Development of the FITELnet-G20 Metro Edge Router

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ABSTRACT With the increasing use of broadband Internet, it is to be expected that fiber-to-the-home (FTTH) service will expand as the means of providing access. And as communications carriers are moving toward IP-based data networks that include voice telephony, requirements for higher performance, greater functionality and higher reliability will be placed on metro edge routers. To respond to these requirements we have developed the FITELnet-G20 metro edge router, which realizes high functionality in the form of QoS, multicasting and virtual private networks (VPNs) based on multi-protocol label switching (MPLS), of which carriers are in great need, by means of full-wire-rate relaying without degradation of performance.

1. INTRODUCTION

With the higher speeds of broadband access lines, the expansion of Internet architecture using the VPN services provided by communications carriers and the establishment of regional information networks, the traffic on IP networks is expanding year by year. Moreover carriers and service providers are also moving toward voice-over IP (VoIP), real-time content distribution, and multifunctional services such as IP-VPN and L2-VPN using MPLS.

This presents the metro edge routers, which connect user access networks and core networks, with requirements for higher performance in relaying data without stress and higher functionality with respect to various services, together with higher service reliability.

At the end of 2001 the FITELnet-G12 was introduced to target Ethernets, which are coming into wider use in a number of markets that exceed the scope of LANs --backbones, metropolitan area networks (MANs) and wide area networks (WANs). In this paper we report on the development of the FITELnet-G20 metro edge router (Photo 1), which represents an extension of the technology of the FITELnet-G12, offering significant improvements in scalability, functionality and performance, plus the performance and high-grade functions only achievable with a backbone core router.

Photo 1 Appearance of FITELnet-G20 metro edge router.

2. FUNCTIONS

In order to allow carriers to operate network services in an economical yet effective manner, and to realize high-quality IP communications in an enterprise environment that uses high-grade applications, the FITELnet-G20 metro edge router is provided with the functions described below.

2.1 Large-Volume Routing Information

The FITELnet-G20 makes possible the handling of sufficient routing information (VRF) and label information to cope with Internet full routes and the IP-VPNs of communications carriers. Table 1 shows the specifications for the route information, etc. for the FITELnet-G20. The FITELnet-G20 is capable of full-wire-rate relaying while searching these large databases.

2.2 VLAN Multiplexing

The FITELnet-G20 supports 2000 802.1q-tag-VLANs and 26 port-VLANs with respect to tag-VLAN and 26 port VLANs on giga-Ethernet and fast Ethernet. For each VLAN it is possible to set whether either IPv4 or IPv6 operates or not. And by using the VLAN aggregation function for IPv4 or by setting individual subnets for IPv6,

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Table 1 Specifications of FITELnet-G20 metro edge router.

No. of VLANs	100 per FE, 1000 per GE (Total: 2026)
IPv4 logic IFs	2,000
L2 MAC learning tables	300,000
IPv4 routing information items IPv6 routing information items	300,000 200,000
ARP entries	50,000
IP-VPN Max. VRF	2,000
MPLS label paths	20,000
MPLS pairs	128
Access list entries	1000 per FE, 10,000 per GE (Total: 20,000)

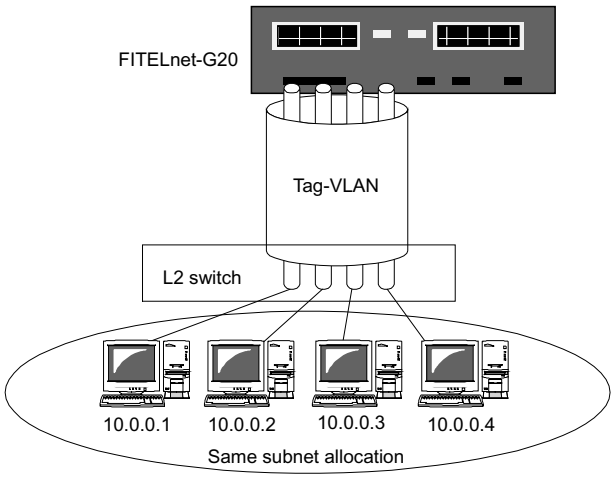

Figure 1 Network segmentation on same subnet using VLAN aggregation.

it is possible to separate address maps into VLAN units [1]. In the address separation environment, the security of each separated segment is assured by parallel use of the ARP filter function. In this way it is possible to realize, in an IP network system, a user accommodation that is both secure and scalable. See Figure 1.

