Implementation of VLAN Path Signaling with Domain Tag Swapping for GMPLS controlled Wide Area Layer-2 Network

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Abstract—Multi-domain GMPLS layer-2 switch capable network with VLAN tag swapping is demonstrated. In this demonstration, we verify three features, establishing path with designating VLAN ID, swapping VLAN ID on software switch, and management of VLAN IDs per domain.

I. INTRODUCTION

A wide area layer-2 network provides high-speed virtual line services among customers’ LANs. The virtual line can be called as a VLAN path, and can be established with VLAN technologies. A VLAN extended layer-2, namely Ethernet, frame has an extended VLAN ID/tag header. A layer-2 switch in the wide area layer-2 network forwards the layer-2 frame in accordance with the VLAN ID and the destination MAC address of the frame. Therefore, when establishing or tearing down a VLAN path, VLAN configuration of all layer-2 switches along with the VLAN path is required.

Generalized Multi-Protocol Label Switching (GMPLS) [1] can be used for automatically set up and tear down of the label switched path (LSP). On demand LSP provisioning from customers is also possible by GMPLS. Within a framework of GMPLS, it is possible to make automatic VLAN path configuration to the layer-2 switches. An automatic VLAN path configuration technique is important challenge especially for the wide area network. In order to accomplish this challenge, the Internet Engineering Task Force (IETF) started to make a framework of the automatic VLAN path setting protocol, namely GMPLS Ethernet Label Switching (GELS) [2].

In the conventional wide area Ethernet, the same VLAN ID value must be used at all Ethernet switches along with the VLAN path. This is because, the Ethernet standard [3] does not allow to assign different VLAN IDs along with the VLAN. However, the range of the VLAN ID value is limited due to 12 bits VLAN tag format, and the assumed network size (number of nodes and paths) is quite large. Thus, when a lot of VLAN paths are established in the network, discovering a commonly unused VLAN ID is quite hard.

To solve this problem, a VLAN tag stacking (Q-in-Q) [4] technology and a MAC encapsulation (MAC-in-MAC) technology are developed. GMPLS can be applied to control the Q-in-Q network and MAC-in-MAC network. However, to set up an end-to-end (user-to-user) on demand VLAN path, multi-layer GMPLS signaling technique is required. To avoid the multi-layer signaling, we challenge to apply a VLAN tag swapping method at domain border nodes. The VLAN

II. LAYER-2 NETWORK ARCHITECTURE

In this section, a multi-domain wide area network architecture is discussed. Figure 1 shows an assumed GMPLS controlled network architecture. The network size is nationwide and the network consists of several domains. A resource manager addresses all node resource information that includes link resources, switch resources, and VLAN resources. In case of the new VLAN path setup, an ingress node asks the explicit route information which includes node-IDs of switches and VLAN IDs of links to the resource manager before making a GMPLS RSVP-TE PATH message. The resource manager computes the route from the ingress node to the requested destination node, makes the explicit route information, and sends the information to the ingress node.

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Fig. 1. GMPLS layer-2 switch capable network architecture
tag swapping enables per domain VLAN ID assignment. Therefore, the resource manager easily searches the commonly unused VLAN ID only within the domain. The detailed description of the resource manager and the VLAN path calculation method is out of the scope of this paper.

We implement a VLAN tag swapping function on a Linux PC based software layer-2 bridge/switch. To control the VLAN tag swappable switches and the conventional no-swappable switches, label usage of the GMPLS RSVP-TE is extended.

III. EXPERIMENTS AND RESULTS

A. Experimental Network

Figure 2 shows an experimental network diagram. This network emulates a part of the wide area layer-2 network shown in Fig.1. There are two domains in the network, and each domain has three nodes. Two swapping nodes which support VLAN tag swapping function located at domain border, are composed of the GMPLS program and the software layer-2 switch program. Four no-swapping nodes are composed of the GMPLS program running on the Linux PC box and the commercially available Ethernet switch. GMPLS RSVP-TE and GMPLS OSPF-TE are run in all nodes. When proper PATH and RESV messages are received, all software and hardware switches are configured and an end-to-end VLAN path is established.

![Fig. 2. An experimental network diagram](image)

B. VLAN path signaling with domain tag swapping

The ingress node sends a RSVP PATH message to the egress node for establishing a VLAN path. Figure 3 shows a schematic diagram of the VLAN path setup signaling. In this figure, the ingress node “A” sends a PATH message to egress node “F”, passing domain border nodes “C” and “D”. The PATH message includes explicit route object (ERO) which indicates a path route to the egress node “F”.

Implemented RSVP-TE program is extended to designate ERO including not only the router-ID but also labels (this is defined in [6]). The VLAN ID of each link is addressed in the generalized label. This feature was already shown in [5]. The ingress node can designate all VLAN IDs along with the VLAN path by receiving the ERO information from the resource manager. In Fig.3, the VLAN path can be established with VLAN ID=200 in the domain X, VLAN ID=60 at the inter-domain link, and VLAN ID=150 in the domain Y, that can be designated by ingress node.

In this experiment, two signaling methods are tried. In the first case, the ingress node designates all VLAN IDs on the VLAN path. This is possible if the resource manager can get all domains’ unused VLAN IDs. For example, resource managers of all domains communicate and exchange the unused VLAN ID information each other. In the second case, the ingress node designates the explicit route and labels only within the domain. It is assumed that the resource manager knows the status of VLAN ID resources within the own domain. In Fig.3, an asterisk means not specified VLAN IDs. When the node “D” receives the PATH message, “D” asks to calculate the ERO to the resource manager within the domain.

The implemented VLAN path control mechanism with the Domain Tag Swapping function is successfully demonstrated at the iPOP 2008 Exhibition [7]. Both signaling methods and interoperability among Ethernet switches and software switches are confirmed.

IV. CONCLUSION

The GMPLS controlled wide area layer-2 network is applicable to the next generation transport network infrastructure. We successfully demonstrated that the VLAN path signaling with the domain tag swapping.

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REFERENCES