Ensuring Interoperability with Automated Interoperability Testing

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EXECUTIVE SUMMARY

This white paper presents a new approach to achieve interoperability via the automation of interoperability testing. Over the past years, interoperability testing has become more and more attractive in standardization and industry to ensure delivery of services across products from different vendors. Today interoperability testing is still largely performed in a time consuming and resource intensive manual manner. We introduce here the work done at ETSI to automate this form of testing and show that it can also be used to assess the compliance of products to specifications and standards. The work has already shown to yield significant cost reductions in industrial and standardization case studies. We explain here why automation is desirable, how automation can be achieved, and present examples of its successful applications.

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Introduction

As proven by the tremendous success of mobile communication, interoperability is one of the key factors to success when deploying new technologies for highly distributed systems. To ensure interoperability of all products part of such systems, efforts in the telecommunication domain relied mainly on type approval or conformance testing, i.e., to test if a product adheres to a set of standards. In most other domains, e.g., the Internet or health care applications, interoperability testing has been the primary means used to ensure interoperability.

Interoperability testing in industry has always been practised in the context of testing laboratories, field trials, and acceptance testing. Recently and in part driven by the convergence of the Internet and telecommunication domains, interoperability testing has also been steadily gaining ground in telecommunication standardization. Several reasons can be accounted for this development. In the Internet domain, for example, interoperability testing has been historically preferred over conformance testing and even driven standard development. In the telecommunication domain, standard development has been the place for ensuring interoperability. Here, conformance testing has been used to ensure that products adhere to standards as well as to drive corrections and improvements of these standards to achieve interoperability. But also here interoperability events, e.g., ETSI Plugtests, have been increasingly used to ensure or demonstrate not only direct interoperability of products based on standards but also conformance to standards.

Although both, pure conformance and interoperability testing, have shown to work successfully in the context of standardization, neither community has accepted the value of the other approach. However, both domains have in common that for successful deployment interoperability has to be demonstrated and maintained over time. Thus, interoperability testing was and is an integral part of technology deployment.

Why is interoperability and interoperability testing important?

Regardless of the application domain – telecommunication, transportation, health care, computation, or etc – end users today are mainly using services that are provided by distributed systems composed of products from different vendors. The overall system complexity is usually too high and costly for a single vendor to develop or maintain one product for the complete distributed system. Another challenge arises from the fact that multiple evolving technologies are continuously integrated and need to interoperate in the such systems.

Service providers use products from different vendors to reduce their cost to build the system needed to sell their service. In addition, service providers increasingly rely on working with other service providers to offer their service, e.g., telecom operators. Finally, the end users expect to be able to use their services anytime from anywhere regardless of the composition of the system they are using. Take your mobile phone as the best example. These facts require interoperability and without interoperability there is simply no chance to succeed in today's market place.

Interoperability testing, generally speaking, assesses the end-to-end service provision across two or more products from different vendors. But when taking a closer look, interoperability testing can mean different things to different people. For ETSI interoperability testing is tied to a systematic approach based on an agreed list of test descriptions which are executed in parallel test sessions during ETSI Plugtests. Test execution traces at standardized interfaces are recorded and analyzed for their compliance to the standards.

Why automate interoperability testing?

Due to the large amount of products and standards involved in complex distributed systems, interoperability testing is a manual, extremely time consuming, cost intensive, and repetitive task. The high amount of required test executions mainly comes from the fact that interoperability testing is not transitive: If a product A interoperates with a product B and C, it does not necessarily mean that B interoperates with C. Another issue is that technically each new product release requires that all interoperability tests have to be re-executed yet again. This results in a clear market need for a approach to automate interoperability testing.

A study performed by Telecom Italia shown in Figure 1 attests significant reduction of regression testing costs via automated interoperability testing for mobile core networks. The cost savings are evident according to the huge number of execution of the tests. Further benefits of the automation are wider test coverage, consistency, and repeatability.

