ITU Forum on Conformance and Interoperability Testing in CIS and Europe Regions
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Validation of protocol specifications
- THE ETSI APPROACH -

Peter Schmitting
FSCOM
ETSI Specialist Task Force leader

Presentation Outline

- About ETSI
- The ETSI Approach
  - Validation
  - Testing
- Use of TTCN-3 at ETSI
- Conclusions
- More on STFs
- More on the development of test specifications

About ETSI

ETSI – Shaping the Future

- European standards organisation setting globally-applicable standards in ICT (Information Communication Technology)
  - Including fixed, mobile, radio, converged, broadcast and Internet technologies
- Independent, not-for-profit, created in 1988
  - Based in the South of France
- More than 760 Member companies and organisations from 63 countries and 5 continents
- Founder member of 3GPP
- Over 23,000 publications – available for free!
  - http://www.etsi.org/WebSite/homepage.aspx

ETSI – World Class Standards

- GSM™ – Developed by ETSI
  - Over 3.5 billion users in over 200 countries
  - 1.3 million new users EVERY DAY!
- ETSI's Lawful Interception standard
  - Being deployed in Europe, USA and Australia, where laws are being introduced to comply with the ETSI Standard
- DECT™ – Digital Enhanced Cordless Telecommunications
  - Adopted in over 110 countries, with over 670 million devices sold and more than 100 million devices being added every year.

ETSI – World Class Standards

- TETRA (Terrestrial Trunked Radio)
  - 2000 contracts in more than 100 countries
  - Emergency services (Fire, Police, Ambulance ...)
- DVB/DAB (Digital Video/Audio Broadcasting)
  - Services available on every continent
  - DVBH (mobile DVB)
- TISPAN (Home for NGN)
  - Next Generation Networks standardisation
- 3GPP LTE
  - The Mobile Broadband Technology

New Growth Areas

- Internet of Things
- M2M Communications (Machine2Machine)
- Reconfigurable Radio Systems
- Multimedia Content Distribution
- Grid Computing & Clouds
- RFID (Radio Frequency Identification)
- Intelligent Transport Systems
- Emergency alerting, e-call
- GSM on aircraft
- Quantum Key Distribution
- Self-managing Internet
- Energy Efficiency
- ...

Creator of the TTCN-3 Standard

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

- **TC MTS (Methods for Testing and Specification)**
  - **Developed TTCN-3**
  - **ETSI Standard (ES)**
- **Key TTCN-3 Standards**
  - **ES 201 873-1: TTCN-3 Core Language**
  - **ES 201 873-5: TTCN-3 Runtime Interface (TRI)**
  - **ES 201 873-6: TTCN-3 Control Interfaces (TCI)**
  - **ES 201 873-7 etc: ASN.1, XML, IDL, Code Documentation**
  - **also all endorsed by ITU-T SG17 (Z.140 Series)**
- **New Extension Packages (drafts)**
  - **Configuration and Deployment Support**
  - **Performance Testing**
  - **Real-time testing**
  - **And others ...**

Why TTCN-3?

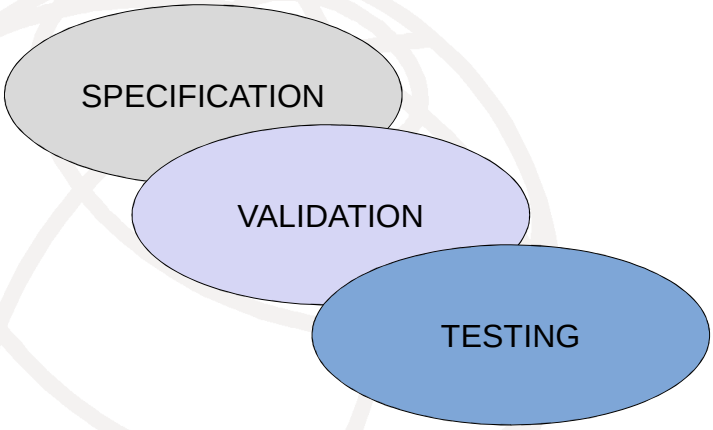
- Specifically designed for testing
  - Concentrates on the test not the test system
  - Independent of the execution environment
- Wide range of applications
  - Mobile communications to Internet to software to …
- Standardised
  - Commonly understood syntax and operational semantics
  - Constantly maintained and developed
  - Off-the-shelf tools and TTCN-based test systems
- Unifies different (all) testing activities
  - Education and training costs can be rationalized
  - Maintenance of test suites (and products) is easier
  - Facilitates a common methodology and style
  - Both on a corporate level and within standardization

