Testing the Mobile Internet

A EURESCOM Project View

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Abstract: This paper presents results from the Eurescom P1016 project on Mobile and IP Network Integration Testing (MINIT). The results consist of Test Suite Structure and Test Purpose documents as well as Abstract Test Suites and PIXIT specifications addressing GSM, GPRS and UMTS Network Integration Testing. The material is of particular interest to mobile operators, standardization bodies and test tool manufactures.

Key words: NIT, GSM, HSCSD, GPRS, EDGE, UMTS.

1. INTRODUCTION

Network operators today are faced with a number of challenges when it comes to protocol acceptance testing of new software releases and corrections. These include:

- Increasing complexity of the networks they operate
- Increasing numbers of releases / corrections per year
- Decreasing test time due to market pressure

Recent research conducted by the GSM Association's Minimum Performance Requirements Interoperability Task Force addressed mobile network evolution and estimated the potential costs to operators resulting from poor testing as US$44m - US$332m per annum [1]. It was also indicated that 31,000 - 36,000 man-days could potentially be lost per annum.

Automatic test procedures will play an important role in mitigating these problems. The ability to run a comprehensive suite of tests on demand with

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minimal human intervention will ensure that new mobile services can be exhaustively tested in a cost-effective manner before deployment. Moreover, by testing protocol conformance to open standards, operators can ensure that acceptance of new supplier software does not introduce unforeseen restrictions on future purchase decisions. Such considerations have motivated the network operators within Eurescom to carry out Research and Development activities in the area of Network Integration Testing (NIT).

2. EURESCOM P1016 PROJECT (MINIT)

Eurescom, the European Institute for Research and Strategic Studies in Telecommunications [2], is the leading organisation for collaborative R&D in telecommunications. Founded in 1991, it has provided comprehensive research management services to network operators, service providers, manufacturers, suppliers and vendors who wish to collaborate on the issues facing the telecommunications industry. Eurescom manages R&D programmes and projects for its members and others. Over the years, these projects have consistently been at the forefront of telecommunication's innovation and have resulted in the development of many standards and new services.

From its foundation, Eurescom has assisted in mastering the challenges associated with network testing. Initial work on automated testing in the P104 project was continued for ATM and Frame Relay in the P410 project and for ISDN in P412. Subsequently, the P613 project extended the work and produced the first test suites for GSM [3]. The P919 project then produced initial test material for GPRS, IP, UMTS and IN-service tests [4].

The Eurescom P1016 project MINIT (Mobile and IP Network Integration Testing) commenced its work in September 2000 and completed its activities in June 2002. It has built upon the results of previous Eurescom activities by importing and extending the P919 output related to the definition of the test architecture and points of control and observation, and by developing formally specified test specifications for identified services. The P1016 project results are described in this paper and will be of particular interest to network operator staff in charge of verification and deployment of telecommunication services, standard bodies concerned with the standardisation of test specifications and test system providers.

3. TESTING METHODOLOGY

The basic concepts of protocol conformance testing are described in [5]. End-to-end testing is based on the emulation of subscriber equipment behaviour at relevant network interfaces. In the case of GSM, the tests can be carried out at the air interface (Um), however it is also possible to use the A-interface for GSM, the Gb-interface for GPRS and the Iu-interface for UMTS. A so-called Test Case replaces the function of the highest protocol (sub-) layer that is present at the interface and a special device ("test probe") implements the protocol entities needed at lower layers.

Each Test Case is associated with a corresponding Test Purpose (TP), for example, verifying that the network has a required capability such as the ability to support certain packet sizes or that it exhibits required behaviour in response to a specific event in a particular state. A collection of Test Cases is known as a Test Suite. The structure of the Test Suites and the purpose for each test are given in the Test Suite Structure and Test Purposes (TSS&TP) document.