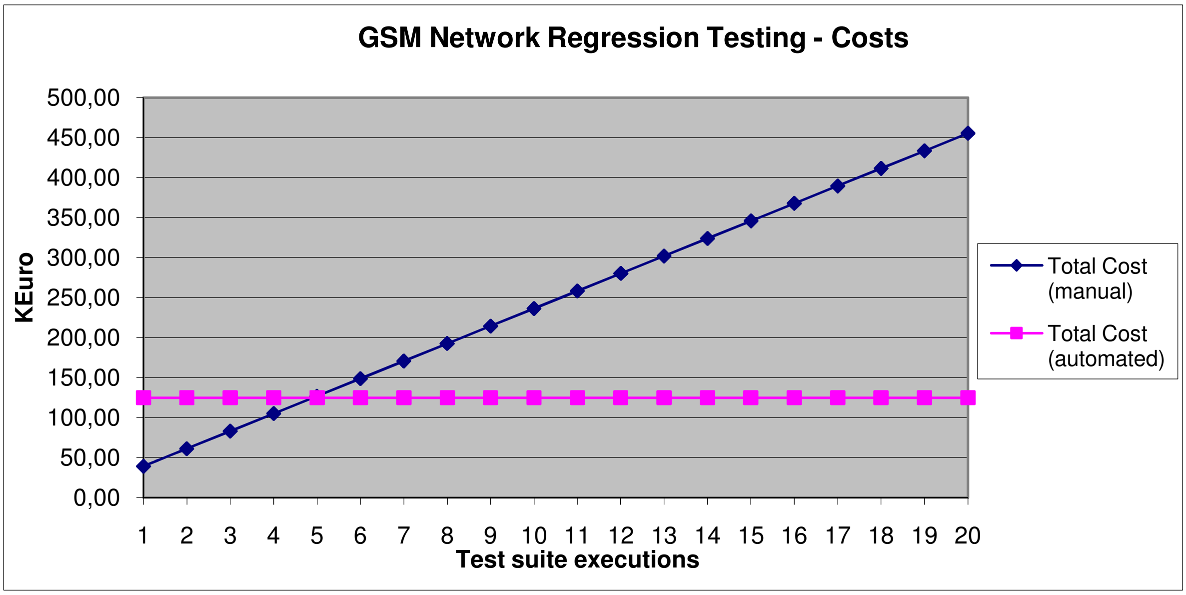

Figure 1: Estimated costs savings for mobile core network regression testing

In addition, as depicted in Figure 2, it is a well-known fact that as later a software bug is identified as the higher the cost of fixing it. Interoperability testing is performed in the last phase before a product goes into live production. Thus, it is the last barrier before a bug may produce incalculable costs. The situation becomes even more dramatic if the bug identified is not only an implementation error but unveils a system problem related to the specifications on which the product implementations are based.

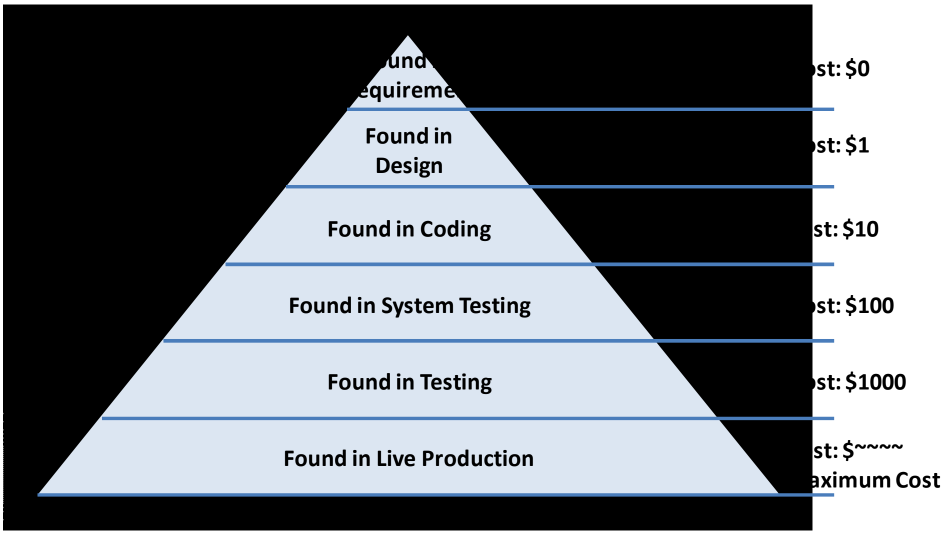

Figure 2: Costs of a single bug found in various stages of the software life cycle

It is clear that for product vendors and service providers automated interoperability testing produces the most benefit with the gains in the efficiency, reductions in time and labour cost. But there is however also another set of stakeholders that has a vested interest interoperability and adherence to specifications which are Standard Development Organizations (SDOs) or Fora.