ETSI - Home of Testing!

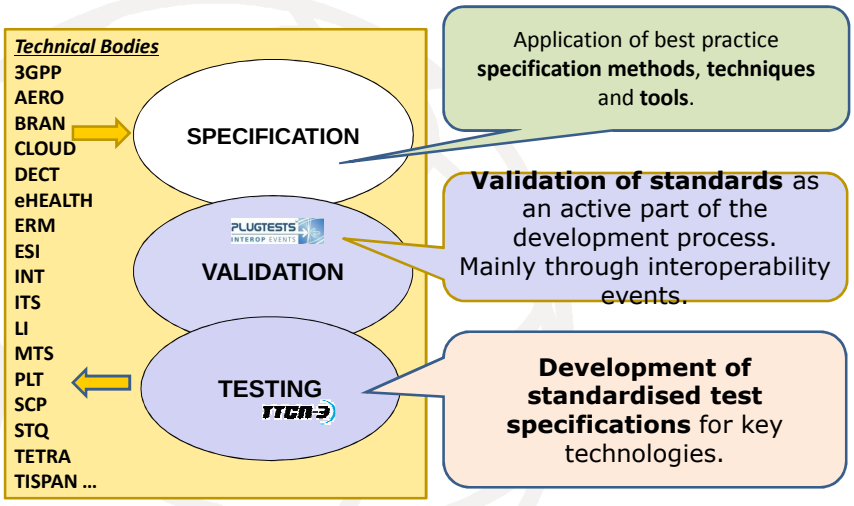
- Standardized Conformance and Inter-operability Test Specifications enable an interconnected world
- Testing and Validation are the red thread running through the entire ETSI standards development process

  ETSI philosophy!
- Only interoperable and protocol conformant implementations ensure
  - Multiple manufacturer product choice for users
    - Business, Governmental, Private users
  - Implementations are easy to use (Plug&Play)
  - Increased market for manufacturers

