On Distributed Concurrent Multi-Port Router Test System

SONG Bo, XU Juan
(School of Computer and Communications Engineering, Southwest Jiaotong University  Chengdu  610031  China)

Abstract  This paper presents a framework of the distributed concurrent multi-port-testing test system (CMPT-TS) for IP routers under development at Sichuan Network Communication Key Laboratory. Having analyzed the actuality of concurrent testing for routers, this paper develops a distributed architecture of CMPT-TS and discusses its functional components in detail. Moreover, a new test definition language, CMPT definition language, is also introduced simply.

Key words  concurrent multi-port-testing test system;  CMPT definition language;  testing and test control notation v3

From late 1970s to early 1990s, testing techniques drew tremendous efforts worldwide, and ISO/IEC JNT 1/SC21 9646 was the milestone representing the framework on conformance testing based on pioneer research works [1]. In this paper, four abstract test methods for end-systems and two test methods for relay systems were classified according to the points of control and observation (PCO). In addition, a semi-formal test definition language called tree and table combined notation (TTCN) was also defined.

Two test methods for relay systems defined in ISO 9646 are “loop-back test method” (LTM) and “transverse test method” (TTM) [1]. The LTM excises testing by sending test data to a router and being looped back to the tester by the router. It had been the most popular test method until early 1980’s for its convenience in application. Since its testing capability is restricted to the implementation related to a single port and the routing function, H. Zeng introduced the TTM in 1984 [2], which enables a pair of testers to test and observe the router through a pair of ports, and was taken in ISO 9646 in the same year. TTM is more powerful than LTM and more appropriate for thorough test.

With the advent of IPv6, the testing of IPv6 routers had redrawn attentions of the network community. Among these activities, “6-bone” project is the most influential one, which involves quite a lot international standards bodies and academic communities. 6-bone is based on the philosophy of encapsulated testing, i.e. to test IPv6 packets encapsulated in IPv4 messages over existing IPv4 network.

Modern routers or switch routers could have tens of ports with two sets of protocol-stack implementation inside: the 3-layer user data transfer plane and the 5-layer signaling and management plane [1]. Therefore, existing testing techniques such as LTM or TTM, designed for testing routers on per port or a pair of ports basis, are unable to cope with the complexity and concurrency in multiple-port interactions. This has stimulated the activity of research on techniques of concurrent multi-port-testing test system (CMPT-TS) presented in this paper. The attribute “concurrent” here is intended to emphasize that parallel tests are taking place at the same time and in a controlled (or synchronized) manner.

This paper first reviews the actuality of concurrent test research at home and abroad in section 1. Section 2 presents a framework of the CMPT-TS under development at Sichuan Network & Communication Key Laboratory (SC-NetComLab), its functional components and operational process are explained further in detail. Finally, a new test suites definition language CMPTDL is introduced simply.

1  Actuality of Concurrent Multi-Port Test Research

There are some activities involving parallel multi-port testing, such as those in Interoperability Laboratory (IL) of US and Institute of Computing Technology of Chinese Academy of Sciences (ICT). Nevertheless they did not attempt to handle the concurrent issues among multi-ports. The IL’s test experiments are carried out in the moonv6 collaboration project between US and Europe. However, it does not adopt the standard test definition
language—TTCN (at present, it has been developed to the 3rd version—TTCN3) to describe test data. Therefore, its test suites are lack of universality and difficult to apply to other test systems. Furthermore, it cannot perform performance testing because of the far distance. As for the ICT, although the project IPv6CTS can realize multi-port test, it don’t take into account concurrent problem for router testing and its test configuration is not flexible. In generally, although research on multi-port test has been carried out in some organizations, while in industry testing of IP routers is mainly restricted to test one port or a pair of ports of a router only. Moreover, some vendors such as Agilent have developed concurrent test products. But these products are different from our concurrent test system for network protocols. Their concurrent test is an analogous technology that enables parallel testing of multiple intellectual property (IP) blocks within each device. In other words, they aim at hardware system.

To make a comprehensive view to IP router test research at home and abroad, testing for IP router is still restricted to test with one or a pair of ports, not with multi-port concurrent test. Therefore, Sichuan Network & Communication Key Laboratory (SC-NetComLab) sets about to research on multi-port concurrent test technology for IP router.

