Gigabit Routers for Advanced IP Networks

Naoya Ikeda
Kenji Hayashi
Yoshifumi Atarashi

OVERVIEW: The Internet and intranets have become very important infrastructures of information technology (IT). While IP traffic volume continues to increase day by day, causing serious congestion, the data for various new types of IP-based applications, such as animated images, voice, and mission-critical e-trading, are being sent over the same IP network at the same time. Because each type of application traffic has specific flow characteristics, each type must be handled with a certain level of guaranteed quality. To meet these quality of service (QoS) requirements, Hitachi developed the GR2000 gigabit router series and began shipping it in February 1999. Hitachi enhanced its performance and added more features in July 2000. The GR2000 takes advantage of such state-of-the-art technologies as high-speed communication, QoS control, and IPv6, so it can be used to construct advanced IP networks. Today, many customers are using the GR2000 to operate their networks.

INTRODUCTION

IP (Internet protocol) networks play a key role in the current communication infrastructure. This is because traffic of various applications, such as animated images, voice, and trading information, are carried on the same network.

Traditionally, networks have provided only “best-efforts-type services,” which means “first come, first served” in terms of bandwidth. Today, network applications require certain levels of quality because each application has particular traffic characteristics. For example, some applications need real-time communication but not large bandwidth. In addition to a guaranteed quality of service (QoS), some IP technologies, for example IP multicasting and IPv6 (IP version 6), are needed for next-generation IP network services.

To meet the requirement for such advanced networks, Hitachi developed a gigabit router, the GR2000, for use in business backbone networks. Hitachi started shipping the GR2000 in February 1999, and many customers are now using it in their networks. Furthermore, Hitachi is continuing to enhance the functions and performance of the GR2000 and is testing new features on experimental networks. In this paper, we describe the GR2000, especially its high-speed processing, QoS functions, and IPv6 functions from the viewpoint of network solutions.

HIGH-SPEED PROCESSING

Hitachi introduced five new models of the GR2000, GR2000-2S, -4S, -6H, -10H, -20H in 2000 and now has a lineup of eight models. These additions were made so as to better fit customers’ networks. The new GR2000-2S is for enterprise networks, and the new GR2000-6H is for common carriers and data centers. The new GR2000-20H is for the backbone network of common carriers; it can handle up to 40,000,000 packets per second (40 Mpps). The five new models use the same basic architecture as the three original models.

The GR2000 achieves gigabit performance by using proprietary hardware for packet processing. It is important for an IP network serving as a business infrastructure to have high-speed processing capability in the real field. The GR2000 supports high-speed processing in four ways.

(1) In a QoS-controlled environment

A gigabit-class network should perform at high speed even when handling QoS-guaranteed services, like priority-control services. The GR2000 can do this because its QoS-control mechanism is based in hardware.

(2) In multicast communication

Before sending multicast packets to other routers or hosts, a router must copy the packets inside itself. Routers based on software cannot do this with high performance. The GR2000, however, can make copies of multicast packets inside itself using proprietary hardware, so performance remains high. It is thus suitable for services that require real-time multicast communication such as a stock-quotation information service.

(3) In packet filtering

In actual network operations, packet filtering is needed for security. In general, routers based on software slow down greatly when filtering packets. The GR2000 does not because it uses proprietary hardware. It is thus suitable for constructing secure high-speed networks.

(4) In MPLS label insertion

Most common carriers will use multi-protocol label switching (MPLS) technology to control traffic and for their virtual private networks (VPNs) service. In general, the MPLS edge routers insert a label into each packet by software, which slows down the network. The GR2000 does not do this because of its hardware-based label insertion. It is thus suitable for high-speed subscriber services provided over an MPLS-VPN.

QoS FUNCTIONS

(1) Need for QoS functions and their application to large-scale networks

The purpose of the QoS functions is to customize the performance of a network to meet the needs of each user or each application. A general example of a QoS-controlled wide area network is shown in Fig. 1. The IP packet data (IP flows) that are QoS guaranteed have first call on the bandwidth, and the non-guaranteed flows share the remaining bandwidth.

Several types of networks have been constructed using the QoS functions of the GR2000, including IP-integrated enterprise backbone networks and large-scale public networks.

A router providing QoS functions in a wide area network should

(a) finely control the traffic according to the specific characteristics of each flow,

(b) control the number of simultaneous IP flows, and

(c) be easy to configure and operate.

(2) Example of wide area enterprise network using QoS functions

Hitachi is now restructuring its existing enterprise network to integrate voice and data by using VoIP (voice over IP) technology and the GR2000, as illustrated in Fig. 2. In the existing network, time division multiplexing is used. The purpose of the restructuring is to reduce costs by using the IP-gateway (IP-GW), which converts voice to IP packets. In this new network, voice IP packet flows, which are critical to delays, are protected by prioritizing the bandwidth for many voice communication channels. Mission-critical traffic is also protected by prioritizing the bandwidth.

