Point-to-Multipoint Services on PBB-TE System

Wonkyoung Lee*, Chang-Ho Choi*, Sun-Me Kim*

**Optical Internet Research Department, Electronics and Telecommunications Research Institute, 161 Gajeong-dong, Yuseong-gu, Daejeon, 305-350, Korea*

wklee@etri.re.kr, chhchoi@etri.re.kr, kimsunme@etri.re.kr

***Abstract*— We have implemented point-to-multipoint (PtMP) services on a packet transport system (PTS) based on PBB-TE. On the implemented PtMP services, a root sent customer frames to three leaves in the forward direction and then MAC-in-MAC frames of IEEE 802.1ah were duplicated and transmitted to three leaves simultaneously. In the backward direction, one leaf transmitted the customer frames and the only root received the frames. IP flow awareness function was added in the PTS to classify layer 3 applications and services. Service interfaces are used to classify services and forward frames over the backbone network. The PTS offers to customers not only three basic types of the port-based, C-VLAN tagged, and S-VLAN tagged service interfaces defined by the IEEE 802.1ah but also an additional type of IP flow service interface. The throughput for the link capacity of 1 Gbps at the four service interfaces were measured 100 % in the leaves of the ingress edge node and the transit node with MAC-in-MAC encapsulation. After removing the MAC-in-MAC encapsulation in the egress edge node, 4 % of the traffic dropped. It attributed that the B-MAC overhead of 22 bytes occupies 4 % of the 512-byte packet.**

***Keywords*— Point-to-multipoint, packet transport system, PBB-TE, MAC-in-MAC encapsulation, service interface**

I. INTRODUCTION

Due to rapid growth of demand for bandwidth in today's network, the network has been evolved into simpler and more efficient structure. In this situation, the core network or the backbone network has been replacing SDH/SONET platforms with packet transport platforms [1]. The packet transport technology such as Provider backbone bridge – traffic engineering (PBB-TE) and MPLS Transport Profile (MPLS-TP) is getting the spotlight as a key point of the next generation network. Provider backbone bridge – traffic engineering (PBB-TE) defined by IEEE 802.1Qay [2] is representative carrier Ethernet transport technology that extends well-known and widely distributed Ethernet services to core of the public network while maintaining simplicity, flexibility, and cost effectiveness of the Ethernet service [3]. The PBB-TE adds transport hierarchy of MAC-in-MAC encapsulation to Ethernet frames and provides traffic engineering for connection-oriented paths and protection switching within 50 ms.

In the next generation network, the PBB-TE technology should provide multicast video streaming services and support traffic engineering for end-to-end label switched paths. However, there have been no proper solutions to multicast services on packet transport platforms based on PBB-TE so far [4]. Moreover, it has not been easy to classify layer 3 applications and services. In this study, we propose a solution to multicast services and IP flow awareness that have been weak points of PBB-TE technology. We have implemented a packet transport system (PTS) based on the PBB-TE. The PTS provides multicast services and IP flow awareness. We have measured traffic throughputs for the link capacity of 1 Gbps at port-based, C-VLAN tagged, S-VLAN tagged, and IP flow service interfaces.