![Fig. 1 The CMPTS composed of test system & test case support tools](image)

2 A Framework of CMPT-TS

2.1 A General Architecture of CMPT-TS

As shown in Fig.1, the CMPT-TS is composed of two parts: CMPT system on the left and Test case support tools on the right. The main function of CMPT system is to deal with testing issues by utilizing executable test suites pre-compiled from test definition languages. Test case support tools include concurrent multi-port test definition language (CMPTDL), test and test control notation version 3 (TTCN-3), and relevant compilers. The CMPTDL is used in defining concurrent test suite, and the CMPTDL compiler separates the concurrent control functions for concurrent multi-port test manager (CMPTM) from tests for TPT-s. The TTCN-3 compiler further converts test suites in TTCN-3 into C programs, which will be further converted into machine executable codes by C compiler.

The main function of CMPTM in Fig.1 is to handle multiple parallel testing in a controllable manner. The TPT can either test router with TTM and LTM as an independent test system or test router scheduled by CMPTM with multi-port test method as a component of CMPT-TS.

2.2 CMPT Manager

CMPTM is the control center and coordinator of the whole distributed test system, whose functionality spans from test configuration of two-port testers (TPT), assignment of executable test suite/groups/cases to individual TPT-s, initiation of a test session, graphic display of test progression, synchronization and coordination of concurrency in parallel tests, dynamic parallel test thread selection, parallel test information logging, ending a test session, and production of test reports. From the viewpoint of software, the CMPTM can be looked as the server. Fig.2 shows its components.

As depicted in Fig.2, the CMPTM is composed of test executor, man-machine interface, log manager, clock manager, test verdict manager, communication
module, test case database, and test case function mapping table. The test executor is the core component of the whole system, which is in charge of calling test cases to execute, and based on concrete requirements of the test cases schedules corresponding components to perform corresponding action. That is, when a test case needs TPT-s to be synchronized, the test executor will call the communication module to send a synchronization message to corresponding TPT-s. Moreover, the test executor still has an important function selecting test cases / test steps dynamically. When the test executor finds some errors during executing a test case or test step, it can stop executing this test case/step and select other nodes in test cases tree to execute.

The man-machine interface is used to input some parameters or show some disposition information and results etc., which permits operator to intervene with test procedure and manually select test cases to execute except selecting automatically.

The log manager is used to record time, main test acts and procedures, results etc. so as to post-analysis. The clock manager is in charge of timing and labeling timestamp in some messages. The test verdict manager collects middle results from every TPT and gets a final verdict and reports to test system. The communication module shields all the realization details and takes charge of communicating with TPT-s including sending or receiving data information and control commands.

2.3 Two-Port Tester (TPT)

The TPT adopts either LTM or TTM as defined in ISO 9646 to test single port or a pair of ports. Which test method should be chosen and how a router should be tested are decided by test requirement for a given router, the test system configuration, and test control data selected (test suite, test groups, and test cases). Adopting LTM or TTM, a TPT may act as an elementary test executor in the CMPT-TS, or as an independent tester in single port or two-port testing. Fig. 3 further decomposes the functional diagrams of a TPT.

As depicted in Fig. 3, the TPT manager is the test commander of a TPT under the control of CMPTM or the test operator. It controls test progression through the following functions: tester configuration, test case selection, giving order to the test case executor, starting or ending a test session, graphic display on the
visual monitor, and so on. A test case executor is the single test case executor; it traverses through a single executable test case, calls up the E/D to encode/decode the protocol data units (PDUs) of the protocol under test, loading the encoded PDU into the PDU of the top layer in the test support layers and de-loading in reverse direction.

Note that the E/D is represented by a dotted box to indicate that an E/D has been included in the executable test suite (ETS) before being compiled. Therefore, the two vertical dotted-arrows only imply conceptual data flows.

The two logging files in Fig.3 differ from one another. The main log file on the top in Fig.3 records the PDU events and data from the interface between the TPTM and the test case executor for post-analysis and generating TPT’s test report. These events and data information will also be passed to TPTM or TPT monitor for display. The subsidiary log file at the bottom of Fig.3 records PDU events of the tested layer and provide an extra post-analysis means.

The support layers in Fig.3 represent different protocol stratum from the layer underneath the layer to be tested down to physical interface corresponding to those in the router under test. For example, they are Ethernet implementation when testing the IPv6 routing functions over Ethernet; while for encapsulated test of IPv6 as in 6-bone project, the highest layer in support layers will be an IPv4 implementation. When it comes to testing of routing protocols, support layers would be an implementation of the protocol stratum from physical layer up to UDP/TCP. In other words, the TPT should be designed as flexible as possible to adapt to different layer focused on and different support protocol stratum corresponding to those in the router under test.

