

Point-to-Multipoint and Multipoint-to-Multipoint Services on PBB-TE System

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Abstract— We have implemented point-to-multipoint (PtMP) and multipoint-to-multipoint (MPtMP) services on a packet transport system (PTS) based on PBB-TE. The point-to-multipoint (PtMP) connection in the PBB-TE system has been realized by grouping point-to-point (PtP) packet transport layer (PTL) trunks and mapping a BSI onto the PtP PTL trunks using a multicast backbone destination address. For providing different capabilities for service selection and priority selection, the PTS offers customers three basic types of the port-based, C-tagged, and S-tagged service interfaces defined by the IEEE 802.1ah. To offer customers different capabilities of the layer 3 applications and services, moreover, an IP-flow service interface have been added. In order to evaluate traffic performance for PtMP services in the PTS, the PtMP throughputs for the link capacity of 1 Gbps at the four service interfaces were measured in the leaves of the ingress edge node, the transit node, and the egress edge node. The throughputs were about 96% because the B-MAC overhead of 22 bytes occupies 4 % of the 512-byte packet.

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

I. INTRODUCTION

THE network has been evolved into simpler and more efficient structure since demands for bandwidth in today's network have been increased rapidly. In this situation, SDH/SONET platforms are being replaced by packet transport platforms as in reference [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. There have been no proper solutions to multicast services on packet transport platforms based on PBB-TE so far [4] since the PBB-TE technology does not allow MAC learning, spanning tree protocol, and broadcast of unknown frame for providing deterministic, protected, and connection-oriented trunks and services. Moreover, it has not been easy to classify layer 3 applications and services due to layer 3 service transparency of the carrier Ethernet transport. 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 of PtMP and MPtMP and IP flow awareness. In order to evaluate the performance of the PtMP services on the PTS, we have measured traffic throughputs for the link capacity of 1 Gbps at port-based, C-tagged, S-tagged, and IP-flow service interfaces.

II. PACKET TRANSPORT SYSTEM BASED ON PBB-TE

As shown in Fig. 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

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address (B-DA), and a B-VID. The ESP is also called a packet transport layer (PTL) trunk. The PTL trunk is provided by an external management system.

