# **TESTING MOBILE IP WITH TTCN**

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AbstractTesting of Internet protocols family with TTCN is an emerging topic<br/>nowadays. Mobile IP is an extension of the standard Internet Protocol version<br/>4 giving the Internet terminals support for mobility. This paper describes our<br/>recent work on development of Mobile IP abstract test suite, demonstrates<br/>results and discusses the future work.

Keywords: Internet, Mobile IP, TTCN, conformance testing

### 1. INTRODUCTION

Testing of communication software and communication protocols has become a necessity long time ago. ISO 9646[1] conformance testing methodology and framework has been introduced to solve the problem of non-interoperable implementations of different vendors. This methodology is being widely supported and used by test laboratories and manufacturers. Abstract test suite (ATS) consists of test cases written in TTCN (Tree and Tabular Combined Notation) test language. Organisations and standardising bodies (e.g. ETSI, ITU-T, ATM forum, etc.) produce abstract test suites (ATS), which are then being used for testing protocols. Passing the tests will increase the probability that the system will inter-operate with other systems conformant to the same standard.

ATS is normally derived from a protocol standard. It has been a common practice for telecommunication standardisation bodies to create both a protocol standard and a conformance testing specification during the standardisation effort. Such approach has been used for example in ATM and GSM standardisation. On the other hand, Internet protocols are described in requests for comments (RFC) without accompanying conformance specification. Usually there is an RFC describing the protocol itself and a set of RFCs covering details and extensions. For example, Mobile IP is described in RFC 2002 [3] and extensions in RFCs 2003-2006.

In this paper we are focusing on the testing of Mobile IP [3,4,6,7] protocol, which is an extension of the standard Internet Protocol version 4 (IPv4). The description of the protocol and infrastructure is given in chapter 2. Chapter 3 discusses testing architectures and our findings. Chapter 5 summarises our results and concludes the paper.

### 2. MOBILE IP

Mobile IP [3,4,6,7], as referred in this paper, is an extension to the Internet Protocol version 4 (IPv4) that adds mobility management. Mobile IP allows a roaming user to change the location of the terminal. The protocol supports both mobility (seamless connectivity on move) and portability (operation in different networks). Mobile IP uses standard UDP (User Datagram Protocol) and ICMP (Internet Control Message Protocol) protocols to deliver mobility management messages. From the layer point of view, Mobile IP is located on top of IPv4 stack. The terminology of Mobile IP defines three basic network entities (nodes):

- Mobile node (MN) is an Internet terminal roaming through the network. MN is similar to a cellular phone. As a cellular phone connects for example via GSM system to telephone network, MN connects via some bearer (e.g. wireless LAN) to Internet. When not roaming, MN is connected in its home network.
- Foreign agent (FA) is a special node serving as a "connection point" for mobile node, looking for mobile nodes, offering connections, and providing tunnelling.
- Home agent (HA) is a node located in home network of mobile node serving as an authenticating authority for mobile nodes, packet forwarder and tunnelling entity.

While away from home network, MN uses FA to obtain connection to the Internet. HA then tunnels all the traffic destined to the address of mobile node in the home network to its care-of address (CoA) provided by FA. Anytime MN changes location, it registers new CoA with its HA.

## **3. TESTING ARCHITECTURES**

The analysis of Mobile IP shows that variety of testing architectures is required in order to test Mobile IP infrastructure conformance. In different testing architectures, the tester replaces one or mode nodes of the Mobile IP infrastructure (MN, FA, or HA) or the Internet.

### **3.1** Test methods

The implementation under test (IUT) is a Mobile IP protocol, operating in the context of MN, FA, or HA. The lower tester (LT) is connected via fixed or wireless Internet link as a service provider to the IUT. The remote test method in single-party testing context (SPyT) can be used to realise the majority of test purposes. For example, it can be applied to testing Mobile IP in MN, unless more than one FA is involved, as shown in *Figure 1*a. In some test purposes multi-party testing context (MPyT) is required.