The machine-executable test suite is independent of implementation and is therefore known as an Abstract Test Suite (ATS). The ATS is specified as a collection of Test Cases together with required declarations and components. It is written in the Tree and Tabular Combined Notation (TTCN). Each Test Case is described by an event tree leading to a test verdict:

- *Pass:* indicating that the observed test outcome is conformant to the requirement(s) on which the test purpose of the test case is focused and is valid with respect to the relevant specification(s)

- *Fail:* indicating that the observed test outcome either demonstrates non-conformance with respect to at least one of the conformance requirement(s) on which the test purpose of the test case is focused, or contains at least one invalid test event with respect to the relevant specification(s)

- *Inconclusive:* where neither a pass nor fail verdict can be given

The Protocol Implementation Extra Information for Testing (PIXIT) contains information regarding the physical set-up and connection of the test that is not part of the protocol. This can be information regarding the system-under-test hardware, socket or telephone numbers, and other information needed to make the test more flexible and to ensure that the person responsible for executing the test does not need to deal with TTCN.

4. POINTS OF CONTROL AND OBSERVATION

Figure 1 indicates the cellular (radio) interfaces where testing can be performed.

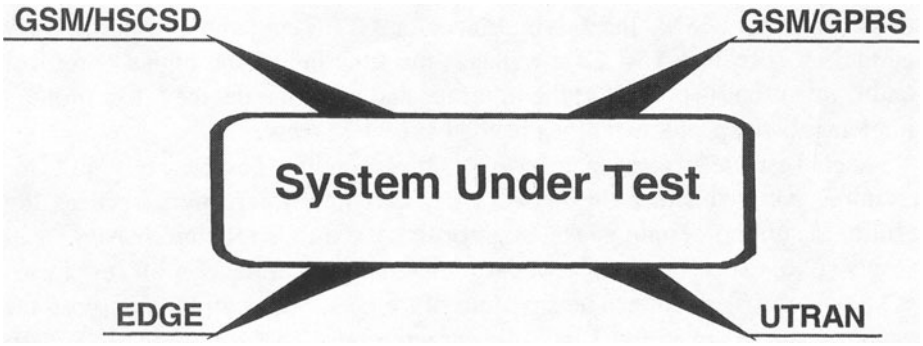

Figure 1. Cellular interfaces where testing can be performed

4.1 IP

The Internet Protocol (IP) provides the functions necessary to deliver a package of bits, an Internet datagram, from source to destination over an interconnected system of networks. An "IP Check" test case can be defined which will behave like a UDP/TCP/ICMP/OSPF/IP layer. The Point of Control and Observation (PCO) for testing IP is shown in *Figure 2*.

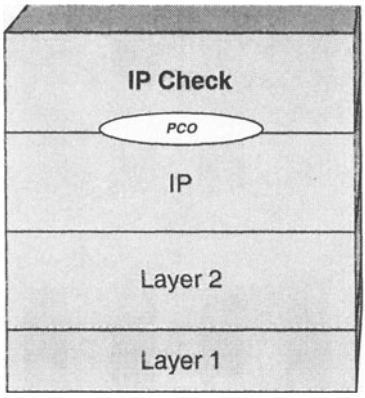

Figure 2. PCO for testing IP

4.2 GSM

GSM and its related technologies present a more complex testing scenario. The protocol stack at the GSM radio interface, including HSCSD and GPRS is shown in *Figure 3*, together with the PCOs which can be used for testing. Note that even though two PCOs are shown, one between SM and GMM and one between (CC, SS, SMS) and MM, this is only to highlight the additional stack for GPRS. In practice, one combined PCO is used for both GSM and GPRS.

