Test Generation for a Protocol During the Standardization Process : An Experience with Mobile IPv6

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Abstract. This paper discusses the interest and difficulty to generate tests for implementations based on specifications which are not yet standardized. The discussion is based on our experience since four years in conformance and interoperability test generation for the Mobility Support for IPv6 protocol which is still a work-in-progress.

1 Introduction

In the context of network components testing, we can identify three main actors : standardization organizations, vendors, and testers. Ideally, a standardization organization publishes a stable standard describing a new protocol or technology. Then after, development of implementations by vendors and associated test suites generation by test laboratories are done in parallel. But, one can observe that this ideal situation is an "old dream". Indeed, these three activities (standards definition, implementations development and test suites generation) are done in parallel. This is even truer in the Internet community.

Several reasons can explain this situation. It is clear that any vendor would like to be the first company to provide components implementing new protocols or technologies. According to the importance to the market of the considered new technology which is under standardization, it can be a good strategy to take the risk to develop corresponding components as soon as possible. What is then expected is that test suites are available as soon as vendors begin to provide implementations. This is impossible to achieve if testers have to wait for a stable and definitive standard before starting test generation. Thus, test generation is done in parallel with development of components. As consequence, the standardization process benefits from feedbacks from both implementers and testers which help to move specifications to a more stable level. This means that testing can be considered as part of the standardization process.

Following this idea, we argue that it is important to generate tests during the standardization process. The paper is structured as follows. In Section 2, we highlight difficulties when developing a test activity during the standardization process. We list problems to be resolved when working on unstable specifications.

This relies on our experience on test generation for Mobile IPv6 [2] protocol (MIPv6) specifications which is still a work-in-progress. Section 3 describes this experiment. Based on this favorable and positive experiment, the section 4 is a statement on interest and advantages in generating test based on unstable specifications.

2 Problems of test generation with unstable specifications

When developing test suites for an unstable specification, several problems arise.

- *Some parts of the protocol may still be not defined.* In this case, it is important that "holes" in specifications do not prevent to generate test for other functionalities. A solution is to make strong abstractions of the specifications. This needs a good knowledge of parts of the specifications that can be ignored without blocking testing.
- *Specifications may include errors and inconsistencies.* Most of errors will be found during the test generation phase. Indeed, test generation requests a careful reading of the specification. This can sometimes prohibit the possibility to generate tests. In this case, the solution usually consists in reporting these errors to standardization organizations until they are resolved.
- *Specifications may include ambiguities.* Ambiguities lead generally to different interpretations of a functionality description. Ambiguities are not always considered as errors. They are sometimes considered as open issues. It is possible that two interpretations of a functionality may coexist at the same time. So tests may accept the two interpretations until the issue is resolved in the specification. Because it is hard to foresee every interpretations of a textual specification, most of them will be detected when testing third-party implementations. Notice that not only tests but also discussions (typically in mailing-lists) help sometimes to resolve ambiguities.
- *The unstable nature of the protocol induces that continuous modifications may occur in test development process.* This obliges to have a "different" approach in the used test methodology. Indeed, these possible modifications must be anticipated and taken into account in the test development phase. Improvement and maintenance of the test suite must be facilitated by suitable design choices : possibility to easily extend data structures, re-usability of generic behaviors, etc.

3 An experience with MIPv6 testing

In this section, we present our testing activity for MIPv6. We use this example to illustrate how problems enumerated above (see section 2) have been resolved.

3.1 MIPv6 and the test generation environment

The IPv6 Mobility Support protocol (MIPv6) is a work-in-progress from the *mobileip* working group of the Internet Engineering Task Force (IETF) [1].

MIPv6 refers to the ability of the IPv6 network [3] to allow an IPv6 node to change its attachment network, while keeping its connectivity to the Internet. Mobility support is achieved by describing three sets of functionalities : Mobile Nodes (MN), Home Agents (HA), and Correspondent Nodes (CN). While MIPv6 specification is still unstable, we are involved in a conformance and interoperability test generation activity since fours years. Within this period, seven versions (from version 13 to the latest version 20 in January 2003) have been released.

In order to execute our test suite, we needed a test tool that can be easily adapted to follow these drafts. Not only the packet format is likely to be often modified, but internal functions may be introduced or modified, like checksum calculation algorithms or cryptographic functions.

We have chosen to use the TAHI v6eval tool. Several reasons can explain this choice. It is a free tool running on freeBSD 4.X, and that allows to code and execute conformance test suites for most of the IPv6 related protocols. We have had the opportunity to work closely with the TAHI project [4] in order to modify the tool according to our test requirements.