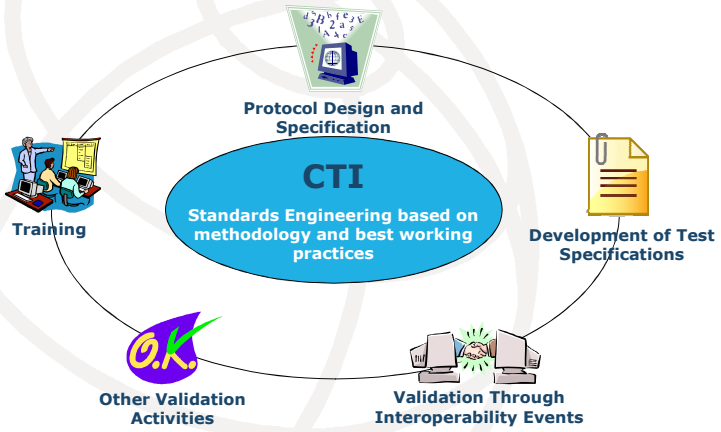
The ETSI Approach



ETSI Approach – Three Best Practices



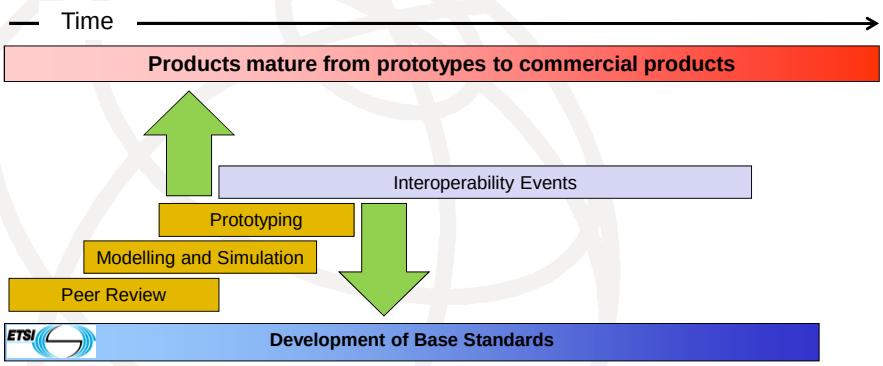
Centre for Testing & Interoperability



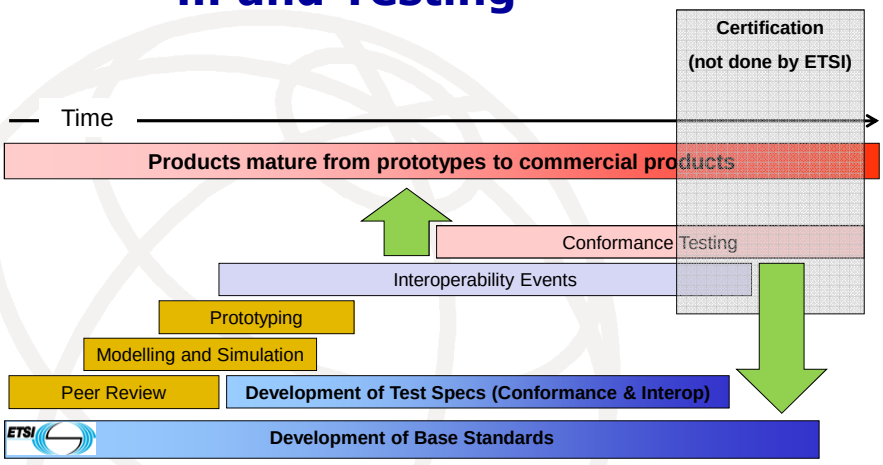
Why Validate Standards?

- Validation reveals problems/errors in
  - Standards and Products
- Validated standards give a higher chance of interoperable products
  - Assurance that they provide the right functionality
  - Gives manufacturers and operators confidence to implement and go to market
- Provides an opportunity to correct errors in a controlled manner
  - Decreases time to market
  - Late fixes in the product cycle are more expensive than early ones

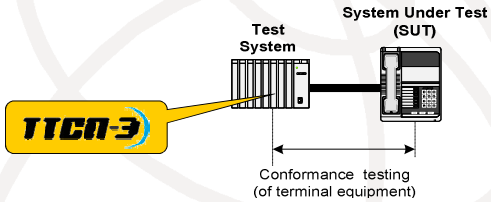
Validation of Standards …



… and Testing



Conformance Testing



Tests a specific (part of a) product for compliance to requirements in a Base Standard

Characteristics of Conformance Testing

- Gives a high-level of confidence that the standardised parts of a product are working as specified
- It is component (Black Box) testing
  - Usually *One requirement -> One test*
- Requires a test system (i.e., executable test cases)
  - Test execution is automated and repeatable
  - Tests in controlled conditions
- High degree of control and observation
  - Can provoke and test non-normal (but legitimate) scenarios
  - Can explicitly test error behaviour (robustness)
- Tests are thorough and accurate but limited in scope
  - At level of detailed protocol messages, service primitives, or procedure calls