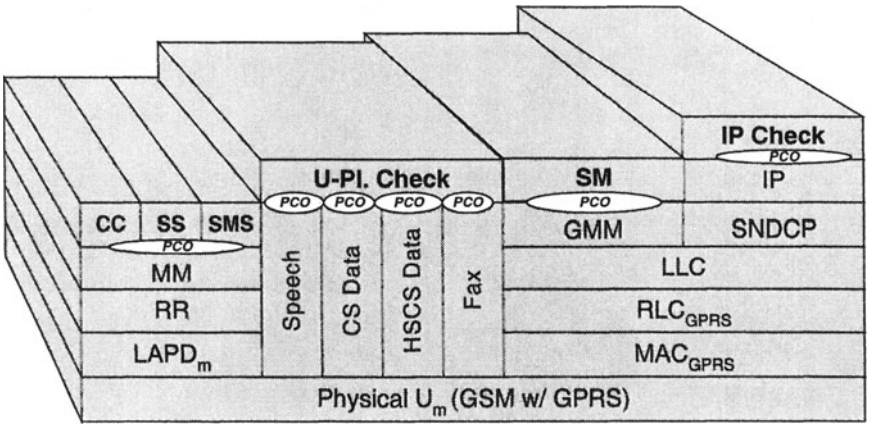

Figure 3. PCOs for testing GSM (including HSCSD and GPRS)

4.2.1 HSCSD

HSCSD testing calls for additional test cases on the C-Plane as well as extended U-Plane checking for the bearer services that result from combining channels. Given that no new Abstract Service Primitives (ASPs) are needed in addition to those defined for GSM, the GSM PCO specification implicitly applies to HSCSD. Several operators currently include HSCSD as a part of their Mobile Internet service.

4.2.2 GPRS

GPRS testing requires a test probe that gives access to the GMM and to the LLC. C-Plane test cases need to be specified for GMM and SM and in addition a capability for testing IP is required.

4.3 EDGE

EDGE technology is based on GSM, so the protocol stack for EDGE and the available PCOs is identical to *Figure 3* apart from modification to the Physical, MAC and RLC levels. EDGE testing does not put any additional requirements on either the ATS or the test system, except that a different type of test probe is used. However, with the advent of EDGE, end-to-end Voice-over-IP (VoIP) may become a reality and, since this is a completely new service, operators should ensure that it really works before offering it to customers. As a consequence VoIP protocols on the terminal interface (e.g. RTP and RTCP) have to be checked in addition to the traditional IP bearer functionality.

4.4 UTRAN

UMTS, in its first release (Release '99), did not introduce many changes from the ATS point of view. UMTS provides wireless access through a UMTS Radio Access Network (UTRAN) and testing requires the use of a Test Probe giving access to the (C-Plane) Service Access Points on top of RRC rather than on top of MM and LLC as in GSM/GPRS. The PCOs for UTRAN testing are shown in *Figure 4*.

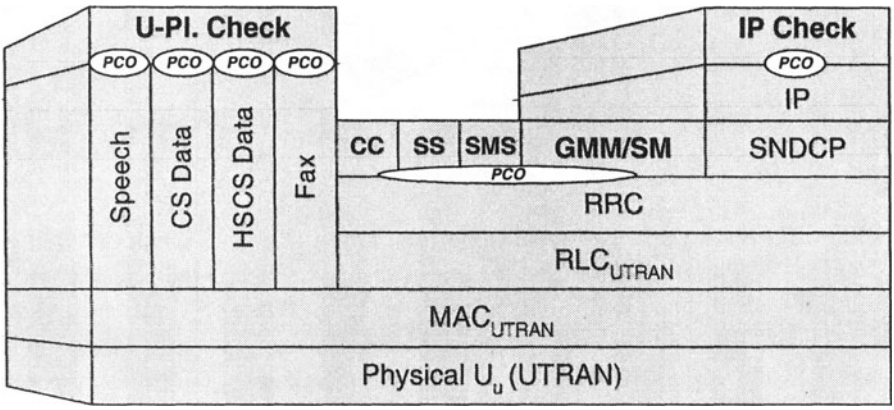

Figure 4. PCOs for UTRAN testing

5. RESULTS

The MINIT project has produced three deliverables. Deliverable 1 provides an overview of project goals and achievements [6], while Deliverable 2 contains the TSS&TPs [7] and Deliverable 3 the corresponding ATSs [8].

