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IMS Network Testing (INT);
Report on the automatic conformance review during the IMS plugtest 2012; TTCN-3 based trace analysis of SIP and Diameter messages

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Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee IMS Network Testing (INT).

1 Scope

The present document presents a summary of experiences collected from the use of automatic interoperability testing in a real-world interoperability testing event at the RCS/VoLTE interoperability event held in Kranj (Slovenia) from 1st to 12th October, 2012. 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 EG 202 810 [i.1].

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

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2.1 Normative references

The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

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

[i.2] ETSI TS 124 229 (V9.5.0): "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 V9.5.0 Release 9)".

[i.3] ETSI TS 186 011-2 (V4.1.3): "IMS Network Testing (INT); IMS NNI Interoperability Test Specifications; Part 2: Test description for IMS NNI Interoperability".

[i.4] ETSI TS 102 901 (V2.1.1): "IMS Network Testing (INT); IMS NNI Interoperability Test Specifications; IMS NNI interoperability test descriptions for RCS".

[i.5] ETSI TS 103 029 (V3.1.1): "IMS Network Testing (INT); IMS & EPC Interoperability test descriptions".

[i.6] 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.7] ETSI EG 202 237: "Methods for Testing and Specification (MTS); Internet Protocol Testing (IPT); Generic approach to interoperability testing".

[i.8] ETSI TR 102 788: "Methods for Testing and Specification (MTS); Automated Interoperability Testing; Specific Architectures".

[i.9] 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.10] 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.11] ETSI TS 101 580-3: "IMS Network Testing (INT); Diameter Conformance testing for Rx interface; Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) proforma specification".

[i.12] ETSI TS 101 606: "IMS Network Testing (INT); Diameter Conformance testing for Gx interface; Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) proforma specification".

[i.13] ETSI TR 101 561: "IMS Network Testing (INT); Enhancement of Automated Interoperability Testing Framework in IMS core networks: Test adapter And codec design suited for TTCN-3 interoperability testing".

[i.14] ETSI TS 101 586: " IMS Network Testing (INT); User Documentation and IMS Codec and Adapter layer software for IPv6 and 3GPP Release 9".

[i.15] ETSI/GSMA/MSF: "RCS VoLTE Interoperability Event 2012; Multivendor testing in global RCS/VoLTE Networks".

NOTE: Available at: http://www.msforum.org/interoperability/RCS_VoLTE_WhitePaper_11_14_2012.pdf

3 Abbreviations

For the purposes of the present document, the abbreviations given in TS 124 229 [i.2] and the following apply:

AS	Application Server
CSCF	Call Session Control Function
DNS	Domain Name Server
ENUM	E.164 NUmber Mapping
EPC	Evolved Packet Core
EUT	Equipment Under Test
GSM	Global System for Mobile Communications
GSMA	GSM Association
HSS	Home Subscriber Server
IBCF	Interconnection Border Control Function
IMS	Internet Protocol Multimedia Subsystem
IP	Internet Protocol
IPX	IP eXchange
ISC	IP Multimedia Subsystem Service Control
LTE	Long Term Evolution
MMTEL	Multi-Media Telephony
MSF	Multi Service Forum
NNI	Network-to-Network Interface
PCAP	Packet CAPture
RCS	Rich Communication Suite/Services
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
URI	Uniform Resource Identifier
VoLTE	Voice over LTE
VPN	Virtual Private Network

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 in EG 202 237 [i.7] 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 in EG 202 810 [i.1], e.g. in the context of ETSI Plugtests.

The methodology for automated interoperability testing has been derived from EG 202 237 [i.7] 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 for 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 EG 202 810 [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 the RCS/VoLTE interoperability event co-organized by ETSI, GSMA and the MSF and held in Kranj (Slovenia) in October 2012.

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 ETSI/GSMA/MSF RCS/VoLTE Plugtest Event

5.1 IMS core network NNI interoperability testing

The Internet Protocol (IP) Multimedia Subsystem (IMS) TS 124 229 [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), and access network independent. IMS does not standardize 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.