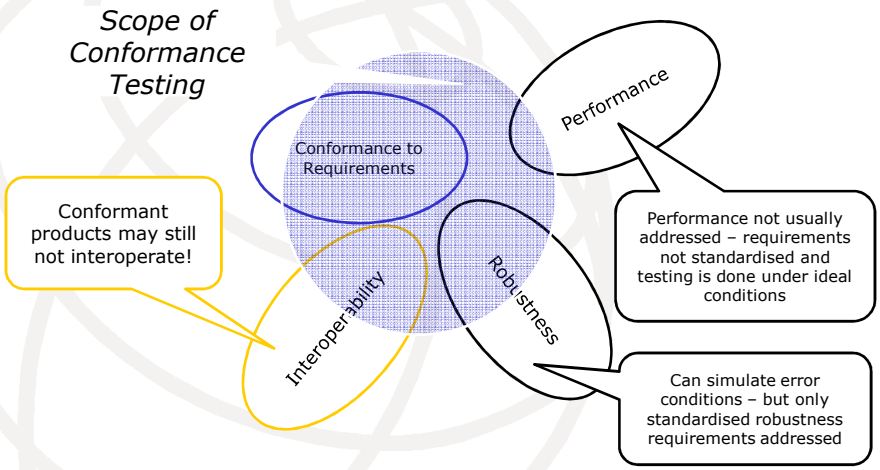
Limitations of Conformance Testing

- **Does not necessarily prove interoperability with other products**
- Tests are focussed on part of a product
  - A system is often greater than the sum of its parts!
  - Does not test the user's 'perception' of the system
  - Standardised conformance tests do not include proprietary features
- Test systems may be expensive
  - But cost may be relative to size of the market

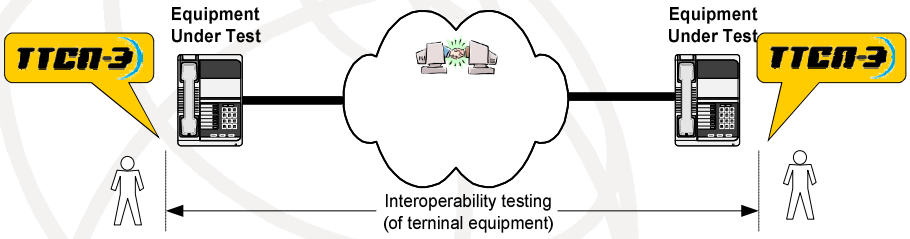
Case Study – 3GPP UE Testing

- 3GPP mobile protocol / signalling testing
- Project was started in 2000
- 40 companies involved
  - A large extent of test industry involved
- 16 experts led by ETSI CTI
  - Aotal budget > 90 person months / year (in 2009)
- 28 Test Suites
  - More than 1400 Test Cases
  - Running on 4 System Simulator platforms
- Delivery every 3 weeks
- Deployed by GCF / PTCRB for UE certification

Scope of Conformance Testing



Interoperability Testing



Tests end-to-end functionality between a collection of products

Pros and Cons of IOP Testing

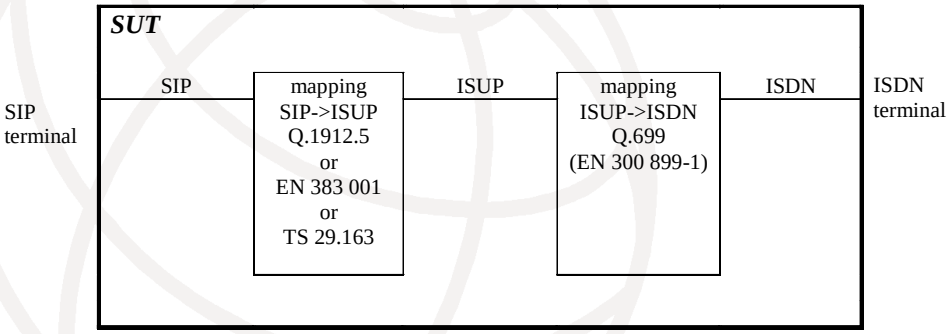
- Gives a high-level of confidence that one product will interoperate with another product
- Manual system (NOT interface!) testing, results based on subjective perception of test operators
  - System not necessarily complete!
- Does not prove interoperability with other products with which no testing has been done
- Does NOT prove that a products are conformant!