These results apply in the following areas:

- NIT between GSM-ISDN, GSM-PSTN and GSM-GSM.
- NIT between UMTS-ISDN, UMTS-PSTN, UMTS-GSM and UMTS-UMTS.
- NIT to verify the overall compatibility for the most used IN-services and the INAP/CAP/ISUP interworking between the mobile and fixed networks. This assures that the appropriate requested features pass between an ISDN subscriber and the mobile subscriber across the national or international ISUP (ISUP V2) interface and the IN-interfaces CAP/INAP.
- NIT to verify the overall compatibility between GPRS (UMTS, GSM Phase 2+) and IP. The alignment of the TSS&TP with ATS remains for further study.

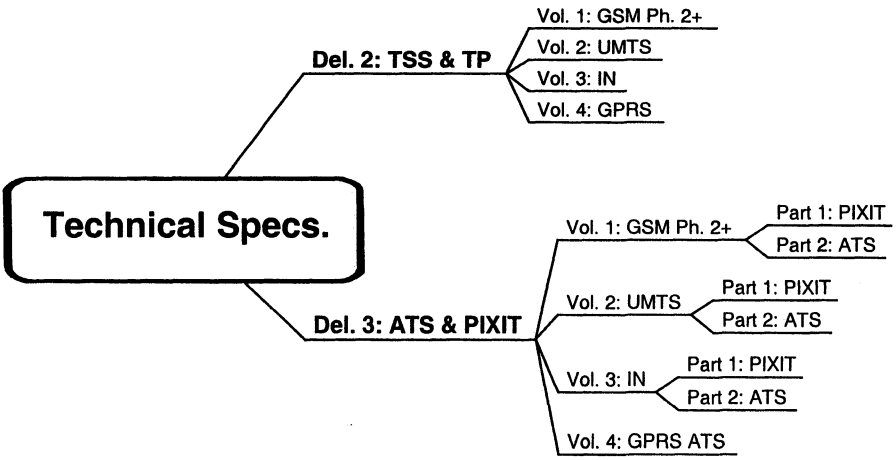

Figure 5. Organisation of MINIT project results

6. IMPACT ON STANDARDS

To date, ETSI [9] has approved MINIT project results as the following Technical Specifications:

- TS 102 110-1 "Network Integration Testing of UMTS with GSM Phase 2+, PSTN and ISDN" containing the Test Suite Structure and Test Purposes for Network Integration Testing of the European ISDN and PLMN, covering Network Integration Testing between ISDN-UMTS, UMTS-PSTN, UMTS-GSM, and UMTS-UMTS networks [10].

- TS 102 111-1 "Network Integration Testing between GPRS and IP Networks" containing the Test Suite Structure and Test Purposes for Network Integration Testing to verify the overall compatibility between GPRS (UMTS, GSM Phase 2+) and IP Networks [11].

- TS 102 112-1 "Network Integration Testing Between IN, PLMN and ISDN" containing the Test Suite Structure and Test Purposes for Network Integration Testing to verify the overall compatibility for the most used IN-services and the INAP/CAP/ISUP interworking between the mobile and fixed networks [12].

- TS 102 112-2 "Network Integration Testing Between IN, PLMN and ISDN" containing the corresponding ATS [13].

- TS 102 113-1 "Network Integration Testing Between GSM Phase 2+, ISDN and PSTN" containing the Test Suite Structure and Test Purposes for Network Integration Testing of the European ISDN and PLMN, covering Network Integration Testing between ISDN-GSM, PSTN-GSM, GSM-ISDN, GSM-PSTN and GSM-GSM networks [14].

Further MINIT project results are expected to be approved by ETSI as:

- TS 102 110-2 "Network Integration Testing of UMTS with GSM Phase 2+, PSTN AND ISDN" containing the ATS corresponding to the TSS&TP above [15].

- TS 102 113-2 "Network Integration Testing Between GSM Phase 2+, ISDN and PSTN" containing the ATS corresponding to the TSS&TP above [16].