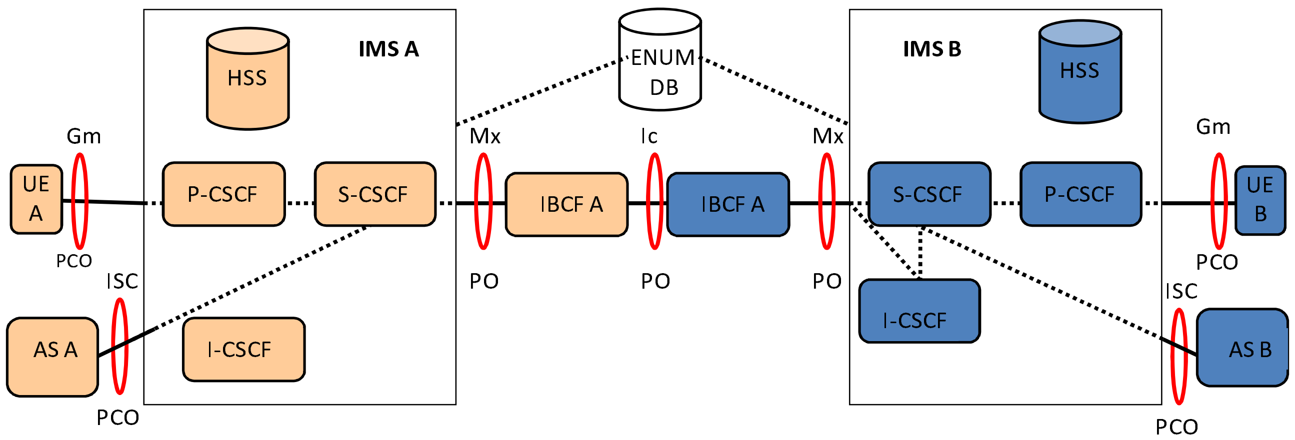
Specific application are defined in the GSMA specifications related to the Rich Communication Suite (or Services) (RCS). RCS is a service upgrade that marks the transition of messaging and voice capabilities to an all-IP world. RCS and Voice over Long Term Evolution (VoLTE) share the same IMS investment and leverage the same IMS capabilities. Wider and large scale IMS deployment, interoperability between different terminal vendor RCS clients and RCS service interworking between operators are the key aims of the RCS Initiative.

IMS core network interoperability testing focuses on the assessment of interoperability of basic services such as basic Voice over IP (VoLTE) 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 (DNS) or E.164 Number Mapping Servers (ENUM) 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. Application servers AS A and AS B are serving the two IMS core networks. 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 SIP messages are exchanged via the IBCF of IMS A and the IBCF of IMS B over the Ic interface which acts as point of observation. This configuration also applies for the verification of interoperability of RCS services with the difference that besides or on top of the mere call information other data may be exchanged over the same interfaces such as presence information or even files for a file sharing service.

Interworking Application Server

CF_INT_AS



Precondition:
Different network operators performing origination and termination, UE_A and UE_B in home networks INT), both UEs registered, AS for UE_A and UE_B (AS), a common interconnect ENUM DB and local ENUM is involved, IBCF is involved, topology hiding may apply.

Test configuration for:
Requests and responses between ASes and UEs

Example:
Initial INVITE in IMS VoIP voice call unconditionally forwarded to UE_B by AS_A (CFU), AS_A acts as routing AS

Figure 1: Example IMS Core Network NNI test configuration

As IMS was adopted for the non-mobile access, the underlying network and attachment architectures and procedures started to diverge such that various types of fixed network could be supported. This prompted a split between the strict IMS standardization and that of the underlying Access Network.

The LTE path started an evolution of both the Radio Access Network and its supporting Core Network architecture into a consolidated Evolved Packet Core (EPC), as part of the System Architecture Evolution. The main targets of the EPC architecture are to provide a flexible and efficient IP-connectivity layer, capable of handling Inter-System Handovers, Policy and Charging Control as well as security for transparent IP services. The approach is more generalized than with IMS which requires SIP signalling for services. EPC is capable of supporting not only an IMS architecture on top, but also has a potential for generic Over-The-Top services.

The EPC to IMS interoperability covers all the interactions on the border interfaces between the IMS and the EPC systems. It has to be noted that this is a bi-directional resource negotiation, event propagation and IP transport interaction point. EPC to IMS interoperability testing adds the additional interfaces SGi and Rx to the test configuration. Figure 2 shows the chosen test configuration.

