a module;
  • component types
  • functions
  • altsteps
  • test cases
  • "blocks of statements and declarations" within compound statements
  • formal parameters

Explain the possibilities of grouping definitions and their use.

Parameterization   20

Introduce the possibilities and advantages of parameterization.

Explain the concepts of static and dynamic parameterization and of parameters by value and by reference.

Explain the parameterization of a
- module
- type
- template
- function
- altstep
- testcase
- signature

Attributes   15

Explain the principles of attributes and their use. Explain the different kinds of attributes being
- display
- encode
- variant
- extension

attributes.

Discuss the TTCN-3 concept of attributes as a language extension mechanism.

Other Presentation Formats   45

Introduce other presentation formats. Explain that they can be mapped to the core language.

Graphical Format   20

Explain the elements of the graphical format and their mapping to the core language.
Mention that the graphical format has its origins in Message Sequence Charts (MSC).
Discuss the advantages and possible use of the graphical format.

Tabular Format   15

Explain the elements of the tabular format and their mapping to the core language.
Mention that the tabular format has its origins in previous versions of TTCN.
Discuss the advantages and possible use of the tabular format.

User-Defined Format   10

Motivate the usage of user-defined formats.
Discuss the possibilities to include user-defined formats in TTCN-3.

Test Execution   90

Discuss the architecture of a TTCN-3 based test system, present the test system components and their interfaces.
Explain that the test execution interfaces provide standardised means to connect an abstract test suite to the actual SUT and to the actual test platform. Discuss the interfaces.

Test system components   15

Introduce the test system architecture consisting of the
   • test execution engine (TE)
   • platform adaptor (PA)
   • system adaptor (SA)
   • test management (TM)
   • test logging (TL)
   • codec (CD)
   • component handling (CH)

TRI   30

Explain the interfaces of the test runtime interfaces (TRI) being
   • TE -> PA
   • PA -> TE
   • TE -> SA
   • SA -> TE

Discuss selected operations (like triSend), their implementation and their potential usage.

TCI   45

Explain the interfaces of the test control interfaces (TCI) being
   • TE -> TM
   • TM -> TE
   • TE -> TL
   • TE -> CD
   • CD -> TE
   • TE -> CH
   • CH -> TE

Discuss selected operations (like tciEncode), their implementation and their potential usage.

TTCN-3 Standard   30

Summarize the TTCN-3 standard parts and related documents (like from ITU-T).

Explain the role of ETSI in the standardisation of TTCN-3. Mention possibilities of contributing to the development of TTCN-3.

TTCN-3 standards   15

Present all current parts of TTCN-3 and outline their structure, i.e.
- Part 1: Core language
- Part 2: Tabular presentation format
- Part 3: Graphical presentation format
- Part 4: Operational semantics
- Part 5: TTCN-3 runtime interfaces
- Part 6: TTCN-3 control interfaces

Discuss the new parts of TTCN-3 and outline their structure, i.e.
- Part 7: ASN.1 to TTCN-3 language mapping
- Part 8: IDL to TTCN-3 language mapping
- Part 9: XML to TTCN-3 language mapping
- Part 10: C/C++ to TTCN-3 language mapping

Standardization and Maintenance of TTCN-3   15

Explain the standardisation process. Discuss the roles of ETSI and MTS.

Explain the change request process for language extensions such as for new language mappings or new language features.

Explain how TTCN-3 is maintained. Explain the possibilities of influencing the maintenance of TTCN-3 through change requests and active contributions in the TTCN-3 community.

Test Design and Development 105

Outline along concrete examples the design and development of a test solution with TTCN-3. Explain the general steps of test design and development and relate them to the TTCN-3 language concepts. Outline exemplarily parts of a TTCN-3 test design and development methodology.

Test purposes and test cases 15

Discuss the general concepts of test purpose and test case and explain the TTCN-3 features for specifying test purposes and test cases.

Explain that TTCN-3 has no dedicated test purpose concept. Instead, TTCN-3 documentation tags or user-defined attributes are to be used to document test purposes and to relate test purposes to test cases.

Outline the structuring of a TTCN-3 test solution into TTCN-3 modules and groups. Explain the usage of groups to reflect the test suite structure. Explain the usage of modules to enable various control parts for the same set of test cases (provided in separate modules).

Provide concrete examples in TTCN-3.

Functional, conformance, interoperability test aspects 45

Discuss the principal aspects of functional, conformance and interoperability testing. Present possible test configurations for functional, conformance and interoperability test solutions.

Discuss which TTCN-3 language features are typically being used for functional, conformance and interoperability tests (to define test data and test behaviour). Explain how these concepts are being used.

Explain along an example the specification of functional, conformance, and interoperability tests in TTCN-3.

Performance, load and scalability aspects 45

Discuss the principal aspects of performance, load, and scalability testing. Present possible test configurations for performance, load, and scalability test solutions.