7. CONCLUSIONS

Operators spend significant time and resources ensuring that features and services work end-to-end on their networks. This often necessitates a close working relationship with vendors to resolve unforeseen problems and interface incompatibilities. This, in turn, may imply hardware reconfiguration and software tuning or implementation of a software-patch or other work-around to resolve problems. The result is often delayed launches or brand-impact, with increased costs due to the need to handle customer complaints. Software upgrades and new version releases also pose notable challenges for operators, who must ensure interoperability within and between networks based on different system vendors and architectures. Primary contributors to interoperability problems are the increasing complexities of wireless networks and the diversity of available options to achieve end-to-end 3G-network solutions.

Network Integration Testing is recommended as the preferred approach to 3GSM testing. Experience with GSM has indicated automated execution rates of some 50 test cases per hour at the radio (Um) interface and rates of up to 500 test cases per hour at the Mobile Switching System (A) interface. The test suites developed by the Eurescom MINIT project and standardised by ETSI will be of benefit to operators of GSM and UMTS networks world-wide, promoting service integrity and reducing the costs of testing. The technical specifications are also of interest to test laboratory managers and test tools implementers dealing with fixed/mobile integration issues. Test probe manufactures should now be encouraged to produce suitable test probes for GPRS and UMTS.

Adoption of MINIT project results by ETSI stresses the value and importance of Eurescom project work. To date, five ETSI Technical Specifications have been approved with two others expected shortly. ETSI has liased these results to 3GPP.

Research is currently in progress to determine the optimum default behaviour for the 3GSM Abstract Test Suites [17]. Thereafter, further study is needed to align the GPRS Test Purposes and Abstract Test Suite.

There is a close resemblance between the higher layer access protocols in GSM/GPRS, and the protocols used in Release '99 EDGE and UMTS networks. The future deployment of "All-IP" core networks is unlikely to change this situation drastically. The introduction of TCP/IP-based protocols for functions previously associated with the user plane (e.g., RTP/RTCP) does not necessitate a shift in testing paradigms and applications can be readily validated using the well-established Network Integration Testing methodology.

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ABBREVIATIONS

3GPP	3rd Generation Partnership Project
ASP	Abstract Service Primitive
ATM	Asynchronous Transfer Mode
ATS	Abstract Test Suite
CAP	CAMEL Application Part
CC	Call Control
EDGE	Enhanced Data (Rates) for GSM (Global) Evolution
ETSI	European Telecommunications Standards Institute
EURESCOM	European Institute for Research & Strategic Studies in Telecommunications
GMM	GPRS Mobility Management
GPRS	General Packet Radio Service
GSM	Global System for Mobile Commutations
HSCSD	High Speed Circuit Switched Data
ICMP	Internet Control Message Protocol
IN	Intelligent Networks
INAP	Intelligent Network Application Part (Protocol)
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISUP	ISDN User Part
LAPD	Link Access Protocol on the D-channel
$LAPD_m$	Modification of the LAPD protocol for mobile
LLC	Logical Link Control
MAC	Media Access Control
MINIT	Mobile and IP Network Integration Testing
MM	Mobility Management
OSPF	Open Shortest Path First
PCO	Point of Control and Observation
PIXIT	Protocol Implementation Extra Information for Testing
PLMN	Public Land Mobile Network
PSTN	Public Switched Telephone Network
RLC	Radio Link Control
RR	Radio Resources
RRC	Radio Resource Control
RTCP	Real-time Transport Control Protocol
RTP	Real-time Transport Protocol
SM	Session Management
SMS	Short Message Service
SNDCP	Sub-Network-Dependent Convergence Protocol
SS	Supplementary Services
TCP	Transmission Control Protocol
TSS	Test Suite Structure
TSS&TP	Test Suite Structure and Test Purposes
TP	Test Purposes
UDP	User Datagram Protocol
UMTS	Universal Mobile Telecommunications System
U-Pl.	User Plane
UTRAN	UMTS Terrestrial Radio Access Network
VoIP	Voice over IP