Other Testing Methods - NIT

- End-to-End NIT (Network Integration Testing) covers testing activities necessary to assess the correct behaviour of interconnected networks from the point of view of access interfaces
- End-to-End tests are based on the emulation of subscriber equipment behaviour on the UNI interfaces where subscriber equipment is connected to the network(s) under test

Example - NIT

- ETSI TS 186 001 series on “NIT between SIP/PSTN network signalling protocols”

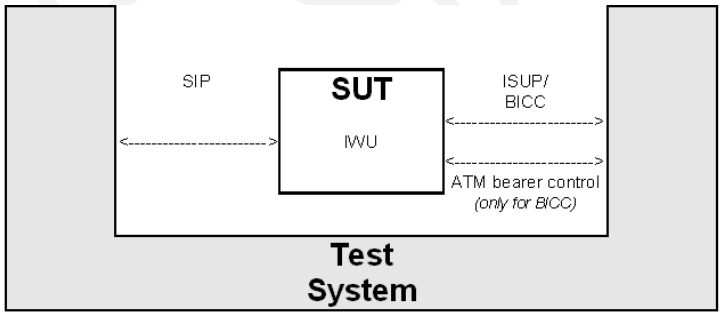


Other Testing Methods - IW

- Interworking Testing (IW) covers testing activities necessary to assess the correct conversion of protocol data between network components running different protocols
  - The IWU (Interworking Unit) is the implementation under test
- IW tests are based on the emulation of network equipment behaviour on the NNI interfaces where the different protocols are running

Example - IW

- ETSI TS 186 009 series on "Interworking between Session Initiation Protocol (SIP) and Bearer Independent Call Control Protocol (BICC) or ISDN User Part (ISUP)"



Use of TTCN-3 at ETSI ...

Use of TTCN-3 at ETSI

- All test suite development done in TTCN-3
  - Some maintenance of legacy TTCN-2 test suites
- Test Suites developed by Specialist Task Forces (STF)
  - At the request of the ETSI Technical Committees
  - Experts recruited from the ETSI Membership
  - Mostly under the technical management of CTI
  - 15 to 20 testing STFs per year

TTCN-3: Testing and Test Control Notation

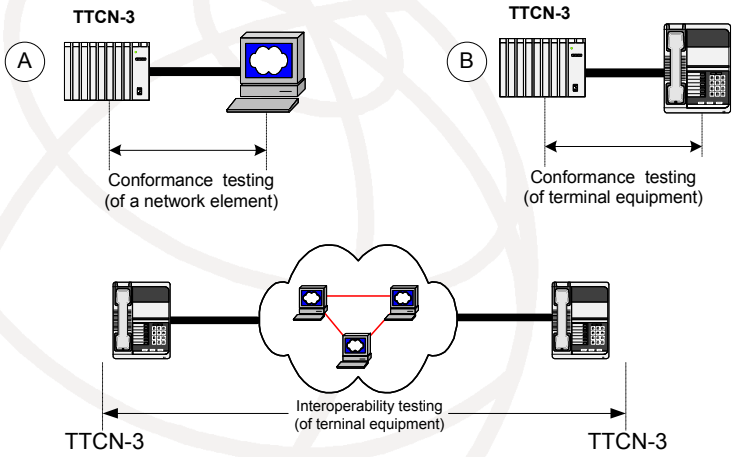
- The standardized alternative to proprietary test systems
- Developed by a large group of testing experts
  - Used by a growing community
  - Proven by tools
  - Maintained at ETSI
- TTCN-3 is a test specification and implementation language

Main capabilities of TTCN-3

- Dynamic concurrent test configurations
- Synchronous and asynchronous communication mechanisms
- Data templates with powerful matching mechanism
- Assignment and handling of test verdicts
- Test case selection mechanisms
- Test suite and test data parameterization

Application of TTCN-3

- May be used for all kinds of testing …



Validation of Tests

- Where possible ETSI Test Specifications are validated prior to publication
- Minimum requirement is that they compile on at least one tool
  - E.g., UMTS compiles on at least 4 platforms
- In many cases we execute the tests agianst live implementations
  - In co-operation with partners (Test Labs and Vendors)
  - E.g., UMTS tests executed against at least 2 different implementations

