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Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Methods for Testing and Specification (MTS).

1 Scope

The present document presents a summary of experiences collected from the use automate interoperability testing in real-world interoperability testing, e.g. ETSI IMS Plugtests. More specifically it addresses the use of test systems which have been developed based on the methodology and framework for automated interoperability testing for distributed systems [i.1].

2 References

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2.1 Normative references

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Not applicable.

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area. For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] ETSI EG 202 810: "Methods for Testing and Specification (MTS); Automated Interoperability Testing; Methodology and Framework".

[i.2] ETSI TS 124 229 (V7.15.0): "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Internet Protocol (IP) multimedia call control protocol based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP); Stage 3 (3GPP TS 24.229 version 7.15.0 Release 7)".

[i.3] IETF RFC 3261: "Session Initiation Protocol".

[i.4] ETSI TS 186 011-2 (V2.3.1): "Technical Committee for IMS Network Testing (INT); IMS NNI Interworking Test Specifications; Part 2: Test descriptions for IMS NNI Interworking".

[i.5] ETSI ES 201 873-1: "Methods for Testing and Specification (MTS); The Testing and Test Control Notation version 3; Part 1: TTCN-3 Core Language".

[i.6] ETSI EG 202 237: "Methods for Testing and Specification (MTS); Internet Protocol Testing (IPT); Generic approach to interoperability testing".

[i.7] ETSI TR 102 788: "Methods for Testing and Specification (MTS); Automated Interoperability Testing; Specific Architectures".

[i.8] ETSI ES 201 873-5: "Methods for Testing and Specification (MTS); The Testing and Test Control Notation version 3; Part 5: TTCN-3 Runtime Interface (TRI)".

[i.9] ETSI ES 201 873-6: "Methods for Testing and Specification (MTS); The Testing and Test Control Notation version 3; Part 6: TTCN-3 Control Interface (TCI)".

[i.10] T3DevKit User Manual.

NOTE: See http://t3devkit.gforge.inria.fr/doc/userref/ fetched on 9.11.2009.

3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AS	Application Server
CSCF	Call Session Control Function
DNS	Domain Name Server
EUT	Equipment Under Test
HSS	Home Subscriber Server (HSS)
IBCF	Interconnection Border Control Function
IMS	IP Multimedia Subsystem
IP	Internet Protocol
MMTEL	Multi-Media Telephony
NNI	Network-to-Network Interface
PCAP	Packet CAPture
SIP	Session Initiation protocol
SUT	System Under Test
TCI	TTCN-3 Control Interface
TRI	TTCN-3 Runtime Interface
TTCN-3	Testing and Test Control Notation 3
UE	User Equipment
VoIP	Voice over IP (VoIP)

4 Automated interoperability testing

Interoperability is a key factor in the widespread commercial success of any given technology in the telecommunication sector. Interoperability fosters diversity as well as competition in a market. Vendors can achieve interoperability of their products only if they agree and implement a common set of open standards. However, standardization does not necessarily lead to interoperability. Standards have to be engineered for interoperability.

In its efforts to formalize interoperability testing of distributed systems, ETSI has produced a generic approach to interoperability testing [i.6] which is targeted for certification of products by the means of interoperability testing, as well as a framework and methodology for automating interoperability testing in general [i.1], e.g. in the context of ETSI Plugtests™.

The methodology for automated interoperability testing has been derived from [i.6] and defines a means for interoperability testing as well as a System Under Test (SUT) based on concepts such as Equipment Under Test (EUT), an interconnecting network, application support nodes, a test coordinator, a test oracle, interface monitors and equipment users. It has been designed to be independent of the technology under test, as well as the test language used to implement the means of interoperability testing. The document on this methodology also discusses topics such as limitations and feasibility of automation, verdict handling, and controllability of EUT interfaces. More information as well as a detailed explanation of these concepts can be found in [i.1].

The present document presents a summary of the experiences and the knowledge gained during the application of the methodology for automated interoperability testing in an interoperability event organized by ETSI.

4.1 ETSI Plugtests

Plugtests™ are interoperability testing events that are organized by ETSI to offer its members as well as non-members a means to assess interoperability between systems and the maturity of standards. These events are attended by vendors that implement systems based on standards and depending on the event also by observers that include customers of these vendors or research partners. A previously agreed interoperability test specification is the basis for each event. Tests are executed in parallel test sessions where implementations from different vendors are paired with each other and attempt to execute as many applicable tests as possible in the given test session time limit. The main goal of ETSI Plugtests is the validation of standards: Interoperability issues as well as deviations from standards observed at these events are reported to relevant ETSI technical committees which use this feedback to further improve standards and their interoperability.