II. PACKET TRANSPORT SYSTEM BASED ON PBB-TE

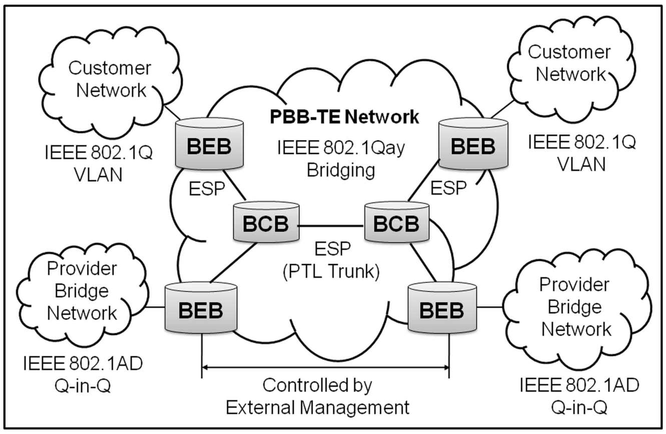


Figure 1. The PBB-TE network

As shown in Figure 1, a PBB-TE network comprises a set of backbone edge bridges (BEBs) and backbone core bridges (BCBs) that are connected by Ethernet tunnels referred as Ethernet switched paths (ESPs) [2]. Backbone edge bridges are responsible for adding transport hierarchy to customer frames in ingress edge nodes and restoring customer frames by removing the transport hierarchy in egress edge nodes. Backbone core bridges in transit nodes are responsible for swapping transport label or backbone VLAN identifier (B-VID). Each ESP as a connection-oriented path is identified by the triplet of a backbone source address (B-SA), a backbone destination address (B-DA), and a B-VID. The ESP is also called as a packet transport layer (PTL) trunk and is provisioned by an external management system.

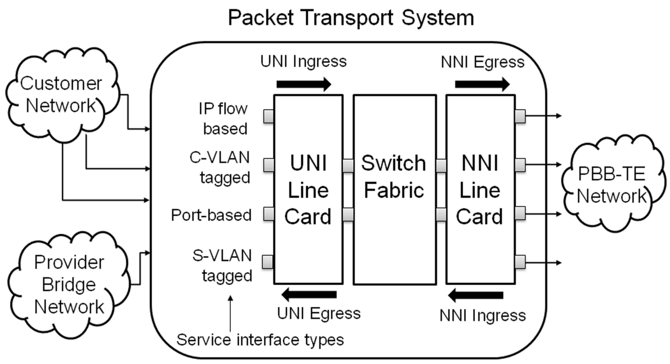


Figure 2. The structure of the packet transport system based on PBB-TE

We have implemented a packet transport system based on the PBB-TE, which provides multicast services and IP flow awareness as shown in Figure 2. The PTS consists of user network interface (UNI) line cards, network to network interface (NNI) line cards, and a switch fabric that connects between the UNI line cards and the NNI line cards. The UNI line card has port-based, C-VLAN tagged, S-VLAN tagged, and IP flow service interfaces. The port-based service interface classifies a backbone service instance (BSI) by just an input port. The C-VLAN or S-VLAN tagged service interface classifies a BSI by an input port and a C-VLAN or S-VLAN identifier. In particularly, we have newly added the IP flow based service interface that classifies IP packets of layer 3 applications and services. The IP flow based service interface subdivides layer 2 flows using 5-tuple information of layer 3 such as a destination IP address, a source IP address, a destination port, a source port, and a protocol. If a port of the UNI line card receives a customer frame, a backbone service instance is allocated to the customer frame and then a PTL trunk composed of a B-DA, a B-SA, and a B-VID is created in the NNI line card. The B-SA and B-DA are MAC addresses assigned to NNI line cards.

III. Implementation of Bidirectional Point-to-Multipoint Services

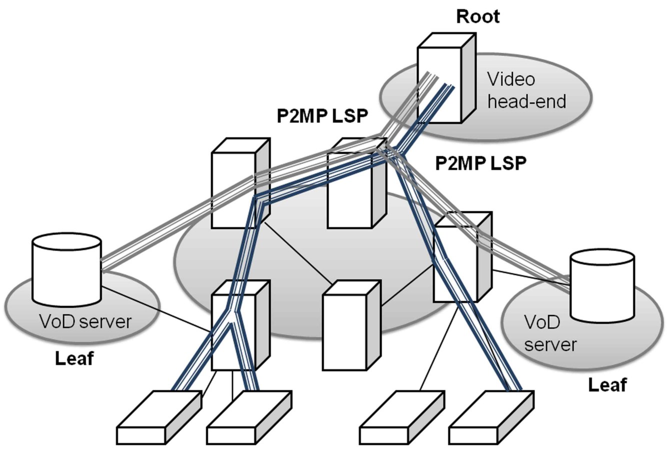
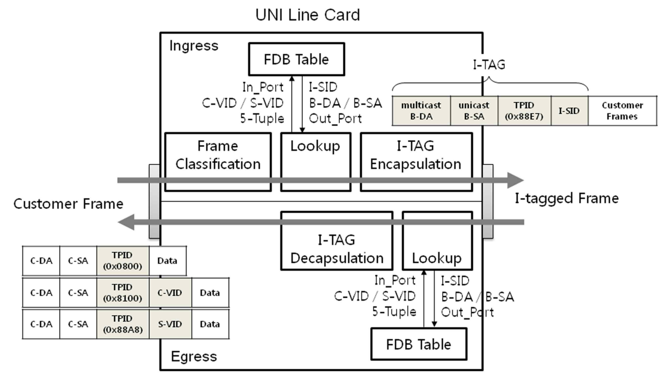
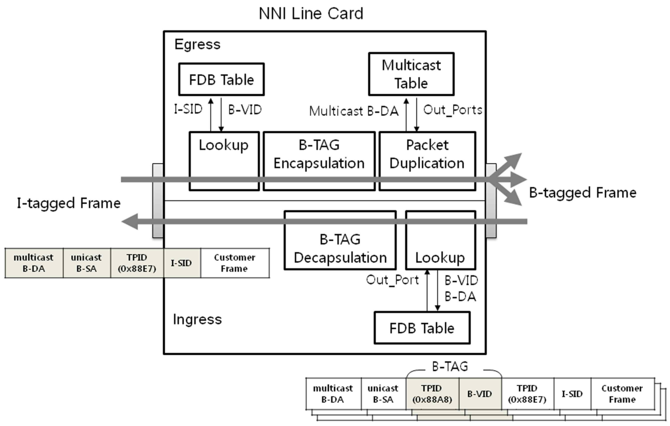


