Service rate test mechanism and management of broadband access network

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Abstract—**As the growth of digital home application, higher subscribed rate of access network is needed by the end users to enjoy the desired service in home network. It is important for service provider to verify the actual service rate is satisfying the expectation of their customers. The popular method to check the service rate is to execute service rate test software on the desktop in home network, and results in the argument between customers and the service provider about where is the problem point with the unsatisfactory test result and lack of the consideration of management issue. In this research, we propose a service rate test mechanism at home gateway with a dedicated test server to exclude all factors of the home networking and capability of tested platform. The proposed approach integrates the TR-069 remote management methodology to increase the management scalability of the proposed service rate test action for a large number of home gateways. We illustrate the implementation and integration procedure of the proposed test approach and TR-069 mechanism of the managed home gateway. We also execute the test of the proposed approach and comfirm its accuracy and stability. The proposed service rate test mechanism provides a convenient way for the service provider to clarify the subscribed line quality of broadband access network, and decrease the complaint of their customers.**

Keywords- service rate test; home gateway; broadband access network; TR-069

I. INTRODUCTION

As the growing deployment for broadband application, new broadband access technologies, such as VDSL (Very-high Digital Subscriber Line), are deployed to transport the service data. Customers subscribe the broadband access service of Network Service Provider (NSP) or Internet Service Provider (ISP) to connect to the Internet. How to clarify the connection problem is an important issue when the customer feels the network is slow, even something trouble, and sends the complaint call to the ISP/NSP.

Some approaches are proposed for end users of broadband access service to verify whether the actual service data rate is satisfying their expectation [1]. The ISP/NSPs have the responsibility to support sufficient access network resource to their customers, but it must be excluding the home networking environment. It is not easy way to identify the slow service rate problem when ISP/NSPs receive the compliant from their customers. In fact, many events of compliant occur constantly just because the setup problem or lower hardware capability of the customers' desktop. The complicated home networking environment would also slow down the actual service rate.

The home gateway in home network is responsible for external connection to a variety of access network, as well as internal connection to service devices and home networking devices. It separates the responsibility of ISP/NSPs from home networking environment. If the service rate test mechanism is implemented in home gateway [2], and periodically executed with a test server outside the access network, the home network environment factors are all excluded. It also has the advantage for the ISP/NSP to collect the testing report of all its subscrbed lines of acess network periodically and automatically with a remote management methodology.

This paper proposes a service rate test approach at home gateway with the dedicated test server. This approach integrates the TR-069 remote management methodology to activate the service rate test action for a large number of home gateways. TR-069 management server also has the ability to collect the testing report of all subscrbed lines. It is a convenient way for ISP/NSP to solve the problem for the subscribed lines of broadband access network directly. This would be decreasing the complaint call and increasing the satisfaction of customers.

II. METHODOLOGY OF SERVICE RATE TEST MECHANISM AT HOME GATEWAY

Service rate test application is widely used to assure the connection speed is worthy the payment of end users. Three service rate test methodologies are discussed:

A. Excuting service rate test by end user

Service rate test mechanism is widely used by the end users to assure the connection speed is worthy of their payment from a desktop to a specific speed test server outside the access network. Two common methods are pointed out:

- First one is activating service rate test by linking to the testing website. Many ISP/NSPs provide the free service rate test website for their customers, but it causes the argument of subjectivity. "Speedtest.net", developed by Ookla, is a very popular service rate test website to help the customers of its cooperated ISP/NSPs to check the service rate from the desktop to Internet and prevents the criticism of subjectivity.
- The second is executing the service rate test software on the desktop of the customer. This method needs

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installing the testing software into the tested desktop before testing. Hinet, the largest ISP in Taiwan, provides "Dr. Speed" test software to verify the service rate for all its customers of broadband access service.

These two methods both have the advantage of simplicity, but suffer from disappointing test result due to bad testing setup or insufficient hardware capability of the desktop.

B. Auto-executing service rate test by a test box

Testing by a hardware box could avoid the influence of wrong testing setup and low capability of desktop. This approach is using a hardware test box which has installed the service rate test software and well testing setup when the end user gets the test box. Samknows, the famous broadband measurement software developing company, launches the "whitebox" to test the service rate from end user to Internet. It gets the advantage of more accuray and auto-testing periodically, but meets the diffculty and cost for the ISP/NSP to deploy the all test boxes to every its customer.