Next to assessing interoperability, SDOs can gain invaluable feedbacks for their standard development processes from automated interoperability testing by evaluating traffic captured at standardized interfaces for its compliance to standard specifications. In one of its interoperability events ETSI has observed 90% interoperability of products but only 60% compliance to standards. Yet another significant but indirect contribution of automating interoperability testing is that it can facilitate remote testing. As the human intervention in the test execution decreases with its automation, remote testing, e.g., in the form of a virtual testing event become feasible.

When products are not interoperating the cause is usually related to ambiguities or unintentional options in the standard specifications which vendors usually interpret and implement in different ways. But how can this observed gap between interoperability and conformance be explained? The main cause that we have identified is that interoperability results achieved in such events, i.e., a controlled environment, can be misleading. Simplifications in the test environment can change the systems behaviour is such a way that it appears to be interoperating. In the real world, however, these deviations from the standard could have caused enormous damage to the technology during its deployment to the market. Therefore, ETSI strongly encourages to accompany pure interoperability testing with conformance checks.

Another current organization that is an advocate of automated interoperability testing is the WiMAX forum (see our later section on users of automated interoperability testing), which has considered to use this type of testing for certificationof interoperability as well as conformance. The TETRA Forum is another example for an organization which is currently actively trying to automate their interoperability testing.

Basic principles of automated interoperability testing

For automating interoperability testing, ETSI developed a generic methodology (ETSI Guide 202 810) which captures all the required concepts and defines a process for test specification development specifically for automated interoperability testing. The concepts summarized in Figure 3 have been derived by a thorough analysis of interoperability testing as it is practiced today in a number of different application domains including IPv6, Robust Header Compression (ROHC), Health Level 7 messaging, grid, cloud, WiMax, UMTS, IPTV, WiMedia, Voice over IP (VoIP) for air traffic control, and smart cards.

The basic idea is to automate user interactions when producing or consuming services (e.g. a voice call) and to verify the signalling by capturing or 'sniffing' the traffic at all standardized interfaces connecting EUTs (Equipment Under Test). All user interactions and traffic capture analysis are centrally handled by the Test Coordinator which also produces a test report. The test oracle is usually also part of the Test Coordinator and is responsible for managing interoperability and conformance verdicts separately.