The FITELnet-G20 also makes possible the free setting of broadcast domains. It is possible, for example, to aggregate different 802.1q VLAN tag-terminal interfaces in the same broadcast domain. Similarly in relaying, when, for example when a tag 100 interface and tag 200 interface are set to the same broadcast domain, layer 2 relaying is possible between terminals beyond both of the interfaces. In this case transmission is accomplished by changing the tag in accordance with the interface.

The FITELnet-G20 also makes it possible to set broadcast domains for each protocol. This enables layer 3 relaying for L3 frames such as ARP, or IPv4 and IPv6, and layer 2 relaying for others within the broadcast domain (Figure 2).

2.3 QoS/CoS Functions

When multiple users are aggregated by VLAN multiplexing on a single Ethernet, it may happen that the maximum traffic of one of the users occupies

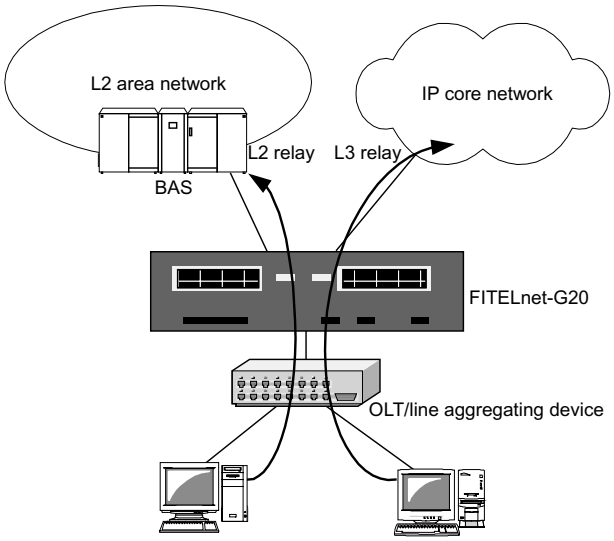

Figure 2 Protocol bridging function.

virtually all of the Ethernet bandwidth, interfering with the communications of the other users. To avoid such a situation, QoS is needed to guarantee bandwidth to each user.

The FITELnet-G20 offers the following full range of QoS/CoS functions:

1) Supports PPQ developed by RIC as well as DiffServ;
2) Offers a fairness function for each VLAN. During VLAN fairness operation, maximum rate control per VLAN and bandwidth control with respect to VLAN groups are enabled. In addition, other traffic such as VoIP can be handled by configuring priorities within the VLAN.
3) Detailed policing is made possible by means of access lists.
4) Policing of both input and output interfaces is supported for each VLAN. Shaping at output interfaces is also supported. This makes possible detailed bandwidth control to the user side.

The FITELnet-G20 thus realizes the above QoS functions in a wire rate communications environment. The architecture for the rapid realization of complex QoS functions is as shown in Figure 3.

2.4 Multicasting

The use of multicasting makes it possible to realize large-scale real-time content distribution or delivery, something that was impossible on conventional, mainly unicast, contents delivery networks (CDNs). In addition the FITELnet-G20, by collaboration with a RADIUS server at the service provider edge, has the function of relaying only data addressed to authenticated users. In this way a CDN can be so configured as to realize general-purpose user authentication and accounting management, irrespective of the delivery server or user environment (Figure 4). And with QoS corresponding to multicasting, video traffic by multicasting are guaranteed even in situations where various traffic is mixed, thereby enabling service differentiation.

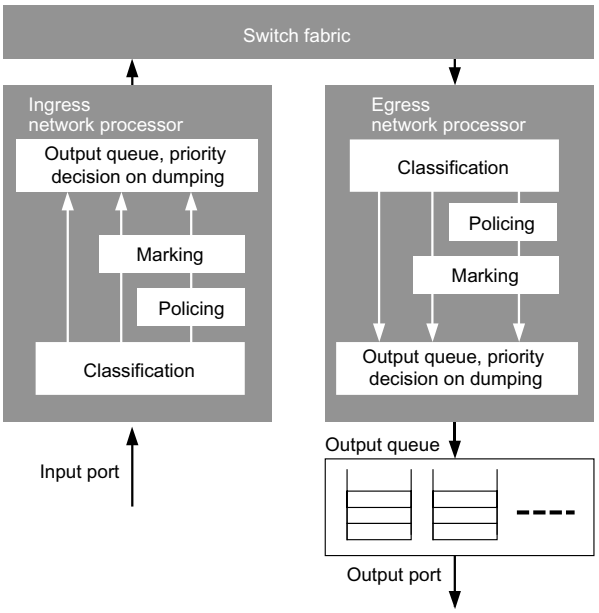

Figure 3 Forwarding flow.