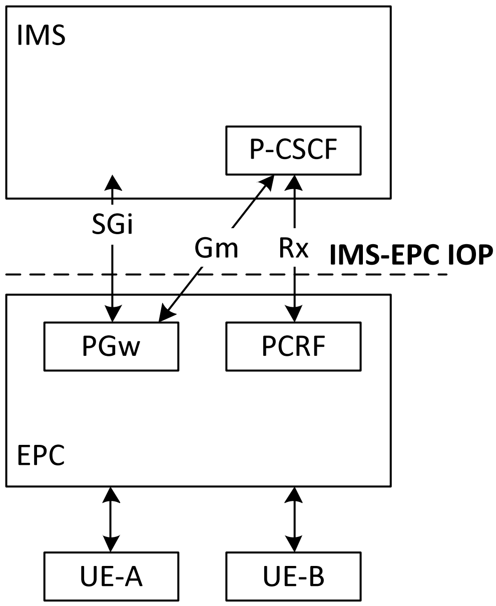


Figure 2: EPC-IMS Interoperability test configuration

5.2 Event Summary

The RCS/VoLTE interoperability event was held in Kranj, Slovenia from October 1st to 12th 2012 at the Sintesio laboratory. See the complete summary of the whole event in the whitepaper "RCS VoLTE Interoperability Event 2012; Multivendor testing in global RCS/VoLTE Networks" [i.15]. The planned main focus was the assessment of the interoperability as well as conformance between IMS core networks (composed of P/I/S-CSCF, IBCF, AS (MMTEL and RCS), ENUM and HSS) which are implemented on the basis of TS 124 229 [i.2] at their NNI for call related services and according to GSMA RCS specifications for the RCS related services. The tests executed at the event were mainly related to basic IMS call functionality, messaging, IMS roaming, and MMTEL supplementary services and were taken from the ETSI IMS NNI interoperability test specification TS 186 011-2 [i.3]. The interoperability test descriptions that had been developed for the RCS service in TS 102 901 [i.4] were finally not used due to the absence of RCS compliant UE equipment.

Interoperability between EPC and IMS was tested following the test descriptions defined in TS 103 029 [i.5]. Tests focussed on the LTE attachment and detachment and IMS registration and de-registration of UE equipment connecting via the LTE radio access network and through the EPC into the IMS core network.

The RCS/VoLTE interoperability event actually involved two host sites, the Sintesio site in Kranj, Slovenia and the China Mobile Research Institute Laboratory site in Beijing, China. The two labs were interconnected via an IP exchange (IPX) network. However, interoperability testing as described in the ETSI test specification have only been performed at the test site in Kranj. All following clauses are therefore exclusively related to the interoperability testing that took place in Kranj.

Vendor equipment was permitted to be located remotely from the host site subject to certain constraints, namely that the UEs, eNodeBs and monitoring equipment needed to be located on site in the Sintesio laboratory in Kranj. Remotely located equipment was connected into the host site via VPNs. Traffic on remote observed interfaces was routed through a central observation point at the host sites in order to allow monitoring equipment to capture and analyze it.

Additional VPN connections enabled participants to have remote management access to any equipment located in the host site, thereby enabling vendors to complement onsite staff with personnel at home locations. The use of remotely located equipment enhanced flexibility and reduced participation costs for vendors.

ETSI has developed an automatic tool to check recorded traces on conformance towards the base standards. For this purpose recorded trace files were analyzed off-line in accordance with the conformance criteria defined in the test specifications TS 186 011-2 [i.3] and TS 103 029 [i.5]. The test tool specifically implemented for this interoperability event is based on the standardized testing language Testing and Test Control Notation Version 3 (TTCN-3) and allowed automatic assignment of conformance test verdicts for message flows containing SIP and Diameter messages. This activity builds on the work related to the validation of ETSI Conformance Test Suites TS 101 580-3 (Diameter on Rx) [i.11] and TS 101 606-3 (Diameter on Gx) [i.12]. Also, in parallel to this validation activity, the tools to enable the automatic conformance checking of traces taken during the interoperability event were developed.

