Test Technology for Carrier Ethernet

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Abstract:
In order to compare the effectiveness of different Carrier Ethernet (CE) technologies, test methods are described in terms of the features of CE defined by Metro Ethernet Forum (MEF), including scalability, reliability, Quality of Service (QoS), standardized services, and service management. It can be seen from the test results that the present CE technologies could satisfy basic requirements of carrier-class network on the abovementioned aspects. However, complete interworking could hardly be achieved between different CE solutions in the short term because of their great difference in service bearer capability, reliability, scalability, QoS and Operation, Administration and Maintenance (OAM) ability.

1 Concept of Carrier Ethernet

The Metro Ethernet Forum (MEF) first introduced the concept Carrier Ethernet (CE) and began the research of CE. According to MEF, CE has five features:

(1) Scalability

- Services are scalable, allowing millions of users to access the same network service;
- Bandwidths are scalable, allowing the rate to range from 1 Mb/s to 10 Gb/s or even higher. The rate can increase by certain granularity.

(2) Carrier-Class Reliability

- Provide a protection switching time of no more than 50 ms;
- Be capable of end-to-end path protection;
- Support aggregation link protection and node protection.

(3) Quality of Service (QoS)

- Deliver guaranteed end-to-end performance;
- Enable selection of end-to-end QoS classes;
- Be applicable to business, mobile and access convergence scenarios.

(4) Standardized Services

- Provide Ethernet and Virtual LAN (VLAN) services;
- Seamlessly integrate Time Division Multiplexing (TDM) services;
- Support circuit emulation services;
- Support existing voice applications.

(5) Service Management

- Support quick service delivery;
- Support carrier-class Operation Administration and Maintenance (OAM);
- Provide the customer network management function.

2 CE-Related Tests

CE has become a hot research topic in the telecom industry. Many international standardization organizations, such as ITU-T, IEEE, IETF and MEF, have started CE-related standardization. Moreover, there have already been several solutions in the market. They are represented by Provider Backbone Bridge (PBB)/Provider Backbone Transport (PBT)[1], Transport Multiprotocol Label Switching (T-MPLS)[2], enhanced Ethernet technology and Virtual Private LAN Service (VPLS)[3]. The five features of CE can be used as the criteria to evaluate these technologies and related tests should be conducted.

2.1 Scalability

The objective of scalability test is to verify the bandwidth and tunnel processing capability a CE solution can provide.

The bandwidth test methodology described in RFC2544[4] can be used to verify whether a System Under Test (SUT) supports wire-speed forwarding through Fast Ethernet (FE), Gigabit Ethernet (GE), and 10GE interfaces.

The tunnel processing capability test is mainly used to verify the maximum number of tunnels, both inner and outer, that can be configured with a SUT, as well as the maximum services the SUT supports in case of a single tunnel (i.e. multi-service multiplexing tunnel capability). The tunnel protection mechanism should be enabled for the SUT and only the results with a protection switching time of no more than 50 ms make sense. The identifications of tunnels vary with SUTs. For example, in PBT, the outer tunnel is identified with Backbone VLAN (B-VLAN) and the inner tunnel is identified with I-SID; in T-MPLS and VPLS, both inner and outer tunnels can be identified with MPLS labels; and in enhanced Ethernet technology, inner and outer tunnels are identified with inner and outer VLAN labels of Provider Bridge (PB).

2.2 Reliability

The objective of reliability test is to verify the tunnel protection switching time of a SUT, seeing if it meets the carrier-class requirement, i.e. no more than 50 ms.

The protection switching time is calculated as follows:

Protection switching time = Number of lost packets / Transmit rate of packets

The end-to-end tunnel switching may be triggered in any of the following conditions: link failure, port failure, and node failure. These triggering conditions should be verified respectively, and the operations involve disconnecting optic fiber, turning off the forwarding port, powering off the device and unplugging the active board. The protection switching test, emulates the actual network based on the equipment configuration with a large quantity of tunnels and heavy data flows that are evenly distributed to all tunnels.