C. Executing service rate test at home gateway

Too many unexpected factors in home network would reduce the accuracy of service rate test by end users of broadband access subscriber line. End users would call for help to the ISP/NSP when they execute the service rate test at desktop or test box in home network with an unsatisfactory test result, and disturbs the ISP/NSP to tell its end users that there is no any problem in access network or server side. The service rate test from home gateway excludes the factors of hardware capability of desktop and complexity of home networking topology. It is a good solution to examine the service rate of broadband access network, and useful for ISP/NSP to clarify the problem point is in access network or home network.

A simplified architecture of service rate test mechanism at home gateway is shown in Figure 1. A speed test server is needed to cooperate with the test mechanism to execute download and upload process. The proposed approach also integrates the TR-69 CPE remote management protocol [3][4] with simple operation and high scalability features to activate the proposed test approach and receive the tested result. It is easy for ISP/NSP to monitor service rate status of all the subscriber lines of access network by ACS and OSS periodically if the tested home gateway is already implemented the TR-069 client function.

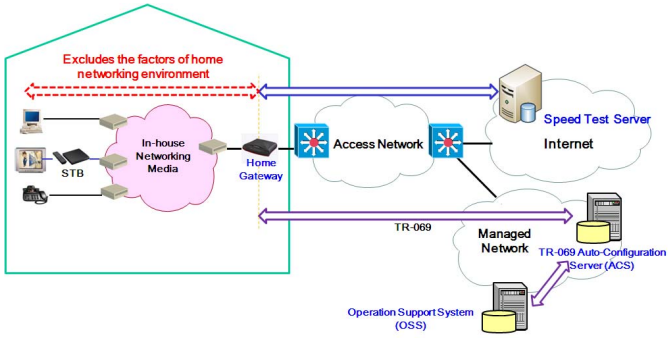

Figure 1. A simplified architecture of service rate test mechanism and management at home gateway

III. IMPLEMENTATION OF THE PROPOSED SERVICE RATE TEST MECHANISM

The proposed test mechanism is activated by TR-069 ACS server. The service rate test and TR-069 client function must be installed into the tested home gateway. To fulfill the implementation process, three issues must be discussed :

- TR-069 parameter definition of the proposed approach.
- TR-069 process flow of the proposed approach.
- Service rate test function and TR-069 client integration of the tested home gateway.

A. TR-069 parameter definition of the proposed approach

TR-069 managed parameters must be defined before the proposed service rate test approach is activated by TR-069 management server. The parameters used for the proposed approach are denoted and described as following:

- ***TestEnable***: enables or disables the service rate test function (data type: *boolean*, and *writable*).
- ***DownlinkStatus***: tested status of downlink test (data type: *int*, and *read-only*). There are two tested status (*success* or *failure*) for the downlink rate test.
- ***UplinkStatus***: tested status of uplink test (data type: *int*, and *read-only*). There are two tested status (*success* or *failure*) for the uplink rate test.
- ***DownlinkRate***: tested service rate (Mbps) after down link test is finished successfully (data type: *unsigned int*, and *read-only*).
- ***UplinkRate***: tested service rate (Mbps) after uplink test is finished successfully (data type: *unsigned int*, and *read-only*).

B. TR-069 process flow of the proposed approach

The TR-069 management of the proposed service rate test has the advantage of auto-testing and high scalability for millions of home gateways. The management flow of the proposed service rate test approach is shown in Figure 2 and describes as following:

(1) OSS notifies ACS to activate the service rate test of the specified home gateway by TR-069 Northbound Interface (NBI), specified in TR-069 technique report.

(2) ACS sends the TR-069 ***SetParameterValues*** RPC (Remote Procedure Call) to the home gateway with ***TestEnable*** parameter set as ***true***, and the home gateway responses ***SetParameterValuesResponse*** message to acknowledge ACS that it receives the command.

(3) The tested home gateway executes the proposed service rate test procedure for uplink and downlink, and outputs the testing result into the other four TR-069 parameters after it receives the ***SetParameterValues*** RPC with ***TestEnable*** parameter set as ***true***.

(4) After the tested home gateway has finished the test, ACS acquires tested result by sending ***GetParameterValues*** RPC with four TR-069 parameters (***DownlinkStatus***, ***DownlinkRate***, ***UplinkStatus***, and ***DownlinkRate***) to the home gateway. The home gateway sends the information of four parameters of tested result to ACS by TR-069 ***GetParameterValuesResponse*** message.

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(5) Finally, ACS sends the test result to OSS by TR-069 NBI interface.

