From Active to Passive
— Progress in Testing Internet Routing Protocols

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Abstract Routing protocols play an important role in the Internet and the test requirements are running up. To test routing protocols more efficiently, several enhancing techniques are applied in the protocol integrated test system described in this paper. The Implementation Under Test is modeled as a black box with windows. The test system is endowed with multiple channels and multiple ports to test distributed protocols. The test suite and other related aspects are also extended. Meanwhile, the passive testing is introduced to test, analyze and manage routing protocols in the production field, which is able to perform the conformance test, the interoperability test and the performance test. The state machine of peer sessions is tested with the state synchronization algorithm, and the routing information manipulation and other operations are checked and analyzed with the methods like the topology analysis and the internal process simulation. With both the active testing and the passive testing, the routing protocol test is going further and more thoroughly and helps a lot in the development of routers.

Keywords routing protocol, test structure, reference implementation, passive testing

1 Introduction

Protocols are the soul of the network, while routing protocols are becoming the most influential ingredient of the Internet. With the rapid development of the Internet, the scale of network is swelling with a more and more complex structure. High performance and stable routing protocols dominate the performance of the whole network. The quality of network products, including software and hardware, is efficiently assured through the protocol testing, which is a focus of many researches and a necessary phase in the manufacture procedure. Currently the most commonly used routing protocols are RIP[1], OSPF[2] and BGP[3]. The former two are used inside autonomous systems while the latter is an inter-autonomous-system routing protocol. There are still other routing protocols presented by some manufacturers and organizations[4–6].

Despite their importance, the testing activity for routing protocols is still rather limited. One of the reasons is that the capacity limitations of the original test theory, test structure and test system were derived from the testing of communication protocols at that time. But the routing protocols possess different features. Several deficiencies are encountered when we start our work on routing protocol test with the Protocol Integrated Test System — PITS[7], which is our second-generation test system and has performed a large amount of test activities on communication protocols.

Therefore, several enhancing techniques were worked out to enable PITS to test routing protocols efficiently. Firstly, the Implementation Under Test (IUT or the Module Under Test, MUT) was modeled as a windowed black box to increase the observability and the controllability. Accordingly, the multiple-channel test method was raised. Not only does the test system interact with MUT of the protocol, it also controls and observes MUT through other channels set up with other modules that interact with MUT. And the test suite is evolved into a heterogeneous one, which can describe test data of different types in most proper formats. These enhancing techniques mainly focus on the refer-
We move some functions from the test execution (TE) to RI, then the ability of RI is enhanced and the burden of TE is reduced. The enhanced RI (ERI) is divided into two sub-layers: the acceptance sub-layer and the submission sub-layer, through which the speed gap between the test system and the network is eliminated and packet loss will never happen. Cooperating with ERI, the packet extension technique helps to describe the whole testing activity integrally and uniformly.

However, some abnormalities will only appear in practice and/or over a long time, such as route oscillations, useless route advertisements and even the exhausted routers. Although the active testing helps a lot to uncover the deficiencies of the implementations of routing protocols, it can hardly deal with such problems. The passive testing can be performed in production filed over a long time without interference on the network. It is able to perform the conformance, interoperability and performance tests. Therefore, passive testing is also adopted in our work on routing protocol test.

The passive testing only observes online and does not send anything to the IUT. It is quite different from the “injecting input and observing output” way. Thus, corresponding techniques proper for the passive testing must be worked out. In order to detect the state machine error of a routing protocol, the state synchronization algorithm is adopted to check possible errors. As to the routing information manipulation, which is the most important aspect of the routing protocol and may also be the most error-prone part, one technique exploited is the topology analysis. The main idea is that correct routing information must describe the network topology correctly. We construct the topology of the network with the routing information exchanged between routers that is collected online and compare it to the actual topology. If differences are found through the comparison then there may be some faults in the routing information manipulation. Other algorithms are applied to further locate these faults and provide the information for the fault correction.

Besides the generic methods like the topology analysis, specific methods like the internal process simulation are also exploited to test the correctness of the routing information manipulation and other features in more detail. Specific modules are coded for specific purposes. These modules will process the routing information collected online, behaving just like what the processes in the router will do and making out correct scenes to compare with the actual results to detect faults. Now we have implemented modules that can test general route selection, route selection with policy constraints, route flap damping, etc.

All these techniques are applied in the testing activity. We have built an ERI for PITS to perform an effective routing protocol test. As to the passive testing aspect, an intelligent online BGP-4 analyzer has been implemented, then a prototype of a more general online test system is developed. Another important advance is that the active testing and the passive testing are combined, the best in each other, helping us a lot in the effort to cover the main features of routing protocols in our test. We have tested commercial routers from different manufacturers. We also offer the test support for the development of new routers as requested, through which the correctness and the quality of these products have been considerably promoted. These methods are applicable for RIP, OSPF and BGP. In this paper, we will mainly focus on BGP-4.

This paper is composed of seven sections. Section 2 analyzes the features and the test requirements of routing protocols. Section 3 discusses the deficiencies of current test systems. Section 4 presents the enhancing techniques for the active testing. Section 5 describes the passive testing introduced in our routing protocol test. Section 6 outlines the implementation and test activities. Finally, related work and conclusions are given.

2 Features and Test Requirements of Routing Protocols

The clear perception of routing protocols is the basis of the test activity. Compared with communication protocols like TCP/IP, routing protocols are quite different. First, the purpose of a routing protocol is to collect the information needed to do routing, which is a basic summary of routing protocol functions (Fig.1). Another extraordinary character of routing protocols is the nature of dis-