3.2 Test generation activity

When a new draft is released, the test suite have to be adapted accordingly. Differences between two versions of a draft may have several effects on the tests suites, according to the type of modification : Modification of packet formats, of procedures, addition or suppression of new procedures and packets, modification of the requirement status. This last item may be the easiest situation. Indeed, the status of an existing procedure may change from optional to mandatory, or *vice-versa*.

Modification of packet formats and procedures can occur independently. This means that only packets declaration part or the behavior description part of an existing test case need to be changed. Creating new procedures is obviously the most costly operation when updating a test suite. In our case, it concerned about 20% of the test cases between two major releases. Suppression of test procedures can also be required. We suppressed 20 test cases between draft 13 and 15 because of a critical modification of a subnet renumbering functionality. We give hereafter some of most significant issues that we faced :

- Several protocol values used in the specification are not yet defined by the IANA [1]. So it was necessary to fix and to agree with vendors on test values, and to configure the test suite in order to use these values.
- The use of security policies is a mandatory part of MIPv6. But it is harder to observe and check MIPv6 functionalities with security. So the security has usually been disabled for testing purpose.
- Until draft 19, there was different interpretations of a packet format called Binding Update. This was an open issue for a long time, so it was necessary for the tester to accept up to 8 different formats for the same packet.

– Draft 19 introduced a Return Routability (RR) sequence that occurs between MNs and CNs before authorizing direct communications. This specification was released shortly before an IPv6 test event. RR was a prerequisite for many tests. But in order to test implementations that did not yet support the functionality, we developed two versions (with or without RR) of the test suites.

3.3 Conclusion on this experiment

For the last four years, we have generated test suites for each of the three MIPv6 entities. Currently, we have developed and use test suites for versions 13, 15, 18, and 19. These versions were considered by many as major releases, which means that the consistency of the specification and the importance of the modifications justified to move on the new release.

This work which consisted in updating a test suite has several advantages. This can be done effectively and quickly by reporting the differences between two drafts (which are reported in an annex of the new release). Expertise gained from the definition of previous test suites allow to accelerate the test suite production. In the general case, we did do not have to restart the whole process of defining test suites from the beginning. We had the opportunities to validate our work in several IPv6 related interoperability testing events related to IPv6. Since the start of this activity, we have observed that the testing demand is strong all along the way of standardization, even though MIPv6 specification is still not yet a standard.

4 Advantages of testing during the standardization process

At first glance, generating a test suite for specifications-in-progress may seem useless. There is a risk that the testing activity will suffer from the unstable nature of the project. Delays and costs for developing test may be lengthened. Modifications of specifications may make unusable developed tests. But testing during standardization also answer to the necessity of providing test suites for a trusted protocol as soon as possible. This is the case of MIPv6 which is considered as a key feature for IPv6. Thus, it appears clear that the right time for providing the test suites is before implementations get deployed. Thanks to our experience on testing Mobile IPv6, we have observed that this can be helpful to testers, implementors, and standardization organisms in several ways. We give some these advantages :

– Testers can provide test suites that will be ready to use as soon as a standard will be published. Indeed, it is possible to save time and costs by updating previous test suites upon a new draft release. Thus, the testing technology can be ahead on implementations. This eases testing of implementations before deployment. This point can be essential for new critical protocols like IPv6 related protocols.

– Developers can use test suites during the development of their implementations. Conformance tests are used in order to calibrate implementations for interoperability purposes. This can be a key point because the interoperability of at least two implementations from different vendors is an usual requisite for standardization, typically in the Internet community.

We can see that the association of the test activity the standardization process can bring benefit to the whole community. For instance, in the Internet community, reports on problems, inconsistencies observed by implementers in drafts or RFCs (Request For Comments) to the IETF (Internet Engineering Task Force) [1] serve to improve standards.

5 Conclusion

In this paper, we have discussed the interest and difficulty to generate tests for implementations based on specifications which are not yet standardized. We have described our experience on generating conformance test for the Mobility Support for IPv6. This support specification is still in the standardization process. We described the problems and advantages of facing evolutionary draft specifications. This experience highlighted the interest of a test activity done in parallel with the specification process. It can help testers to improve their test suites and limit the delay for test generation. It shows also that it can be helpful for the developers and standardization organizations to obtain a stable specifications by providing an early feedback.

References

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