Some ETSI TTCN-3 Test Suites

- IPv6 (TC MTS)
  - Core, Security, Mobility, Transitioning
- IMS (TC INT & TC TISPAN)
  - Interoperability, Network Integration, ISDN Interworking, Supplementary Services
- WiMAX (TC BRAN & WiMAX Forum)
  - Conformance (PCT, NCT), Interoperability
- Intelligent transport (TC ITS)
  - Direct Short Range Communication (DSRC)
- LTE (3GPP)
  - UE conformance
- DMR/DPMR (TC ERM)
  - Terminal conformance
- SIP (TC MTS)
  - RFC 3261 UA and Proxy conformance

TTCN-3 Tools Used at ETSI

- 6 different TTCN-3 Development Environments and Compilers
- ETSI TTCN-3 Documentation Tool (T3D)
- ETSI TTCN-3 Code Quality Tool (T3Q)
- ETSI tools will be made available as Open source
  - More information on TTCN-3 tools available at
  - http://www.ttcn-3.org/

Reasons for Testing

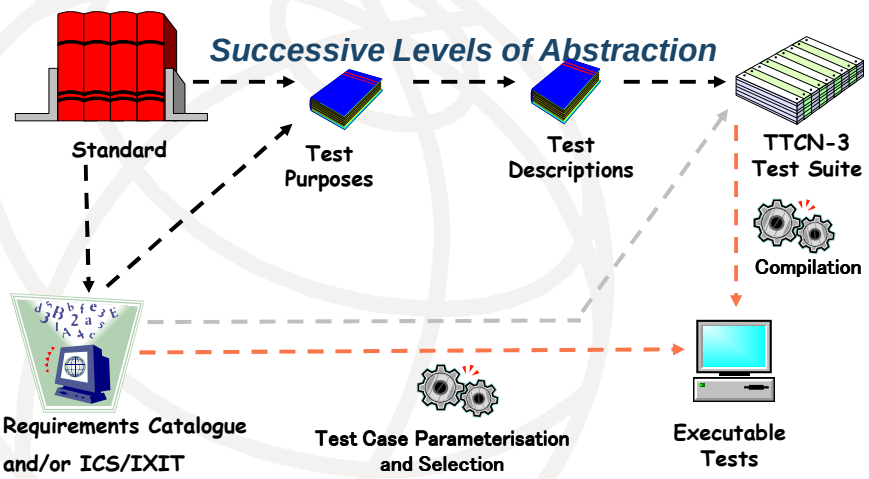
- An interconnected world needs protocol conformant and interoperable products
- Standardized test specifications achieve this objective
- Validation and Testing are cornerstones in the development of ETSI standards
- Validation and testing must be part of the standard development process, NOT a late add-on!
  - Conformance and/or interoperability/NIT/IW
- Synchronise testing activities with the development of the standard
  - Ensure feedback to the base standards
- **Use formal and standardized test methodologies! For ETSI, TTCN-3 is: "The best choice"**

More on the development of test specifications…

Test Suites Developed by …

- Specialist Task Forces (STF)
  - At the request of the ETSI Technical Committees
    - ETSI Funded Work program budget
  - Mostly under the technical leadership of CTI and involving CTI experts and experts recruited from the ETSI Membership
  - Around 15 testing STFs per year
    - E.g., UMTS 18 experts (approx. 90mm/year)
  - May be funded by the EC if part of an interop event