5 Third ETSI IMS Plugtest Event

5.1 IMS core network NNI interoperability testing

The Internet Protocol (IP) Multimedia Subsystem (IMS) [i.2] is an architectural framework for delivering IP multimedia to fixed as well as mobile users. It was originally designed by the wireless standards body 3rd Generation Partnership Project (3GPP). It is a major step in the evolution of telecommunication networks beyond Global System for Mobile Communications (GSM) and a convergence with the Internet. Contrary to other conventional telecommunication frameworks, IMS is based on IP, i.e. the Session Initiation Protocol (SIP) [i.3], and access network independent. IMS does not standardise specific applications, but aids the access of multimedia and voice applications across wireless and wireline terminals, i.e. a form of fixed and mobile convergence. It isolates application services from the access networks and provides a horizontal control layer for them.

IMS core network interoperability testing focuses on the assessment of interoperability of basic services such as basic Voice over IP (VoIP) call and instant messaging between two distinct IMS networks as well as more sophisticated services that require the use of an Application Server (AS), e.g. Multi-Media Telephony (MMTel) and presence. Each IMS core networks consists of Proxy Call Session Control Function (P-CSCF), I(nterrogating)-CSCF, S(erving)-CSCF, Interconnection Border Control Function (IBCF), and Home Subscriber Server (HSS) components. In terms of the automated interoperability testing methodology each IMS core network by itself constitutes an Equipment Under Test (EUT) and two connected IMS networks constitute the System Under Test (SUT). External entities such as IMS User Equipment (UE), Application Servers, and Domain Name Servers (DNS) or simulations of such are used to stimulate and observe the interoperability of IMS core networks. While performing interoperability tests traffic on standardized interfaces such as Gm, Mw, Ic, and ISC is captured and used to determine if each IMS core network follows the IMS standard when realizing IMS services. The focus in this analysis is the inspection of interfaces between different network elements - also called Network-to-Network Interfaces (NNI) - i.e. Mw, Ic, and ISC interfaces.

Figure 1 shows an example test configuration with IMS core networks A and B. Let us assume that the user of UE A has an account in IMS A (i.e. the HSS of IMS A) and the user of UE B has an account in IMS B. An example use case is that the first user - after registering in the network of IMS A - calls with his UE A the second user who is already registered with his UE B in the network of IMS B. In this case, initial (IN) SIP requests are exchanged via the S-CSCF of IMS A and the I-CSCF of IMS B. Subsequent (SU) messages are then exchanged between the S-CSCF of IMS A and the S-CSCF of IMS B. Note that although the connection is (physically) different, the (logical) IMS NNI reference point is the same, i.e. Mw.

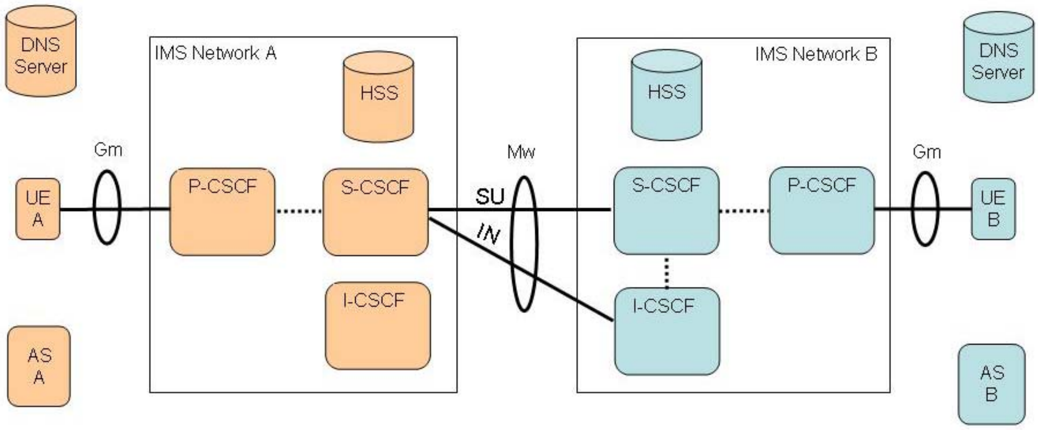

Figure 1: Example IMS Core Network NNI test configuration

5.2 Event Summary

The third ETSI IMS interoperability event held in Lannion, France from October 16th to 23rd 2009 at the Ursulines center. The main focus was the assessment of the interoperability as well as conformance of IMS core networks (composed of P/I/S-CSCF, IBCF, AS (telephony and presence), DNS and HSS) which are implemented on the basis of TS 124 229 [i.2] at their NNI. The tests executed at the event were related to basic IMS call functionality, messaging, IMS roaming, topology hiding, MMTEL supplementary services, and the presence service and were taken from the ETSI IMS NNI interoperability test specification TS 186 011-2 [i.4].