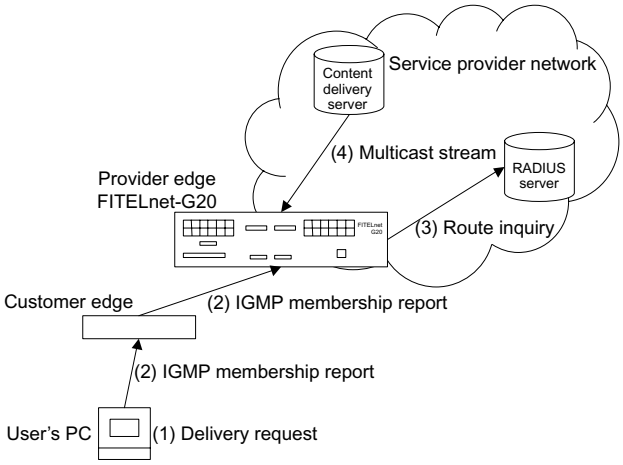

Figure 4 Typical configuration for content delivery system.

2.5 Multi-Protocol Label Switching (MPLS)

Since the time of the FITELnet-G12, forerunner to the FITELnet-G20, we have participated in various MPLS forums and interconnectivity tests, establishing a proven track record in interconnectivity. With the FITELnet-G20 this activity has continued, providing a wide range of MPLS functions (see Table 2).

2.5.1 VPN

MPLS has received attention as the backbone protocol for virtual private network services provided by communications carriers.

The FITELnet-G20 establishes a label switched path (LSP) for a maximum of 50,000 pairs, enabling the configuring of IP-VPNs using the RFC2547bis standard, and L2-VPNs that provide label switching by looking at the MAC Destination Address of the Ethernet frame. It also supports connection to wide-area Ethernet services like metropolitan area networks (MANs) and L2-VPNs.

Table 2 MPLS functions of FITELnet-G20.

IP-VPN	RFC2457bis	○
	No. of VRFs	2000
	Tag-VLAN collaboration	○
Signaling	LDP	○
	LDP expansion (port 711 compatible)	○
	RSVP-TE	○
Traffic engineering	Static	○
	OSPF-TE	○
	IS-IS-TE	○
QoS/CoS		○
L2-VPN (TLS)		○

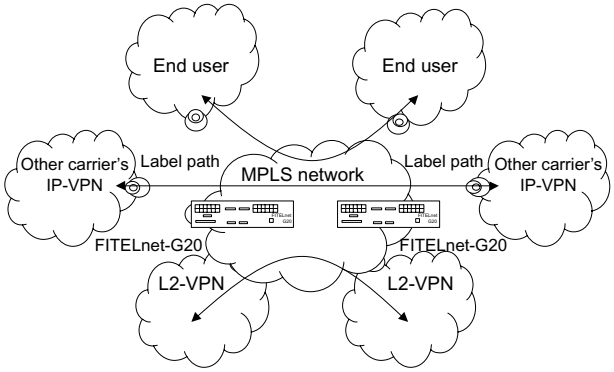

Figure 5 Typical configuration for MPLS-VPN service network.

2.5.2 MPLS-IX

MPLS-IX, which uses MPLS with IX, a technology for interconnection between ISPs, has received attention. Since it is not restricted with respect to data link media, it allows use of wide-area link media such as POS, and is recognized for enabling wide area dispersal of IX. R&D and technology verification are being carried out primarily by distix (next-generation IX research group) [2].

FITELnet-G20 supports the functions required to configure MPLS-IX, including C'sC, LDP on RSVP, and LDP on LDP, accommodating to various types of MPLS-IX (Figure 5).

2.5.3 MPLS QoS

The label path of ordinary MPLS is determined by the IP Destination Address. Thus data destined for the same IP network will pass over the same label path. For this reason, even when a path through which data for a certain IP network passes changes to a congestion state due to other traffic, the data must pass that path. To overcome this problem the FITELnet-G20 is provided with an MPLS QoS function. When MPLS QoS is used the label path is controlled not only by the IP Destination Address, but by a flow that can be designated by a transmitter address or other access list, thereby in effect enabling traffic control to be carried out for the network as a whole (Figure 6).