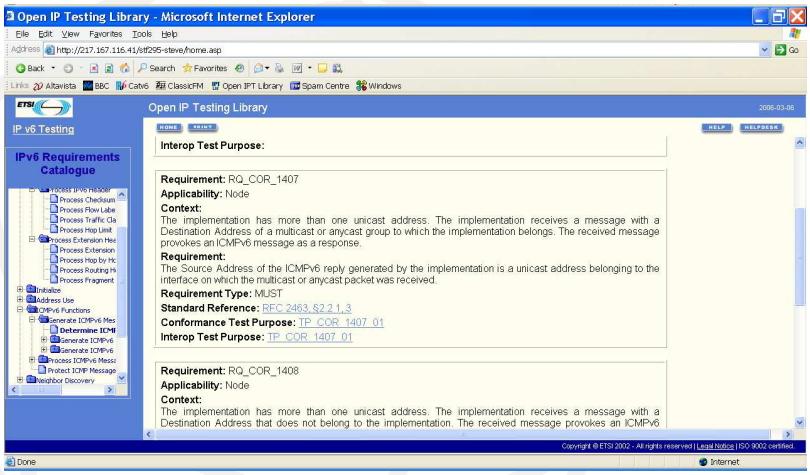
Test Specification Development



The Requirements Catalogue

- Database of all extracted requirements
  - REQ name
  - Reference to base standard
  - Context information
  - Status: Mandatory (M), Optional (O) etc.
  - Dependencies between optional requirements
- Links to Test Purposes
- Links to Test Cases
- Search and grouping capabilities and dependencies

The Requirements Catalogue



Example TPLAN Test Purpose

```
TP id   : TP_COR_0047_01
Summary : 'hop limit of one'
RQ Ref  : RQ_COR_0047
Config  : CF_02_C
TC Ref  : TC_COR_0047_01
ensure that {
--Stimulus
    when {  IUT receives 'Ipv6 packet' from 'Host'
              containing 'IPv6 Header'
              indicating 'Hop limit' set to '1' }
--Expected response
    then { IUT sends 'ICMPv6 Time Exceeded' to 'Host'
           containing 'ICMP code' set to 'ZERO'

             }
```

Test Descriptions

Test Descriptions

- More detailed than Test Purposes
  - But not directly executable
- Act as a design specification for test cases
- Or for manual execution
  - E.g. Interoperability testing
- Contains more information
  - Configuration details
  - Postamble and Preamble sequences
  - Detailed message sequences for test body
  - Parameter values etc.

Example Test Description

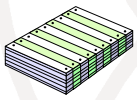
Test Description					
Identifier:	TD_COR_1100_01				
Summary	EUT reassembles a fragmented packet of an original length less than 1500 octets				
Test Purpose:	TP_COR_1100_01	**Reference:**	RQ_COR_1100	**Configuration:**	CF_011_I

```
with { 'the MTU on Link1 set to 1400 octets' }

ensure that {
  when { QE is requested to 'send data requiring a packet
                             length greater than 1500 octets' }
  then { EUT indicates 'receipt of the same data without
                        modification' }
       }
```

Pre-Test Conditions:	• MTU set to 1400 octets on link1		
Step	**Step**	**Verdict**	
		Pass	**Fail**
1	Cause QE to send an Echo Request to EUT with a packet size of 1450 octets and with each octet set to the hexadecimal value "F0"		
2	*Check: Does protocol monitor show that the Echo Request was sent from QE to EUT?*	Yes	No
3	*Check: Does QE receive an Echo Reply from EUT with the packet length the same as the Echo Request and with each octet containing the hexadecimal value "F0"?*	Yes	No
Observations			