Eight IMS core network vendors participated at this event. During the event 495 of 2 805 potential IMS NNI tests were executed out of which 317 were automatically analyzed for conformance. Overall results show a very high level of interoperability (89 %) of IMS core networks but a lower level of overall conformance to the 3GPP base standard (55 %) in the tests executed. Also note that 13 % of all potential tests could not be executed due to issues outside of the IMS core networks caused, e.g. by a lack of the support of a feature by a participating IMS core network.

Tests were executed at match stations in the presence of two IMS core network vendor teams, an independent test session chair (appointed by ETSI), and observers. For each test executed, a member of the IMS network vendor team operated IMS user equipment connected to their IMS network based on instructions from the test session chair. During each test, IMS network traffic at Gm and Mw, ISC and Ic interfaces was captured and saved by the test session chair.

In the first part of each IMS NNI test session 52 tests were attempted to be executed from one IMS network vendor playing the role of IMS A to another IMS network vendor playing the role of IMS B. After 90 min IMS roles were reversed and the 52 tests were again attempted to be executed in the other direction. Testing in the test session focussed only on the assessment of the interoperability between the two involved EUTs and excluded conformance analysis. Interoperability results were recorded based on mutual agreement of all involved parties.

After three hours of interoperability testing test execution was stopped to perform manual conformance analysis. For this purpose, a selected number of tests (as many as possible) were reviewed by the participating vendors and the test session chair using available trace capture tools. This third part of the test session was limited to 60 minutes. Conformance verdicts were assigned for each reviewed test. All remaining tests by ETSI representatives supported by an automated interoperability testing tool specifically implemented for this event. All conformance results were recorded along with comments and issues during the test execution and conformance analysis in ETSI test session reports.

The main interoperability issues encountered in this event were related to calls not going through the networks, unsuccessful registration and problems with user initiated hold and resume functionality. Most issues encountered in conformance analysis were related to the use of Record-Route, P-Charging-Vector and P-Asserted-Identity headers in various SIP requests and responses. During the event it became clear - also as a result of the poor conformance results for topology hiding tests - that there is a common opinion on shortcomings in the descriptions of the topology hiding functionalities in the base specification [i.2]. It seems that those descriptions over-complicate the use of topology by imposing encoding tasks on an IBCF acting as network exit point that do not only not add any extra value to the functionality but also broadcast the fact that topology hiding is used to any connected peer IMS network.

5.3 IMS Interoperability Test Automation

This clause discusses the use of automated testing in the context of the IMS Plugtest. In case of IMS core network testing the operation of IMS user equipment is difficult to achieve since their interfaces are generally graphical and proprietary. In order to automate completely test execution, test adapters for all participating IMS UEs at the event would be necessary. In the case of the IMS Plugtest on the order of 5 different IMS UEs where used during testing. Therefore, instead of driving interoperability testing the IMS interoperability test tool was only used to evaluate the communication of IMS equipment during the interoperability tests via standardized interfaces in an offline modus, i.e. to analyze recorded Packet CAPture (PCAP) format trace captures.

Even if an IMS UE would offer a software interface for its control, it would still be questionable if the automatic operation of IMS UEs in the context of interoperability events is really feasible. Interoperability events run with extreme time limitations. Since vendors pay sometimes significant participation fees, off time for vendors is a luxury that cannot be afforded. Bugs in the test system costs valuable time for such participants at the event. To minimize this risk, a prerequisite is to perform extensive validation of IMS UE operation prior to the event.

5.3.1 IMS Interoperability Test Tool Implementation

For the 3rd IMS Plugtest ETSI implemented a test system based on TTCN-3 [i.5] which is the test automation language of choice at ETSI. Use of TTCN-3 has many benefits including independence from the technology to be tested, independence from a particular testing tool, abstraction, and most important its suitability for standardization purposes.