Figure 3. A point-to-multipoint service

Figure 3 shows a point-to-multipoint (PtMP) service that is the virtual Ethernet communication between one root that distributes multicast video stream and multiple leaves that receive multicast video stream simultaneously. In the PtMP communication, the B-DA conveyed in the backbone service instance tag (I-TAG) is a multicast backbone MAC address and the B-SA is a unicast backbone MAC address as shown in Figure 4(a). In the NNI egress and the transit egress, the MAC-in-MAC frames of IEEE 802.1ah are replicated as many as the number of output port configured by the corresponding multicast MAC address and transmitted to the output ports as shown in Figure 4(b). The PtMP communication in the backward direction is transmission from single leaf to one root. Packet forwarding in the backward direction is the same with that of the point-to-point connection. The PTL trunks that built up PtMP connection are traffic engineered ESPs.



(a)

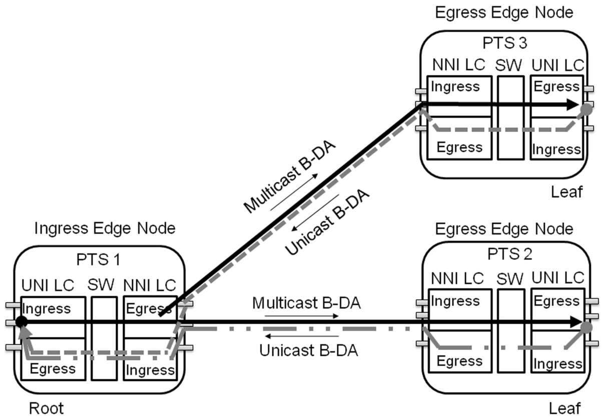


(b)

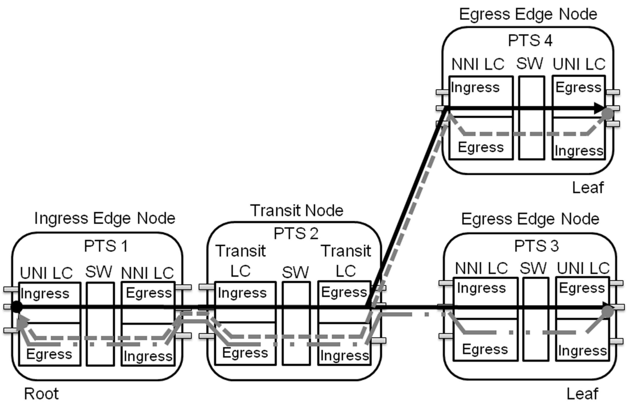
Figure 4. Multicast operation in (a) the UNI linecard and (b) the NNI linecard