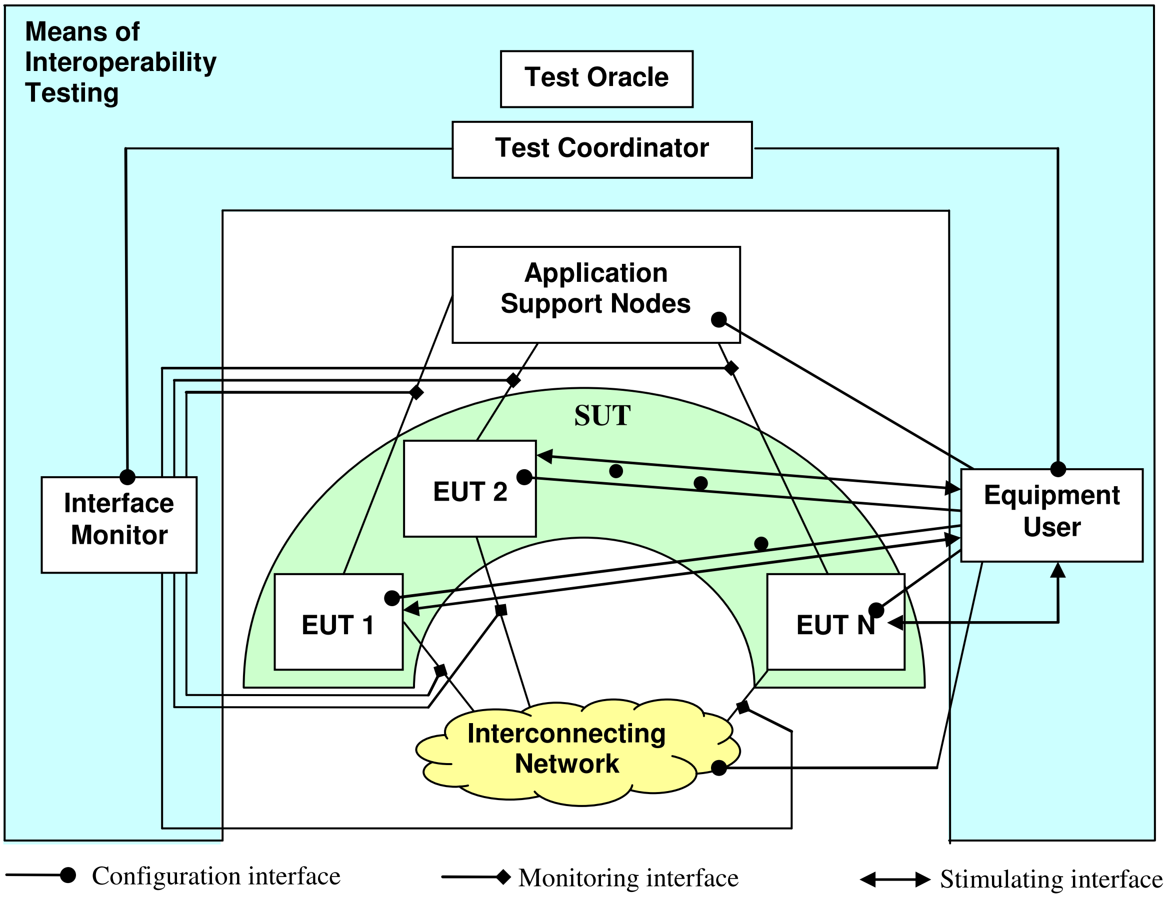

Figure 3: General framework for interoperability testing

In the same document, ETSI also defines process for developing automated interoperability test systems which is depicted in Figure 4. It details the interoperability test design based on a collection of prerequisites, as well as the specification and validation of executable test cases independent of a particular test scripting language.