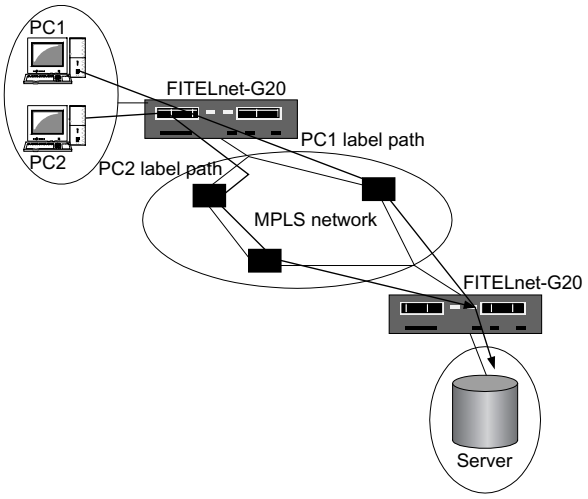

Figure 6 Typical configuration for MPLS-QoS.

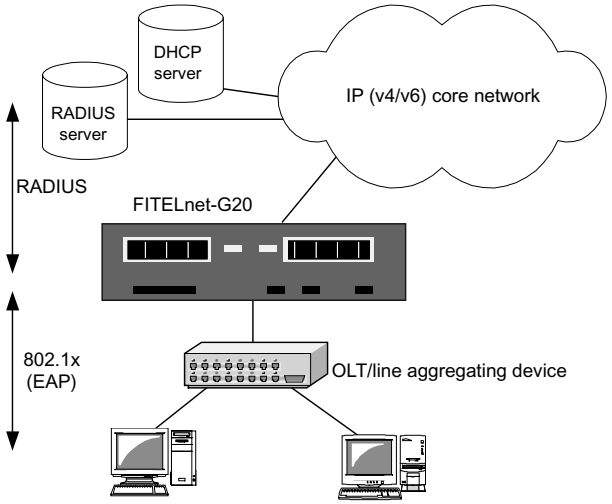

Figure 8 Typical configuration for authentication on network access.

2.6 IPv6

An IPv4/v6 dual stack is provided, thereby supporting a v4 tunnel and v6 tunnel as solutions for transferring from v4 to v6. It also makes it possible for v6 users to be connected over a v4 network (v6 over v4), and conversely for v4 users to be connected over a v6 network (v4 over v6). See Figure 7.

2.7 Access Authentication

The FITELnet-G20 performs user authentication using IEEE802.1x and RADIUS and distributes addresses for authenticated users only, thereby realizing secure plug & play at the edge router [3].

Specifically it expands the concept of 802.1x port authentication at the edge router, performing all authentications with respect to port, VLAN and MAC address.

Automatic address setting for hosts that have been authenticated is carried out for IPv4 by DHCP and for IPv6 by router advertisement. These mechanisms provide a plug & play function of assured security (Figure 8).

3. PERFORMANCE

In relaying equipment functionality and performance are in a trade-off relationship, in which greater sophistication of function brings a comparable drop in performance. For example if the number of items of routing information held is increased the number of routing searches with respect to a certain address also increases, so that the search requires a longer time and relaying performance decreases. Similarly if set to detailed policing, the number of judgment criteria with respect to transferred data increases, and performance again tends to decrease. Enhancing hardware resources to increase speed