TTCN-3 Test Cases



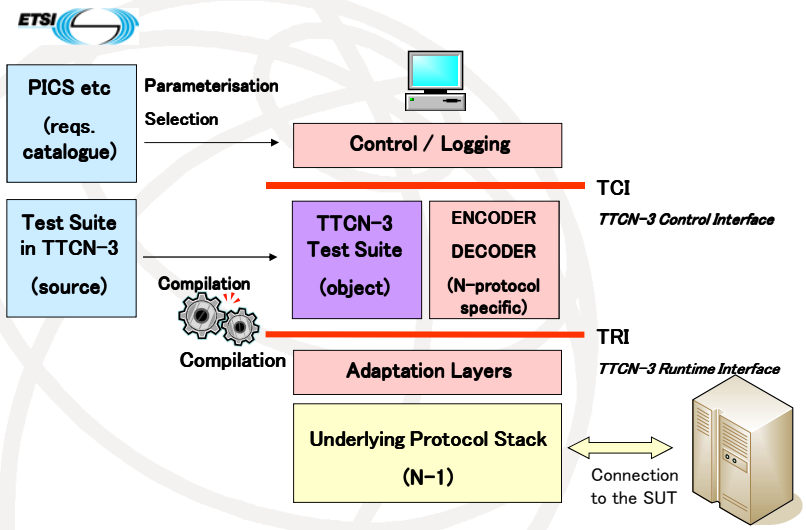
TTCN-3
Test Suite

- Detailed TTCN-3 test script that implements test purpose
  - Can be compiled and executed
- Specifies HOW to test not WHAT to test
  - Preamble
  - Test body (i.e., implementation of the Test Purpose)
  - Postamble
- Assigns test verdicts
- Handles unexpected behaviour as well as the behaviour in the test purpose
- Can be distributed over parallel test components
- Can be entirely automated
- Configurable at run-time

Example TTCN-3 Test Case

```
testcase TC_COR_0047_01() runs on Ipv6Node system EtherNetAdapter {
  f_cf02Up();              // Configure test system for HS->RT
                           // No preamble required in this case
  f_TP_HopsSetToOne();     // Perform test
                           // No postamble required in this case
  f_cf02Down();            // Return test system to initial state
}
function f_TP_HopsSetToOne() runs on Ipv6Node {
   var Ipv6Packet v_ipPkt;
   var FncRetCode v_ret := f_echoTimeExceeded( 1, v_ipPkt );
   if ( v_ret == e_success and v_ipPkt.icmpCode == 0 )
   { setverdict(pass);}
   else { setverdict(fail); }
}
function f_echoTimeExceeded(in UInt8 p_hops, out Ipv6Packet p_ípPkt )
runs on Ipv6Node return FncRetCode {
   var Ipv6Packet v_ipPacket; var FncRetCode v_ret;
   ipPort.send( m_echoReqWithHops(p_hops) );
   alt {
     [] ipPort.receive( mw_anyTimeExceeded ) -> value p_ipPkt
        { return e_success }
     [] ipPort.receive { return e_error } }
}
```

TTCN-3 Test System



ETSI Support for Testing

- Technical Committee MTS
  - Methods for Testing and Specification
  - Standardised frameworks, methodologies, languages
    - For protocol specification
    - For testing
  - "Making Better Standards" http://portal.etsi.org/mbs
- Centre for Testing and Interoperability (CTI)
  - Direct support to ETSI Technical Bodies
  - Application of protocol engineering and best practices
  - Development of test specifications
  - Standards validation, including interoperabilty events (Plugtests™)

More on STFs …

Test Suites Developed by …

- Specialist Task Forces (STF)
  - At the request of the ETSI Technical Committees
    - ETSI Funded Work program budget
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  - Around 15 testing STFs per year
    - E.g., UMTS 18 experts (approx. 90mm/year)
  - May be funded by the EC if part of an interop event

What is a Specialist Task Force (STF)?

- Team of highly-skilled experts working together over a pre-defined period to draft an ETSI standard under the technical guidance of an ETSI Technical Body and with the support of the ETSI Secretariat
- The task of the STFs is to accelerate the standardization process in areas of strategic importance and in response to urgent market needs
- STF work is normally done by the experts in common sessions in the ETSI premises at Sophia Antipolis in France

Who can join, who pays the STF experts?

- Experts for STFs can be proposed by ETSI Members or supported by ETSI Members
- ETSI may provide a financial compensation to the Companies for the work of their experts in the STF
- STF funding is provided either by ETSI, EC/EFTA or by a group of interested Members
- STFs must be approved by the ETSI Board
- STF-like solutions can also be provided by ETSI for Special Projects, Partnership Projects, for study and investigation and/or laboratory activities

THANK YOU!

Peter Schmitting, FSCOM
peter.schmitting@fscom.fr
Tel +33 6 08 51 51 87