Discuss which TTCN-3 language features are typically being used for performance, load, and scalability tests (to define test data and test behaviour). Explain how these concepts are being used.

Explain along an example the specification of performance, load, and scalability tests in TTCN-3.

Open Data Interface   60

Outline the open data interface of TTCN-3 to link the TTCN-3 type and data system with other external type and data systems.

Explain the principals of the language mapping from external languages to TTCN-3. Select one of the existing language mappings (ASN.1 to TTCN-3, IDL to TTCN-3 or XML to TTCN-3) and provide details of it by giving examples of the mapping rules and of the usage.

Explain how to define own language mappings.

CORBA IDL   30
(if IDL is selected for a detailed explaination)

Explain the principal structure of the mapping rules. Discuss the usage of the mapping to test CORBA object based systems and applications. Explain the relation of this mapping to other IDL techniques.

Provide the IDL specification for a concrete example and discuss selected mapping rules for this example.

ITU ASN.1   10

Explain the principal structure of the mapping rules. Discuss the usage of the mapping to test ASN.1 based interfaces and protocols.

W3C XML   10

Explain the principal structure of the mapping rules. Discuss the usage of the mapping to test XML based interfaces, protocols and applications.

Other Languages   10

Explain the approach to develop own mapping rules. Explain the central elements of the mapping such as scoping, identifiers, types and values. Use potentially an example such as Java or SQL for the explaination.

TTCN-3 test tools   30

There are a number of tools that support different aspects of TTCN-3 based testing. Explain the various types of tools including editor, compiler, execution environment, test generator, test validator, debugger, etc.

Review existing tools.

Provide – if possible – tooling to be used for the exercises.

Different components of a TTCN-3 test platform   15

Classify the TTCN-3 tools into
   • Test design and development (for editing, test validation, test generation, compilation)
   • Test execution (for adaptation and execution, result generation and analysis)
   • Test management (for test control and inclusion into the overall test process)
and explain their properties.

Provide concrete examples for each tool class.

Tool supported TTCN-3 based test process   15

Outline a TTCN-3 based test process in relation to the fundamental test process (as defined in ISTQB Certified Tester, Foundation Level).

Explain that TTCN-3 is a test technology for test analysis and design and for test implementation and execution. Explain that TTCN-3 needs to be linked with planning and control and with evaluating exit criteria and reporting.

6   Glossary

ASN.1	Abstract Syntax Notation One
CD	TCI Codec Interface (Encoder/Decoder)
CH	TCI Component Handling Interface
CTMF	Conformance Testing Methodology and Framework
ETSI	European Telecommunication Standards Institute
ETSI ES	ETSI European Standard
ETSI MTS	ETSI Working Group on Methods for Testing and Specification
FIFO	First In First Out
GFT	Graphical Format of TTCN-3
GUI	Graphical User Interface
IDE	Integrated Development Environment
IDL	Interface Description Language
ICS	Implementation Conformance Statement (defined in CTMF)
ISO	International Standards Organization
ITU-T	International Telecommunication Union
IUT	Implementation Under Test
IXIT	Implementation ExtraInformation for Testing (defined in CTMF)
MTC	Main Test Component
PA	TRI Platform Adapter Interface
PCO	Point of Control and Observation
PTC	Parallel Test Component
SA	TRI System Adapter Interface
SUT	System Under Test
TA	TRI Test Adapter Interface
TC	Test Component
TCI	TTCN-3 Control Interfaces
TE	TTCN-3 Executable
TFT	Tabular Format of TTCN-3
TL	TCI Logging Interface
TM	TCI Test Management Interface
TRI	TTCN-3 Runtime Interfaces
TSI	Test System Interface
TTCN-2	Tree and Tabular Combined Notation
TTCN-3	Test and Testing Control Notation
XML	Extended Markup Language

7 References

[1]   ETSI ES 201 873-1 (V3.1.1): "Methods for Testing and Specification (MTS); The Testing and Test Control Notation; Part 1: TTCN-3 Core Language".

[2]   ETSI ES 201 873-2 (V3.1.1): "Methods for Testing and Specification (MTS); The Testing and Test Control Notation; Part 2: TTCN-3 Tabular Presentation Format (TFT)".

[3]   ETSI ES 201 873-3 (V3.1.1): "Methods for Testing and Specification (MTS); The Tree and Tabular Combined Notation; Part 3: TTCN-3 Graphical Presentation Format (GFT)".

[4]   ETSI ES 201 873-4 (V3.1.1): "Methods for Testing and Specification (MTS); The Testing and Test Control Notation; Part 4: TTCN-3 Operational Semantics ".

[5]   ETSI ES 201 873-5 (V3.1.1): "Methods for Testing and Specification (MTS); The Testing and Test Control Notation; Part 5: TTCN-3 Runtime Interface (TRI)".

[6]   ETSI ES 201 873-6 (V3.1.1): "Methods for Testing and Specification (MTS); The Testing and Test Control Notation; Part 6: TTCN-3 Control Interface (TCI)".