The GR2000 was also used in the Cyber Kansai Project (http://www.ckp.or.jp), which tested a very challenging experimental network using Diff-Serv (differentiated services) technology based on the IETF standard. MPEG-2 video streams and heavy traffic in

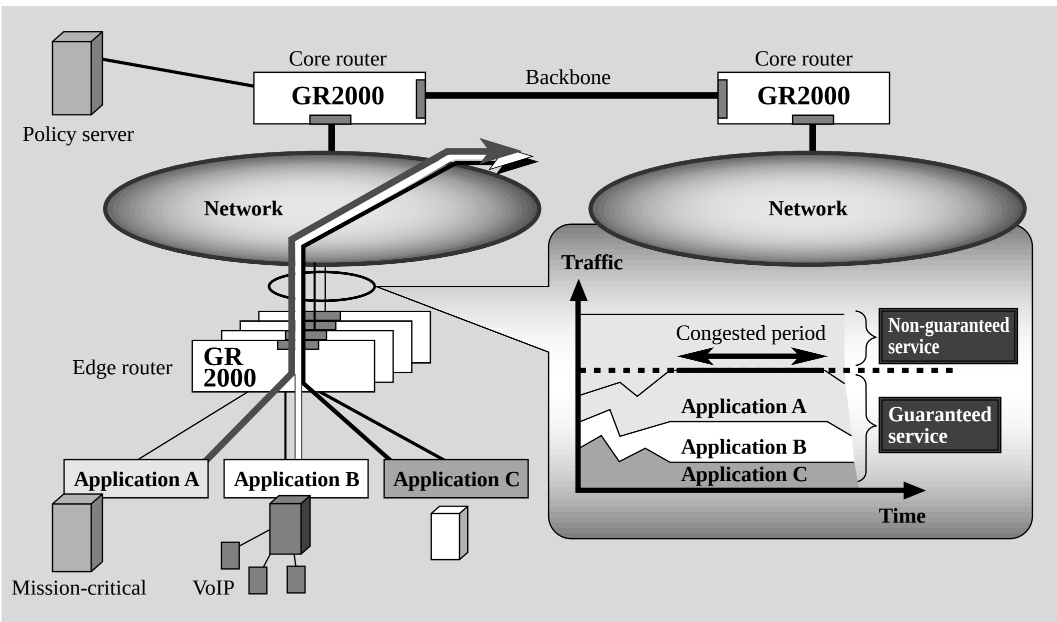

Fig. 1—General Example of QoS-Controlled Wide Area Network.
The GR2000 can finely control the IP QoS according to the application characteristics.

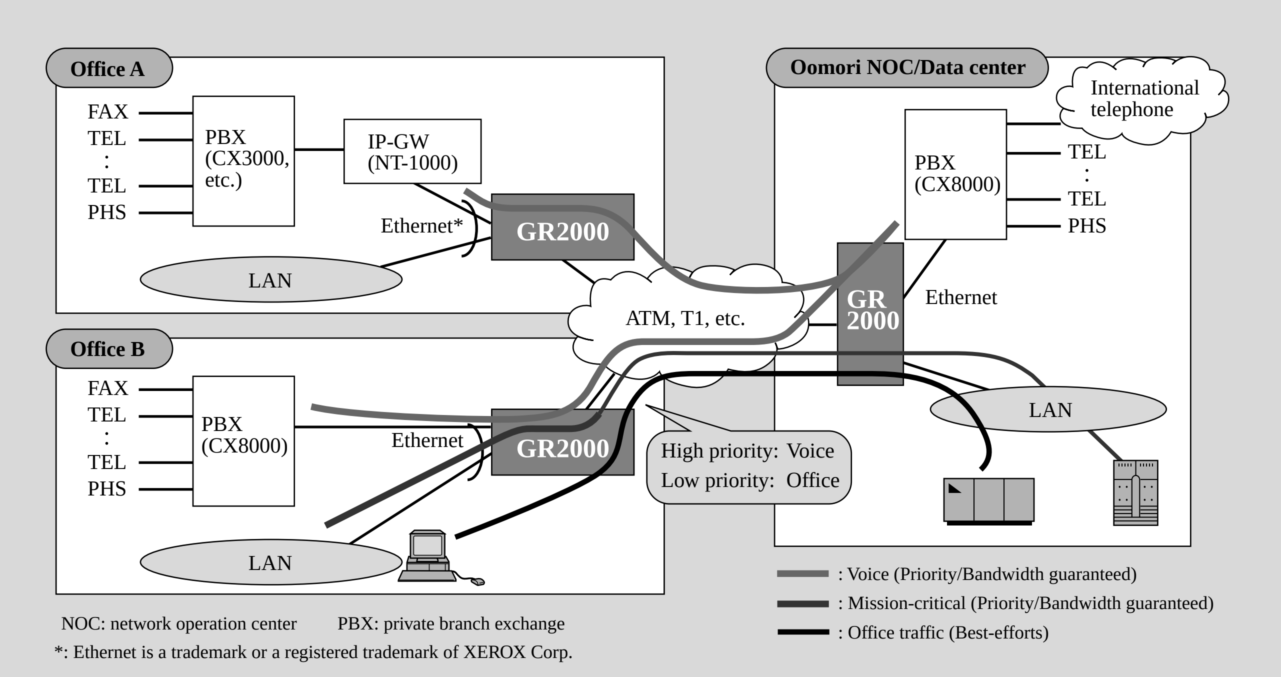

Fig. 2—Hitachi's New Backbone Network Using the GR2000's QoS Functions.
Hitachi's new network uses QoS control of the GR2000 to protect and prioritize voice and mission-critical business traffic.

the networks between Tokyo and Osaka were used to verify the Diff-Serv-based QoS of a next-generation wide area network. The GR2000 used in the experiment also had the Diff-Serv function, provided by its proprietary hardware.