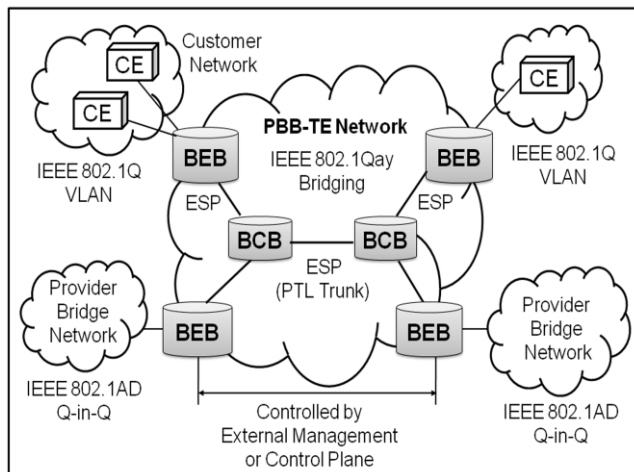


Fig. 1. The PBB-TE network

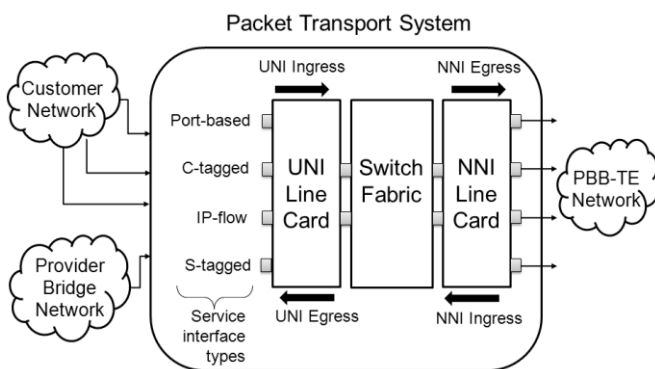


Fig. 2. The structure of the packet transport system based on PBB-TE

Figure 2 is the structure of the packet transport system based on the PBB-TE that has been implemented. 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 PTS has three types of customer service interfaces called the Port-based, C-tagged, and S-tagged, which offers customers one or more types of service interfaces, each providing different capabilities for service selection, priority selection, and service access protection. To offer customers different capabilities of the layer 3 applications and services, moreover, we have added a type called the IP-flow as the customer service interface. The port-based service interfaces that attach to VLAN-unaware bridges (802.1D Bridges), routers or end-stations, classify a backbone service instance (BSI) by just an input port. The C-tagged service interfaces that attach to C-VLAN bridges (802.1Q Bridges), classify a BSI by an input port and a C-VLAN identifier. The S-tagged service interfaces that attach to a provider bridged network, map a service instance identified by an S-VLAN identifier to a backbone service instance identified by a backbone service instance identifier (I-SID). IP-flow service interfaces subdivide 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 the B-DA are MAC addresses assigned to NNI line cards.

III. IMPLEMENTATION OF BIDIRECTIONAL POINT-TO-MULTIPOINT SERVICES

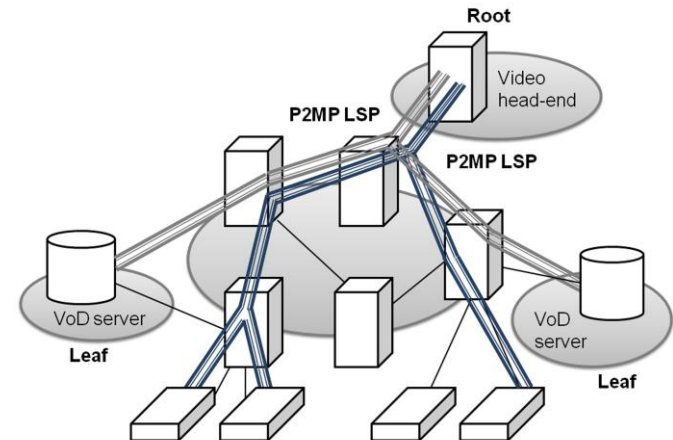


Fig. 3. A point-to-multipoint service

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.

Figure 5 shows the proposed method for the PtMP service in the PTS system based on the PBB-TE. A backbone service instance is allocated to a customer frame by the backbone service lookup table in the UNI LC according customer service interfaces. PtP PTL trunks connected with each leaf node are created in the NNI LC. A multicast B-DA (MB-DA) maps the backbone service instance (BSI) with PtP PTL trunks. In the switch fabric (SW), the MAC-in-MAC frames are copied as many as the number of output slots. In the NNI LC, the MAC-in-MAC frames are replicated as many as the number of output ports in a slot. By grouping PtP PTL trunks and mapping a BSI onto the PtP PTL trunks using a multicast B-DA (MB-DA), PtMP connection in the PBB-TE system could be realized.