The network topology used for reliability test can be ring, grid or dual-homing, depending on the technology adopted. In case of ring networking mode, it is required to test such multiring topologies as intersecting and tangent topologies.

The switching protection test should be conducted for unicast and multicast tunnels respectively so as to verify the protection of the SUT for broadcast services and multicast services.

Besides, it is necessary to verify if any packet is lost during the tunnel is switched back after the failure is recovered.

2.3 QoS

The objective of QoS test is to verify whether a SUT can meet the requirements for carrier-class QoS.

QoS test involves such aspects as access control policy, traffic labeling policy, admission control policy, and queue dispatching mechanism.

The access control policy test aims to find out whether the SUT can correctly configure access control policies for L2, L3 and L4 traffic and whether the forwarding performance is affected after the Access Control List (ACL) is configured.

The traffic labeling policy test is to see whether the SUT can mark or remark a data flow with a QoS class according to the predefined traffic labeling policies. The QoS classification can be based on IEEE 802.3, 802.1ah, MPLS or IP Type of Service (ToS) / Differentiated Services (DiffServ).

The admission control policy test is to check whether the SUT can, based on Committed Information Rate (CIR) or Peak Information Rate (PIR), execute rate control over the access flows, as well as to check the bandwidth granularity the SUT can control.

The queue dispatching mechanism test is to test whether the SUT supports such priority queue dispatching mechanisms as Priority Queuing (PQ), Weighted Fair Queuing (WFQ), or Weighted Round Robin (WRR).

In addition, during QoS test, it is required to verify single-layer and layered QoS strategies respectively.

MEF14[5] is reference for the QoS test.

2.4 Service Support Capability

The objective of service support capability test is to verify whether the SUT supports such service types as Ethernet Line (E-Line), Ethernet LAN (E-LAN), E-TREE and TDM.

In the E-LAN service test, it is required to pay special attention to the method the SUT creates E-LAN services and the way it learns remote Media Access Control (MAC) addresses.

The E-TREE service test is used to verify whether the leaf nodes can be isolated from each other and whether multicast function can be achieved via E-TREE service.

In TDM service test, it is required to measure such performance indexes as delay, jitter and error code rate. The test port can be framed E1, non-framed E1 or channelized Synchronous Transport Module (STM)-1, depending on the configured devices.

Besides, it is necessary to verify whether the SUT supports TDM clock synchronization, including clock synchronization in Circuit Emulation Service (CES), clock synchronization of Ethernet, and time synchronization, specified in IEEE 1588 standard.

MEF9[6], MEF18[7] and MEF19[8] are reference for the service support capability test.

2.5 Service Management

Service management test mainly involves two aspects: Network Management System (NMS) and OAM mechanism.

The test for NMS should be conducted based on the Fault, Configuration, Accounting, Performance, Security (FCAPS) functional module. Tested items should include topology discovery, service creation, fault monitoring, and performance management. During the test, any created service should be verified with emulation service flows.

The OAM mechanism test should be based on IEEE 802.3ah[9], IEEE 802.1ag[10], ITU-T Y.1731[11] and G.8114[12] standards. With a protocol analyzer, the test is used to check the formats of Continuity Check (CC), Loopback (LB) and Link Trace (LT) messages as well as the messaging flow of Ethernet/T-MPLS OAM mechanism for consistency, seeing if they are compliant with related standards.

3 Practice of CE Test Methodologies

In recent years, the author has participated in the tests of four CE solutions, i.e. PBB/PBT, T-MPLS, Enhanced Ethernet and VPLS using the above test methodologies. The test results show that existing CE solutions can meet the carrier-class networking requirements in terms of service bearer capability, reliability, scalability, QoS and OAM mechanism, but they cannot interwork or interoperate with each other in the short term because of the great differences between them.