(3) Policy-based QoS network management

In a large-scale network, the traffic characteristics change dynamically. For example, even in the same application, the priority may vary with the time zone. Hitachi is now developing a QoS-managed network system that uses the GR2000 in combination with a QoS policy server. It will support automatic dynamic QoS management.

IPv6 FUNCTIONS

(1) Scarcity of IP addresses under current system

The explosive growth of the Internet is causing a scarcity of IP addresses, and the problem is becoming worse every day. In the current IP address structure, "IPv4 (IP version 4)," the address space is 2^{32} (about 4 billion), which is not enough for future Internet services. Network address translator (NAT) technology is being used to resolve the problem temporarily. NAT translates many private addresses into a few global addresses. However, this is not an ideal solution, especially for today's Internet services. In the future,

TABLE 1. Problems Caused by Scarcity of IP Addresses
The scarcity of IP addresses has been resolved by ad-hoc (e.g., NAT) over the last five years. However, there are still problems such as duplication of private IP addresses and restrictions on applications.

	Solutions till now	Current problems
Company/ Campus	• Use private IP addresses for intranet • Translate global IP address when internal hosts access external servers	• VPN construction is difficult because NAT is unidirectional ("private" to "global") • Duplication of IP addresses on merger, etc. • Application restriction (e.g., ftp isn't available) • Increasing operation/ administration costs
Carrier/ISP	• Temporarily assign IP addresses to users when session is linked up • Use private IP addresses and network address translator	• Semi-static address assignment because of permanent connection services • Difficulty of services in increasing number of users, hosts and network devices • Increasing operation/ administration costs

NAT: network address translator

even more various Internet services and applications will be created, so that NAT will not even be a good solution, as shown in Table 1.

(2) Status of IPv6

The next-generation Internet protocol, IPv6, is the technology standardized by the IETF to succeed IPv4. IPv6 has a huge address space, 2^{128}. It will not only improve network scalability, it will make it easier for enterprise users and carriers to design and operate networks. However, the terminal equipment and network equipment needed for IPv6 was not yet available, although many IPv6-compatible products have been developed and some equipment and software such as Solaris*[1] and Windows 2000*[2] are available as products or trial versions this year. Some common carriers and service providers have announced that they will start commercial services using IPv6 this year.

(3) Hitachi's activities related to IPv6

Hitachi has been a leader in undertaking activities related to IPv6 technology. Hitachi is a member of the KAME project (http://www.kame.net), which is developing and deploying IPv6 software.

Hitachi has transported the KAME protocol stack to the GR2000 and has tuned it for the GR2000 architecture. An IPv6-compatible-version of the GR2000 has already been used on dozens of trial networks. This version of the GR2000 is based on software to improve flexibility. Hitachi is planning a new version based on IPv6 hardware with the same performance level as current IPv4 hardware. In addition, Hitachi has tested the interoperability of IPv6 between the GR2000 and other vendors' equipment.

CONCLUSIONS

We have described Hitachi's GR2000 gigabit router series and presented examples of the solutions it provides. The GR2000 has received several awards, including the R&D 100 award by R&D Magazine and the grand prize in the carrier infrastructure construction product section at Networld+Interop 2000 TOKYO. Hitachi will continue to improve the performance and capabilities of the GR2000 in order to offer the best solutions to its customers.

*[1]: Solaris is product name of Sun Microsystems, Inc.
*[2]: Windows 2000 is a registered trademark of Microsoft Corp. in the U.S. and other countries.

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ABOUT THE AUTHORS

Naoya Ikeda
Joined Hitachi, Ltd. in 1981, and now works in the Network Solution Department of the Enterprise Server Division. He is currently engaged in development of network solutions and new technologies. Mr. Ikeda is a member of the Information Processing Society of Japan, and can be reached by e-mail at nikeda@ebina.hitachi.co.jp.

Kenji Hayashi
Joined Hitachi, Ltd. in 1986, and now works in the Platform Systems Planning Department of the Enterprise Server Division. He is currently engaged in development of marketing and planning for network and system products. Mr. Hayashi is a member of the Information Processing Society of Japan, and can be reached by e-mail at knhaya@kanagawa.hitachi.co.jp.

Yoshifumi Atarashi
Joined Hitachi, Ltd. in 1991, and now works in the Network Solution Department of the Enterprise Server Division. He is currently engaged in development of network solutions and new technologies. Mr. Atarashi is a member of the Information Processing Society of Japan and the WIDE project, and can be reached by e-mail at atarashi@ebina.hitachi.co.jp.