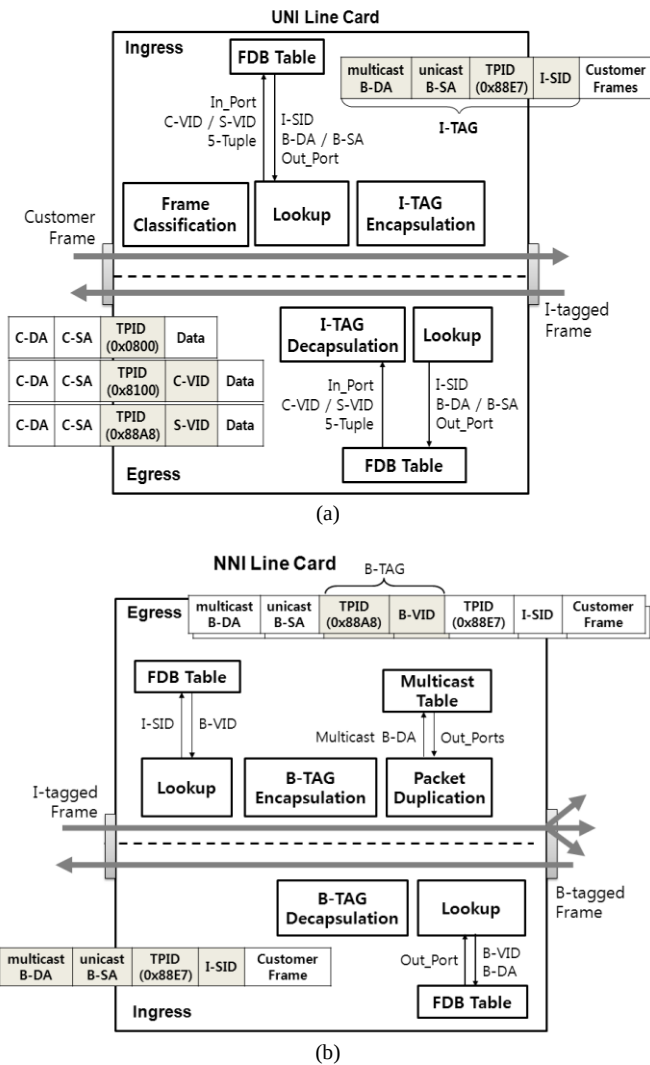


Fig. 4. The PtMP operation in (a) the UNI linecard and (b) the NNI linecard

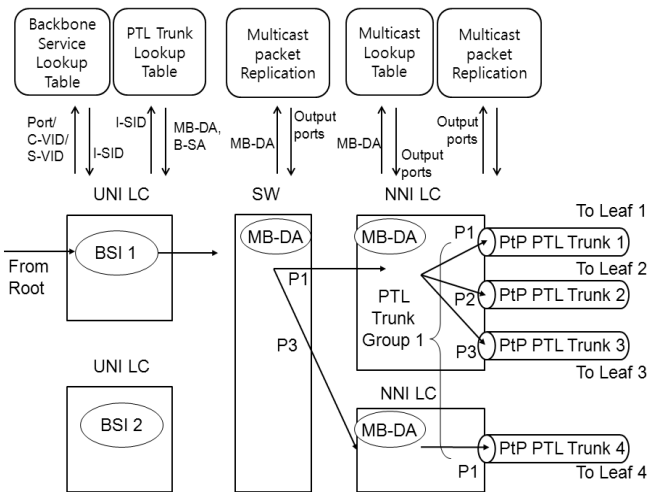


Fig. 5. The proposed method for the PtMP service in the PTS system

IV. IMPLEMENTATION OF BIDIRECTIONAL MULTIPOINT-TO-MULTIPOINT SERVICE

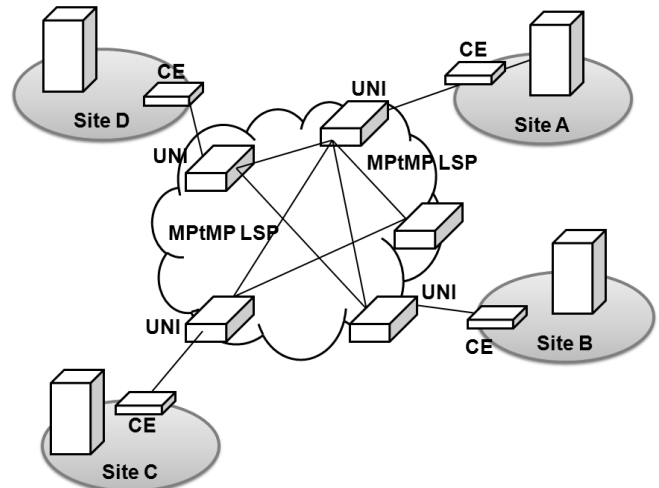


Fig. 6. A multipoint-to-multipoint service

As shown in Figure 6, Multipoint-to-multipoint (MPtMP) services provide multipoint-to-multipoint virtual Ethernet connection between two or more UNIs. More UNIs can be added to the same virtual Ethernet connection. The MPtMP configuration creates a wide area network (WAN) for customers with connectivity between every network site without restoration. The difference between MPtMP and PtMP is that the MPtMP has root endpoints only, which implies there is no communication restriction between endpoints, on the other hand, PtMP has both root and leaf endpoints, which implies there is a need to enforce communication restriction between leaf endpoints.