In a single network test scenario, intra-network testing utilized a single RCS VoLTE architecture created using components from different vendors. Testing included LTE attachment and detachment to/from the network, SIP registration and deregistration (to/from IMS), SIP voice session establishment, SIP multi-media session establishment, SIP session teardown, MMTel Service Configuration and MMTel Service usage. The conformance validation software based on the test descriptions in TS 103 029 [i.5] was successfully applied for the LTE attach/detach and the IMS register/deregister tests.

In a multi-network test scenario, interworking testing utilized a two RCS/VoLTE architectures created using components from different vendors. Testing focused again on SIP voice session establishment, SIP multi-media session establishment, SIP session teardown, MMTel Service Configuration and MMTel Service usage. Also here the automatic conformance validation software, this time based on TS 186 011-2 [i.3], was applied to the traces recorded during the interoperability test sessions.

Use of the automatic tool to check recorded traces on conformance was performed off line as a background activity during the event to perform SIP / DIAMETER conformance criteria checking on trace files captured during the RCS/VoLTE interoperability testing.

Trace captures of the manual interoperability test executions were recorded independently. For the offline analysis of these trace captures two conformance criteria verification test tool instances were used in parallel. Each test tool instance was first configured with IP address and port information of all participating 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 or if it was caused by a problem in the test system. The test engineers used the same TTCN-3 test suite but executed it with two different commercial TTCN-3 tools.

Here, the "Pass" verdict has been given in cases that the analysis of the test execution trace shows that all components participating in a test fulfilled all of the verdict criteria specified in the test specification for that test. The "Fail" verdict has been given in cases that the analysis of the test execution trace show that at least one entity participating in a test violated one or more of the verdict criteria specified in the test specification for that test. The "Inconclusive" verdict was assigned in cases were some non-conformant condition had been observed which was either not part of the verdict criteria, e.g. the test never got to through its preamble, or could not be performed in its totality, e.g. a user equipment was not able to add and drop media streams to an existing SIP dialogue. So in both cases the verdict criteria cannot be checked - therefore the test is assigned an "Inconclusive" verdict.

The results showed several syntax errors in SIP headers exchanged between different equipment such as missing "<" and ">" characters in P-Associated-URI headers and the use of superfluous space characters at the end of SIP message lines. Those results were reported to the vendors involved. Related to this, it was noted that different implementations behaved differently on receipt of such syntax errors- i.e. some were relatively tolerant in some cases where others rejected or ignored such syntactically invalid protocol data units.

Diameter signalling messages turned out to be syntactically correct and no coding errors caused the conformance review software to assign Fail-verdicts based on the analysis of the exchanged Diameter messages. Only the Diameter procedures that are relevant to the interoperability tests covering UE attachment, de-attachment, registration and deregistration were considered as the ETSI test specification TS 103 029 [i.5] focuses on those procedures.

5.3 IMS Interoperability Test Automation

This clause discusses the use of automated testing in the context of the RCS/VoLTE interoperability test event. 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 RCS/VoLTE interoperability test event several 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 RCS/VoLTE interoperability test event ETSI implemented a test system based on TTCN-3 ES 201 873-1 [i.6] 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 TR 102 788 [i.8]. 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 RCS/VoLTE interoperability test event 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 earlier IMS interoperability events. 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 TS 186 011-2 [i.3], a TTCN-3 Control Interface (TCI) ES 201 873-5 [i.9], i.e. a SIP/SDP and a Diameter codec, and a generic TTCN-3 Runtime Interface (TRI) ES 201 873-6 [i.10], 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. Details of the implementation and the design principles for the test adapter and codec software modules used for the TTCN-3 interoperability testing are found in TR 101 561 [i.13] and updated and extended in TS 101 586 [i.14].

5.3.2 Use of the Test Tool

Trace captures of manual interoperability test executions were recorded independently in parallel test sessions. For the offline analysis of these trace captures two 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 earlier IMS interoperability events 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 earlier IMS interoperability events all traces were analyzed manually. Also note that the effort spent on the RCS/VoLTE interoperability event 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. This applied in particular for the Diameter related software modules as they were used for the first time at this event.

The redesign of the TTCN-3 test suite from the earlier TTCN-3 test suite prototype used in previous IMS interoperability events and the addition of the Diameter protocol and IPv6 functionality 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.

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	February 2013	Publication