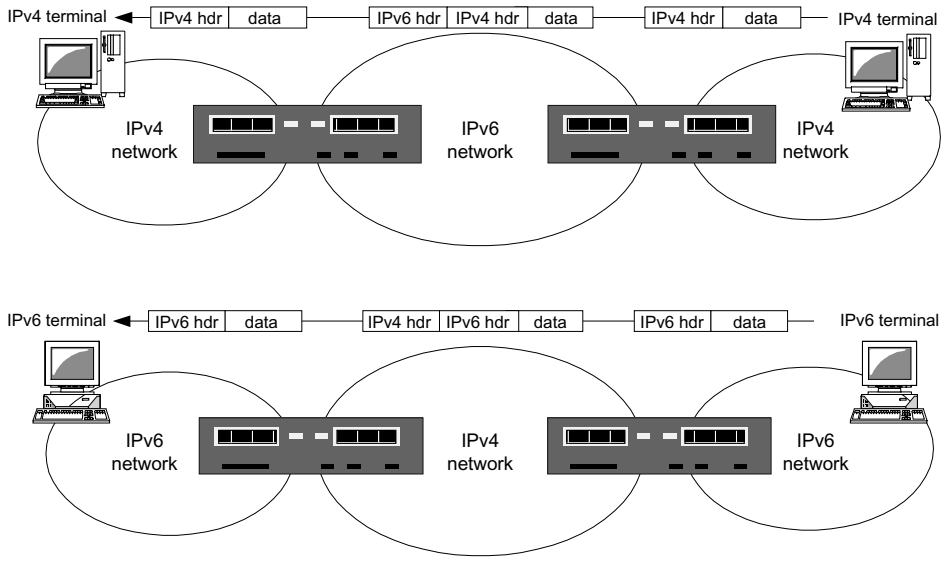

Figure 7 v4 over V6 and v6 over v4.

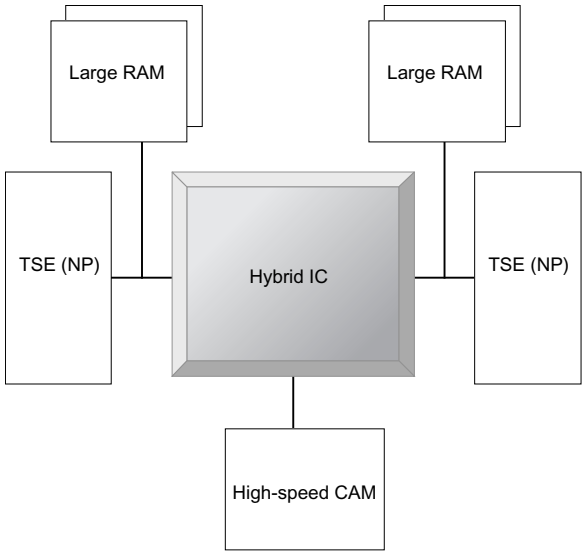

Figure 9 Hybrid method using CAM and tree search engine.

will obviously cost higher. The FITELnet-G20 uses a programmable high-performance network processor and incorporates other techniques for increasing performance, so that it can provide higher functionality, higher performance and lower cost.

3.1 High-Speed Searching with a Hybrid (CAM+TSE) Method

Since the FITELnet-G20 handles 300,000 entries of routing information, higher speed searching of this huge volume of data for the required information is the key to higher performance. Hardware-based search techniques may be broadly divided into two types:

1) Content addressable memory (CAM), and
2) Tree search engines (TSE).

CAM methods are capable of extremely fast searches, but cost increases in proportion to the number of data items searched. TSE methods, on the other hand, use inexpensive memory and therefore realize cost savings, but the search time tends to increase rapidly with the number of search targets. The FITELnet-G20 adopts a hybrid system that combines the advantages of these two methods (Figure 9).

The FITELnet-G20 achieves even higher efficiency by sharing the high-cost CAM among a number of network processors. It incorporates logic for effecting this sharing and, by developing custom logic that clears the CAM access bandwidth bottleneck due to sharing, and achieves asynchronous CAM access from multiple threads of the high-speed network processors, thereby realizing CAM sharing.

3.2 Collaboration with QoS Functions

Another important work of the network processor's search function is to support QoS functions. As in routing searches, a variety of searches (access list searches) occur with respect to QoS. Each time a frame is relayed, the network processor searches the access list corresponding to that frame and if it gets a match, carries out QoS processing in accordance with the policing set up in the access list.

In access list searches, the FITELnet-G20 uses a portion of the CAM search from the hybrid search referred to above, making it possible to perform complex access list searches at high speed. This high-speed search capability makes possible the complex MPLS QoS function with no degradation of performance.

4. CONCLUSION

In this paper we have reported on the functions of the FITELnet-G20 metro edge router, and on the techniques used to realize them. Making use of programmable network processors and accumulated network solution technologies, we believe we have developed a metro edge router that can meet the needs of customers. We believe that in the future new requirements will be placed on metro edge routers with respect to functionality and performance, as well as scalability, and we intend to respond with flexibility.

REFERENCES

1) D. McPherson and B. Dykes, "VLAN Aggregation for Efficient IP Address Allocation," Feb.2001, RFC3069
2) Nagami, Nakagawa et al., Design of Distributed IX Architecture Using MPLS (in Japanese)
3) IEEE Std 802.1x-2001 Port-Based Network Access Control