The MPtMP solution based on the PBB-TE technology has implemented differently from that of the PBB technology. The PBB-based MPtMP solution have used MAC learning and spanning tree protocol used in the conventional bridge, however, MPtMP solution based on the PBB-TE have realized by the combination of point-to-point paths provisioned.

To describe the MPtMP solution based on the PBB-TE, Figure 7(a) and Figure 7(b) show the MPtMP operation such as the copy and flooding of flooding packets and C-SA learning. The learned Result Lookup block of the Figure 7(a) looks the C-DA up in the C-SA learning table and checks whether the C-DA of a customer frame has been learned or not. If the C-DA is not learned, the customer frame is encapsulated with a multicast B-DA for flooding process. If the C-DA is learned, the customer frame is encapsulated with a unicast B-DA. The C-SA MAC learning, which is the learning process for C-SAs, B-DAs, B-SAs, and input ports of remote sites, has been added in the UNI egress. If the B-DA is a multicast MAC address, the flooding of packets into the PtP PTL trunks takes place in the NNI egress. If the B-DA is a unicast MAC address, the PtP transmission into a specific PtP PTL trunk takes place.

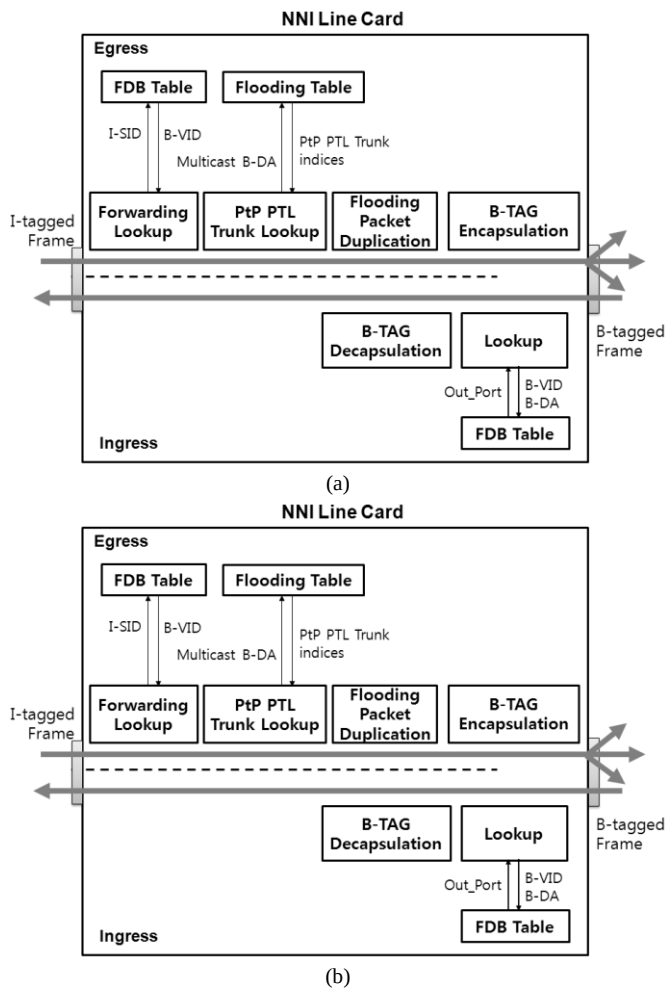


Fig. 7. The MPtMP operation such as copy and flooding of packet and C-SA learn in (a) the UNI linecard and (b) the NNI linecard