IV. Experiments and Results

Figure 5(a) and Figure 5 (b) show examples of bidirectional point-to-multipoint services using the packet transport systems. In case of Figure 5(a), one root was formed at the UNI line card (UNI LC) of the ingress edge node and multiple leaves were connected with the NNI line card (NNI LC) of the ingress edge node. On the other hand, multiple leaves were connected with the transit line card of the transit node in case of Figure 5(b). Figure 6 describes the test configuration for the bidirectional PtMP service considering both Figure 5(a) and Figure 5(b). A root was the P11 port of the PTS 1. The P13 port of the PTS 1 and the P23 port of the PTS 2 corresponded to two leaves with MAC-in-MAC encapsulation. Another leaf was the P32 port of the PTS 3. Packets were duplicated in the NNI LC of the PTS 1 and transmitted to the P12 and P13 ports simultaneously. Packets were also duplicated in the transit egress LC of the PTS 2 and transmitted to the P22 and P23 ports simultaneously. In the UNI LC of the PTS 3, B-TAGs of received frames were removed and then transmitted to the P32 port.



(a)



(b)

Figure 5. Examples of bidirectional point-to-multipoint services using the packet transport systems

When the R port of the traffic generator sent customer frames corresponding with the four service interfaces, the L3, L2, and L1 ports of the traffic analyzer received packets simultaneously. As shown in Figure 7, the frames received at the L3 and L2 ports were MAC-in-MAC frames encapsulated with B-TAG, on the other hand, the frames received at the L1 port was the customer frames that B-TAG was removed in the egress edge node. The backward transmission means that packets are forwarded from one leaf to one root and it is not point-to-multipoint connection but point-to-point connection. When the L3 port of the traffic generator sent customer frames corresponding with various service interfaces from (a-1) to (a-4), the only R port of the traffic analyzer received the customer frames.

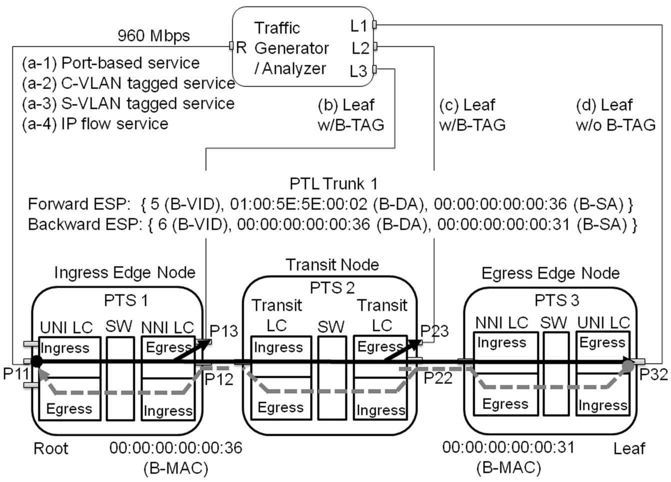


Figure 6. Test configuration of the bidirectional PtMP service

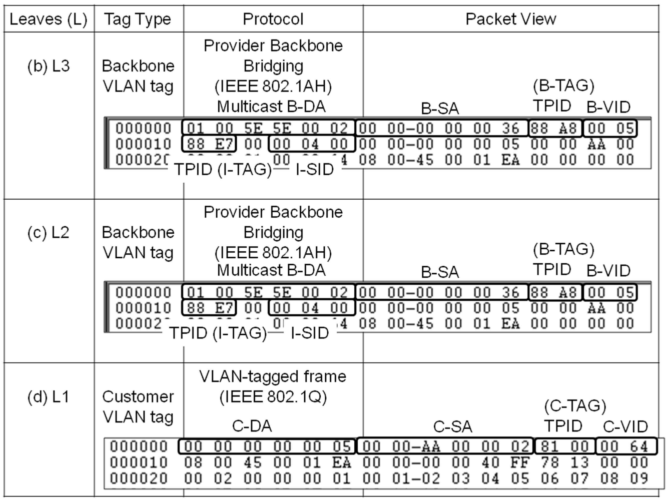


Figure 7. Frames received in the three leaves

We have measured PtMP throughputs at output ports of the ingress edge node, the transit node, and the egress edge node. Each input traffic rate for port-based, C-VLAN tagged, S-VLAN tagged, and IP flow service interfaces was 1 Gbps including IPG and preamble. To exclude impacts of policing and shaping, policing and shaping set to be off. Table 1 shows experimental results of throughputs for the bidirectional PtMP service. Throughputs for 512-byte packet and physical link capacity of 1 Gbps were measured 100 % at the two ports of the ingress edge node and the transit node. In the egress edge node, however, 4 % of the traffic dropped. It attributed that the B-MAC overhead of 22 bytes occupies 4 % of the 512-byte packet.