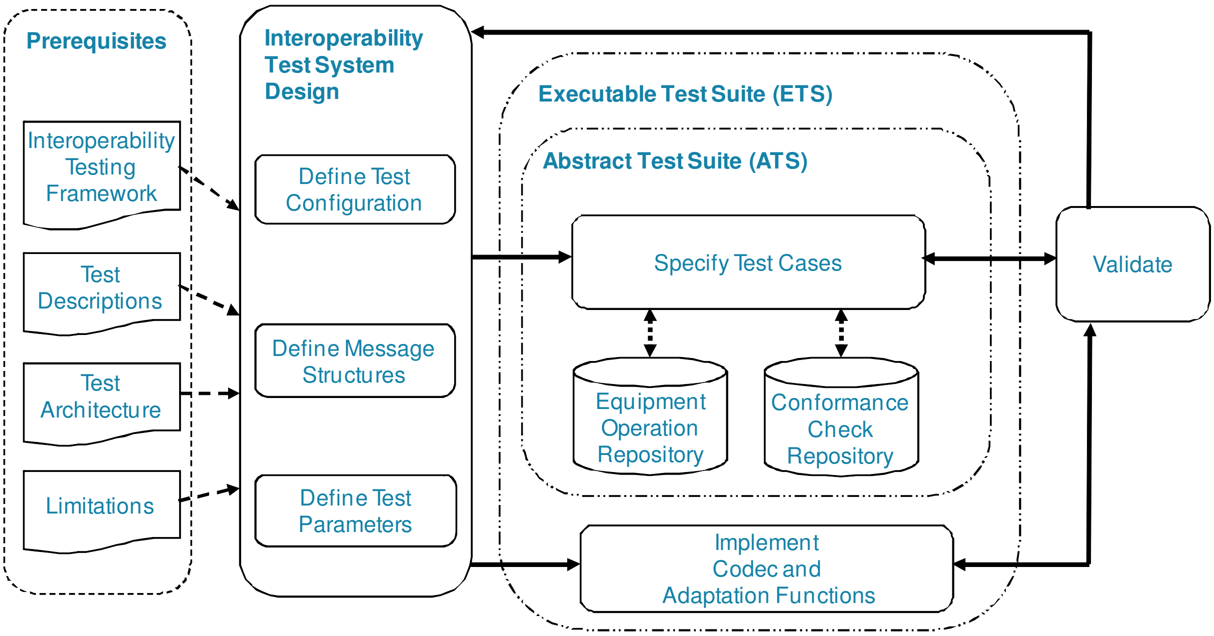

Figure 4: The development process for an interoperability test system

Who should be interested in automating interoperability testing?

One obvious place for using automated interoperability testing is interoperability events. These events are usually hosted by SDOs or fora, and bring together products from different vendors purely for the purpose of executing tests for a period which may last from a couple of days to a couple of weeks. Examples for such events include the following.

- **ETSI Plugtests**: ETSI hosts about 15 interoperability events called Plugtests per year. Each focuses on different information and communication technologies. In one of these events – the 3rd IP Multimedia Subsystem (IMS) Plugtest – the ideas discussed in this paper were put into practice. This event included eight different IMS core network vendors who assessed their system's ability to deliver IMS-based services across different networks in different configurations by executing a total number of 480 end-to-end tests within a five day period. Based on figures from previous IMS Plugtests, ETSI recorded a reduction of cost by 50% for the analysis of test session results using automation as compared to previous manual analysis. The evaluation of test session results included separate assessments of end-to-end interoperability as well as conformance of participating products with IMS standards. The results of this interoperability event are reported in the ETSI Technical Report 102 789.
- **IHE Connect-a-thons**: This weeklong interoperability event is organized each year by the International Healthcare Enterprise (IHE), an initiative by healthcare professionals and industry to improve the way of sharing information by computer systems in healthcare. This event provides an opportunity to vendors to test their products. IHE publishes integration profiles which address specific clinical needs and processes and promotes the coordinated use of established standards such as Digital Imaging and Communications in Medicine (DICOM) and Health Level 7 (HL7).

Another place were automated interoperability can be deployed effectively is in the context of more static and often highly distributed test beds. Such test beds are frequently used in industry to perform interoperability testing, e.g., by operators to evaluate how a new product or product update affects the rest of their network, but also test houses, research institutes, and other organizations to assess the adoption of standards or certify products against their standards. Examples for a successful deployment of automated interoperability testing in this setting include the following.

- **WiMax network interoperability test bed:** This test bed has been developed by the WiMAX Forum in the context of their own certification program. It is used to assess end-to-end operation of networks composed of products from different vendors. Interoperability testing is used here to automatically operate terminal devices and to analyze traffic at standardized reference points. Observed benefits in this case have been a simpler test specification as compared to a pure conformance testing approach, a high degree of reuse of the test code for driving vendor specific interfaces, a very flexible design for a multi-vendor test architecture, and the ability to control automatically any equipment that is part of the test bed.
- **Telecom Italia's mobile core network test bed:** This test bed was developed to cope with the validation of Telecom Italia's mobile core network which is a highly complex and distributed system where several of components from different providers must interoperate to provide the modern and sophisticated services to mobile phone users. A basic scheme of this complex network is depicted in Figure 5. All involved components may be produced by different vendors but need to interoperate without any problem. For this complex architecture, it is inevitable to automate interoperability testing to assure interoperability.