V. EXPERIMENTS AND RESULTS

Figure 8(a) and Figure 8(b) show examples of bidirectional point-to-multipoint services using the packet transport systems. In the Figure 8(a), packets are replicates and multicasted in the ingress edge node. In the Figure 8(b), packets are replicated and multicasted in the transit node. Figure 9 describes the test configuration for the bidirectional PtMP service considering both Figure 8(a) and Figure 8(b). Packets transmitted from the traffic generator were inputted into the P11 port of the PTS 1. And then, packets were duplicated in the NNI LC of the PTS 1 and transmitted to the P12 and P13 ports simultaneously. Packets transmitted from the P12 port of the PTS 1 were inputted into the P21 port of the PTS 2 and were duplicated as many as output ports configured by the multicast B-DA of 01:00:5E:5E:00:02 in the transit LC of the PTS 2 and were output to the P22 and P23 ports simultaneously. Packets transmitted from the P22 port of the PTS 2 were inputted into the P31 port of the PTS 3, and then, packets in which B-DA, B-SA, and B-VID were removed, transmitted to the P32 port of the PTS 3.

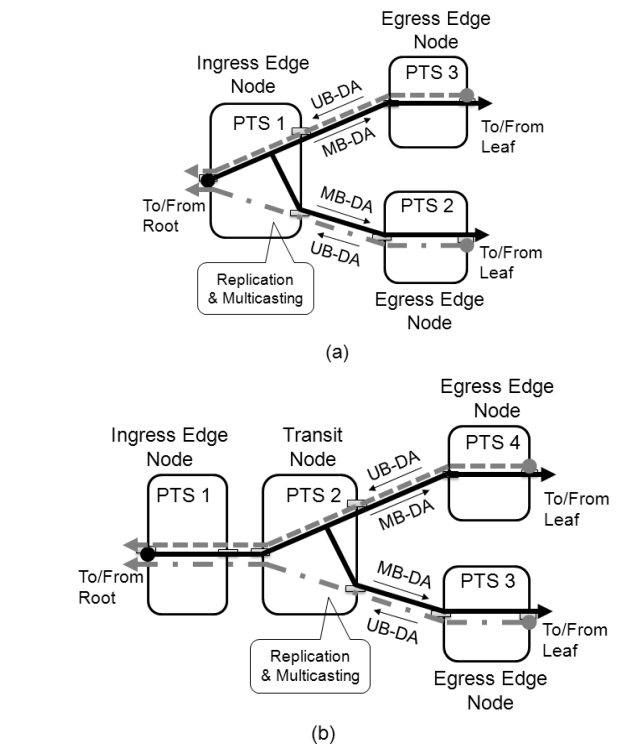


Fig. 8. Examples of bidirectional point-to-multipoint services using the packet transport systems

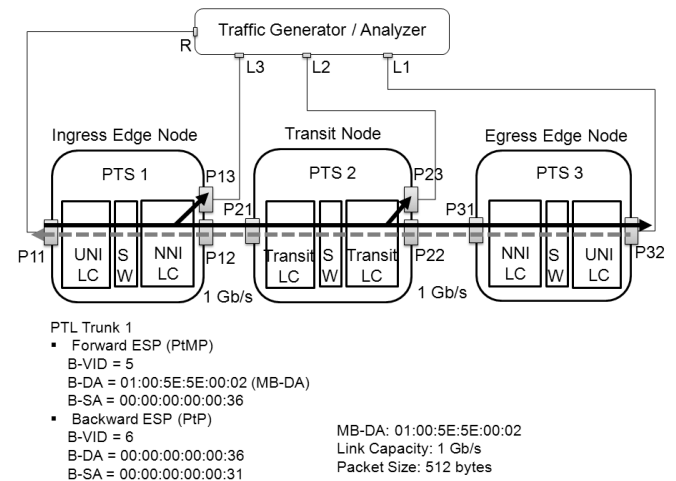


Fig. 9. Test configuration of the bidirectional PtMP service

Customer packets at the rate of about 960 Mbps except inter-packet gap and preamble were transmitted from the R port of the traffic generator to the P11 port of the PTS 1 with the four service interfaces. The customer packets were untagged frames, C-tagged frames with the C-VID of 0x64, and S-tagged frames with the S-VID of 0xC8 according to the service interface types of port-based, C-tagged, IP-flow, and S-tagged. Packets were received simultaneously at the L3, L2, and L1 ports of the traffic analyzer connected with the P13 port of the PTS 1, the P23 port of the PTS 2, and the P32 port of the PTS 3.