A detailed description of the TTCN-3 IMS interoperability test system design is described in [i.7]. The interoperability test system has been designed and established on a library-based test architecture to support its reusability in the context of interoperability testing of other technologies.

The test system used at the third IMS Plugtest has been implemented from scratch using two different commercial TTCN-3 compilers in all phases of development. The starting point for the design and development was the experiences collected with a first proprietary TTCN-3 trace analysis tool prototype that had been used in the second IMS Plugtest. IMS interoperability test tool development included the implementation of reusable TTCN-3 libraries for interoperability testing and equipment operation, i.e. the upper tester, a TTCN-3 IMS interoperability test suite based on [i.4], a TTCN-3 Control Interface (TCI) [i.8], i.e. a SIP/SDP codec, and a generic TTCN-3 Runtime Interface (TRI) [i.9], i.e. an interoperability test adapter. The test adapter implements functionality for PCAP file reading, trace filtering, as well as the creation of text terminals which provide instructions for equipment operation. The basis for the codec and adapter development was the open source development kit t3devkit [i.10] which provides libraries for codec and adapter implementation in C++. During the test system development, numerous improvements had to be applied to this kit to make it feasible with this test tool. Integration problems with one of the TTCN-3 tools required the use of another test adapter implementation.

5.3.2 Use of the Test Tool

Trace captures of manual interoperability test executions were recorded independently in four parallel test sessions. For the offline analysis of these trace captures three IMS interoperability test tool instances were used in parallel. Each test tool instance was first configured with IP address and port information of all participating IMS core network equipment and user equipment. Then recorded trace captures were analyzed by executing the corresponding test case. The trace was accepted in case the final verdict was a pass. In the case of a fail verdict, each test execution was checked in order to determine if the reason for the failure was indeed caused by non-conformant behaviour of an EUT or if it was caused by a problem in the test system. The test engineers used the same TTCN-3 IMS interoperability test suite but executed it with two different commercial TTCN-3 tools.

5.3.3 Event Feedback on Automated Interoperability Test Tool

In general, the use of the IMS interoperability test tool was a great success. A comparison with the time and effort spent on interoperability trace analysis during the first IMS Plugtest shows a reduction of 50 % in time. This reduction has been reached by applying automated trace analysis through the execution of the IMS interoperability testing tool by the test engineers. Note that in the first IMS Plugtests all traces were analyzed manually. Also note that the effort spent on the third IMS Plugtest also includes efforts spent to validate tests, remove bugs in the test system, and to implement changes to the test specification that arose during the event. After the validation phase, the test engineers reported that (independent of the TTCN-3 compiler used) that it is feasible to analyse five test sessions with the test tool per day.

The redesign of the TTCN-3 test suite from the first TTCN-3 test suite prototype has significantly improved the handling of the tool for test engineers. Key points here were the introduction of the concept of test sessions, separation of IMS UE and network information, and hierarchical template design. These concepts allowed consistent and quicker updates of the test suite especially during validation. On an average, the test engineers reported that one day is needed to understand and extend the TTCN-3 code of the test tool.

Another positive point is that participating vendors appreciated very much the instant conformance feedback from the tool. Some mentioned that this service is a key differentiating factor compared to other IMS interoperability events that they attend. For them, the only path to achieve interoperability within a technology like IMS is standards and their adoption.

Experiences also included some points for further improvement. One aspect was that most of the test suite validation had to be performed just prior or during the event. This problem was caused in part by the lack of availability of traces especially for new tests but also from the fact the test system had been implemented from scratch. The biggest source of error in the test system has been incorrect TTCN-3 template specifications. In the future, traces used for validation should include as many message exchanges as possible. Ideally for each test, one passing and one failing trace should be available for its validation.

A second aspect for improvement is a better integration with the ETSI test reporting tool where test engineers manually uploaded all the results, as well as the reasons for failure.

Finally, the TTCN-3 tools showed room for improvement in helping test engineers to locate error as quickly as possible. The comments mainly apply to the presentation of test case execution. The following features were listed as being highly desirable by the test engineers:

- visualization of message exchanges to be able to get the big picture;
- ability to see what requirement or test purpose has failed (in this test suite the requirement identifier was encoded in the template identifier);
- detailed information on mismatches including at least field identifiers and template identifiers where the first mismatch occurred;
- the ability to jump in an execution trace to the next alt statement;
- port identifiers with receive statements;
- each component verdict should include the test component identifier; and
- special marking or emphasis on the first fail or inconclusive verdict.

History

Document history		
V1.1.1	January 2010	Publication