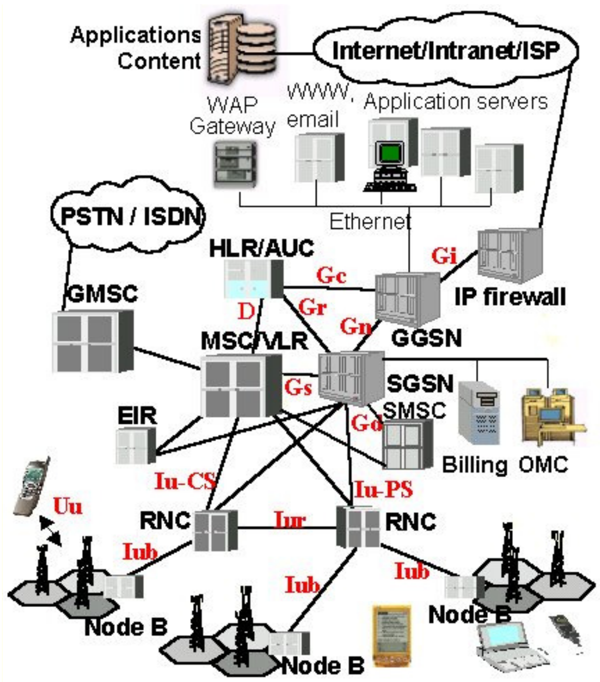

Figure 5: Mobile core network

Conclusions

As systems used for most commercial service provisioning have evolved and involve today hundreds of hardware and software components, also the costs for validating such systems and ensuring interoperability grow above expected bounds. Manual testing is today the most dominant way to perform interoperability testing. Manual testing is however highly costly and leaves room for human error simply considering the its repetitive nature and the number of interfaces involved in the testing of these complex systems. An additional challenge is the increasingly geographically distributed nature of these systems.

In this paper we have presented an approach to automate interoperability testing which has been proven and used is used in industrial case studies. We believe that the deployment of a systematic approach for automated interoperability testing is absolutely critical to ensure true interoperability, reduce cost and time-to-market, as well as to cope with system evolution, system validation, and regression testing for any multi-vendor, distributed system.

About the authors

- Olaf Bergengruen is a test engineer at Rohde & Schwarz in Munich working on test systems for mobile phones.
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- Tuncay Namli is a software engineer and architect of test systems for health care applications at the Software Research & Development and Consultancy (SRDC) in Ankara
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- Stephan Schulz is the Chief Technical Officer at Conformiq Software and serves currently as the chairman of ETSI's Technical Committee Methods for Testing and Specification (TC MTS)
- Luca Serazio, is a test engineer in Testing Lab at Telecom Italia and is in charge of the validation of the mobile core network, its services, and of automation of testing.
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Further reading

From its work on automated interoperability testing ETSI has produced a number of deliverables which are freely available:

- ETSI EG 202 810: "Methods for Testing and Specification (MTS); Automated Interoperability Testing; Methodology and Framework"
- ETSI TR 102 788: "Methods for Testing and Specification (MTS); Automated Interoperability Testing; Specific Architectures"
- ETSI TR 102 789: "Methods for Testing and Specification (MTS); Automated Interoperability Testing; Summary of ETSI experiences about using automated interoperability testing tools"

- T. Vassiliou and S. Schulz, "Automated Interoperability Testing with TTCN-3 - How to increase efficiency", TTCN-3 User Conference, Sophia-Antipolis, 2009.
- S. Schulz and T. Vassiliou, "Automated Interoperability Testing with TTCN-3 - Experiences from ETSI's STF 370 project", TTCN-3 User Conference Asia, Bangalore, 2009.

Other relevant documents:

- ETSI EG 202 237: "Methods for Testing and Specification (MTS); Internet Protocol Testing (IPT); Generic approach to interoperability testing".
- ETSI TS 186 011-2: "Technical Committee for IMS Network Testing (INT);IMS NNI Interoperability Test Specifications;Part 2: Test descriptions for IMS NNI Interoperability"
- F. Fischer and P. Kremer, "Using TTCN-3 to control the WIMAX interoperability testbed", TTCN-3 User Conference, Sophia-Antipolis, 2009.
- ETSI White Paper (Sophia-Antipolis, France, 2008): "Achieving Technical Interoperability - the ETSI Approach", Hans van der Veer and Anthony Wiles.