Figure 10 described the frames captured at the L3, L2, and L1 ports. The frames output from the P13 and the P23 ports were MAC-in-MAC frames encapsulated with backbone VLAN tags (B-TAGs), on the other hand, the frames transmitted from P32 port of the PTS 3 were the customer frames that B-TAG was

removed in the egress edge node. When the L3 port of the traffic generator sent customer frames corresponding with various service interfaces, the only R port of the traffic analyzer received the customer frames.

Traffic Analyzer	Tag Type	Protocol	Packet View
L3 port	Backbone VLAN tag	Provider Backbone Bridging (IEEE 802.1AH)	B-TAG
	Multicast B-DA	B-SA	TPID B-VID
	01 00 5E 5E 00 02	00 00-00 00 00 36	88 A8 00 05
	88 E7 00 00 04 00	00 00-00 00 00 05	00 00 AA 00
	TPID 81 00 I-SID 4	08 00-45 00 01 EA	00 00 00 00
	I-TAG		
L2 port	Backbone VLAN tag	Provider Backbone Bridging (IEEE 802.1AH)	
	Multicast B-DA	B-SA	TPID B-VID
	01 00 5E 5E 00 02	00 00-00 00 00 36	88 A8 00 05
	88 E7 00 00 04 00	00 00-00 00 00 05	00 00 AA 00
	TPID 81 00 I-SID 4	08 00-45 00 01 EA	00 00 00 00
L1 port	Customer VLAN tag	VLAN-tagged frame (IEEE 802.1Q)	C-TAG
	C-DA	C-SA	TPID C-VID
	00 00 00 00 00 05	00 00-AA 00 00 02	81 00 00 64
	08 00 45 00 01 EA	00 00-00 00 40 FF	78 13 00 00

Fig. 10. Frames received in the three leaves

In order to evaluate traffic performance for PtMP services in the PTS, 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

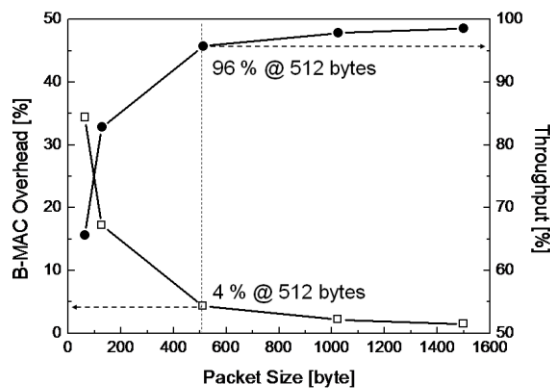


Fig. 11. Impact of B-MAC overhead on the traffic throughput according to packet sizes

Figure 11 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.

VI. CONCLUSION

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 since the PBB-TE technology does not allow MAC learning, spanning tree protocol, and broadcast of unknown frame for providing deterministic, protected, and connection-oriented trunks and services. Moreover, it has not been easy to classify layer 3 applications and services due to layer 3 service transparency of the carrier Ethernet transport. We have implemented the packet transport system based on PBB-TE, which provides the multicast services and the IP flow awareness. The PBB-based MPtMP solution have used MAC learning and spanning tree protocol used in the conventional bridge, however, MPtMP solution based on the PBB-TE have realized by the combination of point-to-point paths provisioned. Traffic throughputs for the packet of 512 bytes and the link capacity of 1 Gbps have been measured at port-based, C-tagged, S-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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