Figure 1. a) The remote test method [1][2], b) Implementation of the remote test method

The implementation of the test method is shown in *Figure 1*b. The service provider is Internet connection with the standard TCP/IP protocol stack on both IUT and tester sides. Tester is connected via gateway, which implements two PCOs (UDP and ICMP). The gateway encodes and decodes PDUs (protocol data units) and interfaces with TCP/IP stack.

The following discussion enumerates identified testing architectures. When the Mobile IP in MN is tested, one or more FA is replaced with LT. For majority of test cases, the single-party test context suffices. For example, testing the hand-over requires several LTs and the use of multi-party testing context. If several LTs are used, they are represented by parallel test components and concurrent TTCN is used.

When the Mobile IP in FA is tested, one or more MNs and one or more HAs are replaced with LT. Similarly, when the Mobile IP in HA is tested, one or more FAs are replaced with LT. In each of these cases, sequential or concurrent TTCN can be used. The exact infrastructure of Mobile IP nodes substituted by LT may be unique for each test purpose, as long as MN, FA, HA or Internet nodes may communicate with an arbitrary subset of peer entities. This implies a general rule formulated as follows: in case LT replaces only one Mobile IP entity, then single-party testing will suffice, otherwise multi-party testing context shall be used.

### 3.2 Gateways

The analysis of the traffic produced by Mobile IP entities showed the need for two points of control and observation (PCO) in each LT. One PCO handles UDP and the other ICMP messages. Mobile IP adds specific PDUs to these protocols. These two PCOs are implemented by one gateway.

Gateways (see *Figure 2*) are connected to the tester via the Internet. The location of gateways and tester is arbitrary because their connection is handled by CORBA (Common Object Request Broker Architecture) and its IIOP (Internet Inter-ORB Protocol). Gateway implements all the PDU encoding and decoding functionality as needed.

# 3.3 Tester

The tester is software that processes tests written in TTCN (see [1][2] for details) testing language. We have used OpenTTCN tester [5], which unlike others does not generate executable test suites (ETS) from TTCN but interprets the program on the fly. For the detailed example of tester deployment in sample scenario see *Figure 2*.



Figure 2. Tester, gateways and IUT deployment in MN/FA/HA sample scenario

The tester can be located in the same computer as gateways or in any other computer connected via the Internet. In our case the tester is located in a separate computer. As mentioned in the previous section, CORBA is used to connect the tester with gateways. The connection setup between the tester and the gateway is simple, as the file containing a CORBA object reference is supplied to the tester that registers the gateway as a specific PCO.

# 4. MOBILE IPATS

To validate the developed Mobile IP testing architecture, a limited set of test cases has been created.

Mobile IP is defined in RFC 2002 [3] using quite informal English language prose description. Unfortunately, to our best knowledge, there is no formal specification available. Protocol engineers participating in the project derived the test purposes. The test purposes were specified using message sequence charts (MSC) and then translated to TTCN manually.

So far, only test purposes using single-party testing context has been realised. In the future, multi-party testing context is planned as more complicated test purposes are used in such scenarios as hand-overs between different foreign agents or processing of simultaneous requests.

# 5. CONCLUSIONS

Architecture for Mobile IP conformance testing has been discussed in this paper. The research effort conducted so far allows testing of all three Mobile IP entities, namely mobile node (MN), foreign agent (FA), and home agent (HA) in various architectures. The complexity and the number of possible testing architectures have been higher than that regularly found in the telecom protocol conformance testing. The used tester-gateway concept allows distribution of means of testing and IUT over the Internet so that even multi-party testing context can be realised. The produced abstract test suite contains a limited set of test cases, which were written manually. Direct translation of test purposes specified in message sequence charts into test cases in TTCN was used. The future work would benefit from the existence of formal specifications of Mobile IP protocol. That could make the automatic test case generation possible or facilitate the manual creation of test cases.

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