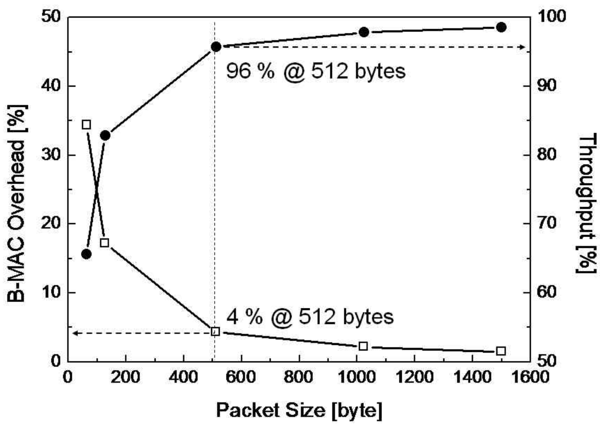


Figure 8. Impact of B-MAC overhead on the traffic throughput according to packet sizes

Figure 8 explains the impact of the B-MAC overhead that occupying the packet on the traffic throughput according to packet sizes. The larger the packet size is, the smaller the percentage of the B-MAC overhead is, and then, the fewer packets drops. In bidirectional PtMP connection, we have measured the throughput of 96 % for the leaf without MAC-in-MAC encapsulation and the throughputs of 100 % for the two leaves with MAC-in-MAC encapsulation at four service interfaces.

V. Conclusions

The PBB-TE technology is the carrier Ethernet transport technology that provides connection-oriented Ethernet, end-to-end QoS, and robust OAM. However there have been no proper solutions for multicast services in the PBB-TE technology. We have implemented the packet transport system based on PBB-TE, which provides the point-to-multipoint services and the IP flow awareness. Traffic throughputs for the packet of 512 bytes and the link capacity of 1 Gbps have been measured at port-based, C-VLAN tagged, S-VLAN tagged, and IP flow service interfaces. The throughputs of leaves with MAC-in-MAC encapsulation (IEEE 802.1ah) were measured 100 %. After removing the MAC-in-MAC encapsulation in the egress edge node, 4 % of the traffic dropped. It attributed that the B-MAC overhead of 22 bytes occupies 4 % of the 512-byte packet. The larger the packet size was, the smaller the percentage of the B-MAC overhead was. Therefore the larger the packet size is, the impact of the B-MAC overhead of the PBB-TE technology on the traffic throughput will be reduced. This study supplements solutions for multicast and L3 level services of the PBB-TE technology, therefore the packet transport system based on PBB-TE could support broadband services such as IPTV or multicast video streaming.

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TABLE 1. EXPERIMENTAL RESULTS OF THROUGHPUTS FOR THE BIDIRECTIONAL PTMP SERVICE

Root(R) w/o IPG and Preable			**Leaves (L) w/o IPG and Preable**								
			(b) L3 @ Ingress Edge Node			**(c) L2 @ Transit Node**			**(d) L1 @ Egress Edge Node**		
Service Interface Type	Sent Rate [bps]	Received Rate [bps]	Sent Rate [bps]	Received Rate [bps]	Thr. @ 1 Gbps	Sent Rate [bps]	Received Rate [bps]	Thr. @ 1 Gbps	Sent Rate [bps]	Received Rate [bps]	Thr. @ 1 Gbps
(a-1) Port	962,380,162	924,181,618		963,902,306	100 %		963,888,463	100 %	962,380,228	924,178,011	96.03 %
(a-2) C-VLAN	962,382,935	923,630,780		963,639,605	100 %		963,626,538	100 %	962,380,155	923,626,853	95.97 %
(a-3) S-VLAN	962,384,903	924,181,825		963,902,264	100 %		963,888,715	100 %	962,385,961	924,176,515	96.03 %
(a-4) IP Flow	962,381,866	924,182,627		963,902,442	100 %		963,888,984	100 %	962,382,150	924,178,562	96.03 %