2.4 Real Distributed CMPTS (RDCMPTS)

Based on the following reasons, CMPT-TS adopts distributed architecture composed of multiple PCs: one PC acts as server and performs CMPTM’s functions, and others are looked as TPT-s.

1) Performance/price ratio

Even if a mini-computer is made use of testing router with tens of ports, the difficulty and equipment costs cannot be ignored, but cheap PC is easy to realize and the ratio of performance and price is high.

2) More flexible system configuration

The TPT-s based on PC can test a pair of ports by TTM without CMPTM, and so easy to realize portable test products. Moreover, the CMPTM with distributed architecture has greater ability to apply the changes of number of ports.

3) Compatibility between TTCN3 and CMPT-DL

With this approach, the test suites defined in TTCN-3 can still be used in TPT-s possibly with necessary modifications, which could save a lot of human power in test definition. Consequently, the specification of a new test definition language, CMPT-DL, needs only to focus on test concurrency and coordination and leave ramification of single-thread test definition to TTNC-3. Fig.4 shows the real test environment.

2.5 A New Test Definition Language

The TTCN is a standard test definition language, which has been developed to 3rd version-TTCN3 at present. Compared with the former 2 versions, the 3rd version adds some synchronous mechanism. However, considering those reasons as follows, authors extend TTCN3 and define a new language-concurrent multi-port test definition language (CMPT-DL).

1) Synchronization mechanism

Although the TTCN3 imports the concept of coordinate point (CP) for paralleling test, it is still lack of detail synchronous description. As for CMPT-TS which is composed of multiple computers, a more specific and unambiguous operable synchronous mechanism is necessary.

2) Performance testing needs a new description mechanism

Because the TTCN3 emphasizes particularly on function testing, it is lack of description mechanism for performance testing and real-time. Performance testing with CMPT-TS requires a strict real-time control mechanism.
3) The complexity of concurrent description

It is very difficult for a same language to consider both coordination in paralleling test and details in single test. If there is a high-layer macroscopic definition language, it is very beneficial to separate macroscopic description including coordination and synchronization for paralleling test from microcosmic detail description for test based single or a pair of ports.

Based the above reasons, authors define the new language CMPTDL. The main structure of CMPTDL is showed as follows:

CMPTM_NAME: //the test case name.
DESCRIPTION: //the part is used to describe the test aims.
VARIABLE_DEFINITION: //the part is used to define variables.
FUNCTION_PART: //the part is used to define functions and import functions from Function - Test Case Table.
BEHAVIOR_PART: //the detail operation is described in here.
END

Because of the limitation of pages, the details of CMPTDL cannot be listed. Tab.1 gives some basic elements.

<table>
<thead>
<tr>
<th>Tab.1 Some basic elements of CMPTDL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element name</td>
</tr>
<tr>
<td>Arithmetic operator</td>
</tr>
<tr>
<td>Relational operator</td>
</tr>
<tr>
<td>Data types</td>
</tr>
<tr>
<td>Basic Statement</td>
</tr>
<tr>
<td>Macro</td>
</tr>
<tr>
<td>Function management</td>
</tr>
<tr>
<td>Partial keywords</td>
</tr>
</tbody>
</table>

3 Conclusions

The work presented in this paper is still in its experimental stage. And there are many works have to be done before the CMPT-TS is put into full test service. The main reason is the compiler has not been finished yet. However, by translating test cases manually into C codes, and compiling them into executable test cases, authors have had some simple tests for IP routers. These tests have shown its merits over existing practices on router testing, not only in performance testing but also in conformance testing. It can advance test efficiency largely, compared with existing test systems. Multiple test cases can be finished to test in one time, which can not be realized in existing test systems. On other hand, test process also becomes simpler and more flexible. By changing few configurations, tester can finish different tests. The use of CMPT-TDL makes test definition simpler and clearer. It breaks a new path for concurrent test definition. The authors wish that this work could be helpful for testing community in widening the scope of testing and in exploring concurrent testing techniques.

Acknowledgement

The authors appreciate the support of Doctor Innovation Funds of Southwest Jiaotong University.

References


Brief Introduction to Author(s)

SONG Bo (宋波) is now a Ph.D. candidate at Southwest Jiaotong University, majoring in computer network. His current research fields include protocol testing, network architecture and network security. XU Juan (徐娟) is now a master student at Southwest Jiaotong University, majoring in computer network. Her research interests are in the area of protocol testing.