3.1 Service Bearer Capability

Test results demonstrate that the abovementioned four solutions can bear broadband Internet access and IP voice services. But as to private line services, multicast services and TDM services, their performance and complexity in implementation differ. In bearing private line services, the enhanced Ethernet technology performs poorly if isolated from user information because the entire network devices have to learn the users' MAC addresses. As a result, the network is vulnerable to attacks. On the contrary, in PBB/PBT, T-MPLS and VPLS technologies, only the User Network Interface (UNI) of Provider Edge (PE) rather than the core device is used to learn the users' MAC addresses, so the isolation effect is good. As for multicast services, all four solutions can deliver the services, but their implementation complexities differ: The enhanced Ethernet technology can easily achieve multicast services as ring networking mode is adopted; while the implementation of multicast services with PBB/PBT, T-MPLS, VPLS/Ethernet over MPLS (EoMPLS) technologies is quite complicated and diversified and there is still no uniform standard. For TDM services, PBB/PBT, T-MPLS and VPLS technologies can provide TDM interface or CES interface, while enhanced Ethernet technology cannot provide full support for such services. As to synchronous clock transfer function in TDM services, most manufacturers are trying to develop solutions.

3.2 Reliability

For broadband Internet access, IP voice services and private line services, all four solutions can achieve a protection switching of less than 50 ms in case of link or node failure. For multicast services, some technologies cannot ensure a protection switching of less than 50 ms, which will be a focus in future research. Moreover, manufacturers adopt different implementation mechanisms for access link protection. In addition to standard Rapid Spanning Tree Protocol (RSTP), many manufacturers have developed special technologies to improve the protection switching efficiency. The test results show that in case of a failure, uplink traffic with RSTP technology may suffer a switching over 100 ms; while the special technologies developed by manufacturers can ensure a switching less than 50 ms. However, these special technologies are unlikely to interoperate with each other because they are proprietary to different manufacturers.

3.3 Scalability

Currently, the leading CE manufacturers have developed devices that support 10GE interface, expanding their interfaces from FE to 10 G, thus meeting the basic requirement of MAN networking. In terms of support for tunnel, the devices, having different processing capabilities, provide different number of services, which range from several to ten thousands. This can meet the MAN's minimum requirements for two-layer networking. Among all technologies, PBT, T-MPLS and VPLS are the most scalable.

3.4 QoS

With respect to QoS flow classification and queue dispatching, four solutions can classify the flows based on VLAN label and port, and support such queue dispatching algorithms as PQ, WFQ and WRR. In addition, most manufacturers' devices can implement layered QoS function.

3.5 Service Management

At present, many manufacturers' network management systems can provide visualized topological views and enable service creation but their configuration complexities differ. In most of these systems, each network element has to be configured separately, thus leading to quite complicated operations. Only a few of them allow simple and quick service creation. In these systems, only the head node and end node of a service have to be configured during service creation, while the intermediate nodes can be automatically generated and broadcast by the system. Because the control planes of PBB/PBT and T-MPLS solutions do not support control signals, static configuration method is applied in the network management system for service creation. In order to enable batch configuration of services, most manufacturers provide related Application Programming Interfaces (APIs) and achieve such function with scripts. This function cannot be performed via the network management interface at the moment, bringing inconvenience for the operators in daily maintenance.

In respect of OAM support, most manufacturers' devices support 802.1ag protocol, but the performance management functions defined in Y.1731 protocol are only realized in the network management systems of some manufacturers.

4 Conclusion

As each CE technology has its own application scenarios, it is required to make the test scheme based on the technology under test as well as application scenarios.

With increasing attention and investments from operators, manufacturers and research organizations, various CE technologies are continuously developed. Therefore, the test methodologies should be improved accordingly so as to meet the growing evaluation requirements for CE technologies.

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Biography

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Zhao Feng received his master's degree from Beijing University of Posts and Telecommunications. He is a senior engineer at the Institute of Communication Standards Research, China Academy of Telecommunication Research, Ministry of Industry and Information Technology of the People's Republic of China, mainly engaged in research, standardization and test methodologies of IP network technologies. He has presided over or participated in several projects of "863" Program and took part in making several standards. Up to now, he has been awarded 2 prizes for his outstanding scientific achievements and has published over 10 papers.