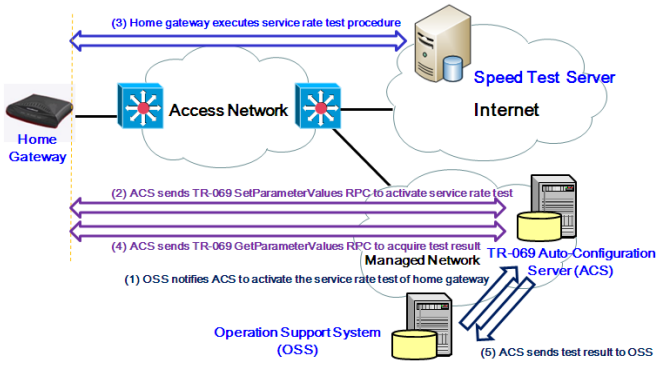

Figure 2. Management flow of service rate test mechanism by TR-069

C. *Integrating rate test and TR-069 client function of home gateway*

Before service rate test is executed, service rate test and TR-069 client function are both integrated into the home gateway. How to integrate two functions is the critical issue of the proposed approach.

The TR-069 client function of the home gateway is to handle the TR-069 RPC request sent by ACS, and send the response message to ACS. For the service rate test approach, TR-069 client function must add the procedure to determine whether the ***TestEnable*** parameter of service rate test approach is configured by TR-069 SetParameterValues RPC. If this parameter is set as true, service rate test function is activated.

The process of the proposed service rate test mechanism is executing the rate test procedure with the speed test server after receiving the procedure call of TR-069 client function, then output the test result into four parameters (***DownlinkStatus***, ***DownlinkRate***, ***UplinkStatus***, and ***UplinkRate***).

IV. EXPERIMENTAL TRIAL OF THE PROPOSED APPROACH

Install the proposed test function in a VDSL home gateway which links to the VDSL Digital Subscriber Line Access Multiplexier (DSLAM), and verify its accuray and stability. The test architecture and setup is shown in Figure 3 and described as following:

- Three VDSL line conditions for downstream (*100Mbps, 50Mbps, and 12Mbps*) and upstream (*40Mbps, 20Mbps, and 3Mbps*) data rate are taken into account to execute the different service rate tests.
- Repeat the proposed service rate test approaches 10 times for both downstream and upstream subscriber line rate conditions.
- Calculate the average test rate and standard deviation degree of 10 tested results to verify the stability of the test approach. The standard deviation degree is value of the actual standard deviation divided by the actual subscriber data rate.

The test result is listed in Table I. The proposed service rate test approach show its accuray according to the average tested rate result is close to the corresponding VDSL data rate. The reason why the test result of downstream 100 Mbps condition is smaller than 100 Mbps is the limitation of fast ethernet switching design of tested home gateway. The proposed service rate test approach show its stability according to the standard deviation degree result which are all smaller than 1.33%.

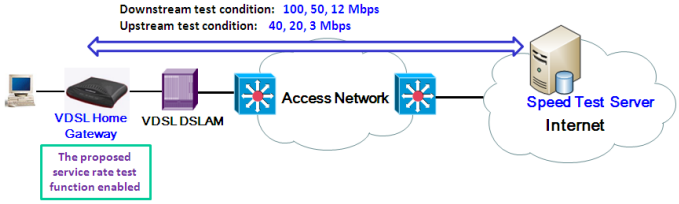

Figure 3. Test architecture of the proposed service rate test approach

TABLE I. TEST RESULT OF PROPOSED SERVICE RATE TEST APPROACH

VDSL line condition		Average tested rate (Mbps)	Standard deviation degree (%)
Downstream	*100Mbps*	92.91	1.33
	50Mbps	52.47	0.45
	12Mbps	12.51	0.77
Upstream	*40Mbps*	40.09	1.05
	20Mbps	20.68	0.51
	3Mbps	3.15	0.32

V. CONCLUSIONS

In this paper, we propose a service rate test approach at home gateway and integrate the TR-069 management methodology for the ISP/NSP to verify the subscriber line of access network providing sufficient network resource periodically without complaint call of the customers. We also define the TR-069 parameters needed for the proposed approach and point out the integrated system architecture and procedure of the proposed rate test with TR-069 function into the VDSL home gateway. Finally, verify the accuracy and stability of the proposed test approach by VDSL broadband access service.

The benefit and strength of proposed approach is already confirmed. Hardware based testing procedure reduces the influence of capability issue for the service rate test result. Executing test at home gateway excludes all factors of home networking environment and gets high accuracy. Managing and activating the test by TR-069 ACS reduces the appearance of bad manual test setup. TR-069 management topology has the high scalability for the ISP/NSP to maintain service quality assurance for millions of access subscriber lines.

In this paper, we just explain how to activate the test approach by TR-069 ACS, but not focus on tunning test procedure to increase the test precision. It is further work to take additional discussion of some test setup to progress the accuracy of proposed test approach.

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