Carrier Network Infrastructure for Integrated Optical and IP Network

Noboru Endo, Ph. D.
Morihito Miyagi
Tatsuo Kanetake, Ph. D.
Akihiko Takase, D. Sc.

OVERVIEW: As more and more services become available on the Internet, carrier IP networks are becoming more of a social infrastructure. They and their nodes must thus support higher speeds, larger capacities, and higher reliability. In this paper we describe Hitachi's carrier IP network systems and how they fulfill these requirements. For backbone IP networks Hitachi provides a large-capacity, multi-functional IP node, the GR2000, and is developing a next-generation tera-bit-class IP node architecture. For backbone and metropolitan optical networks, Hitachi provides SONET/SDH and DWDM transmission systems. Furthermore, a transparent transponder multiplexer system has been developed to facilitate adaptation of legacy low-speed traffic to high-speed networks. For access networks, Hitachi is developing a scalable, multi-layer switching access node architecture. For service and operation support, Hitachi has proposed a novel active network technology for providing new services. Additionally, an operations support system is available for flexibly introducing services and reducing operation costs.

INTRODUCTION

THE Internet is growing to a worldwide scale, and the volume of Internet traffic has been doubling every four to six months. The various applications, such as the World Wide Web and electronic commerce, running on the Internet are turning the carrier IP (Internet protocol) networks that serve as the Internet backbone into a social infrastructure. These IP networks and their nodes must thus support higher speeds, larger capacity, and higher reliability[1)]. Various services, e.g., quality of service (QoS) guaranteed, virtual private networks, and multicasting, should be supported on carrier IP networks at low cost.

To meet the need for high-speed, large-capacity, and highly reliable carrier IP networks, Hitachi provides such products as the GR2000 backbone IP node and the AMN5192 10-Gbit/s transmission system.

In this paper we describe Hitachi's carrier IP network solutions for backbone networks, access networks, and service and operation. We also discuss the IP network architecture of the future, an integrated optical and IP network, and its migration scenario.

HITACHI'S CARRIER NETWORK SOLUTION

Hitachi provides a wide range of carrier network solutions, from a backbone network node to service and operation, as shown in Fig. 1. In this paper, we summarize these solutions; they are discussed in detail in other papers in this special issue.

Backbone Network

(1) IP network

Hitachi provides the GR2000 backbone IP node to support the need for higher transmission speed, capacity, and reliability. The GR2000 supports various functions, including high-speed packet forwarding, QoS control, multicasting, hardware filtering, and multi-protocol label switching (MPLS), and is currently in actual use.

To meet the need for expanded IP network capacity in the future, nodes will need to have an architecture that enables a large number of links to be accommodated, which will require systems that can switch a number of ports at high speed. We are developing a scalable architecture that supports large-capacity switching, high-speed links, and high port

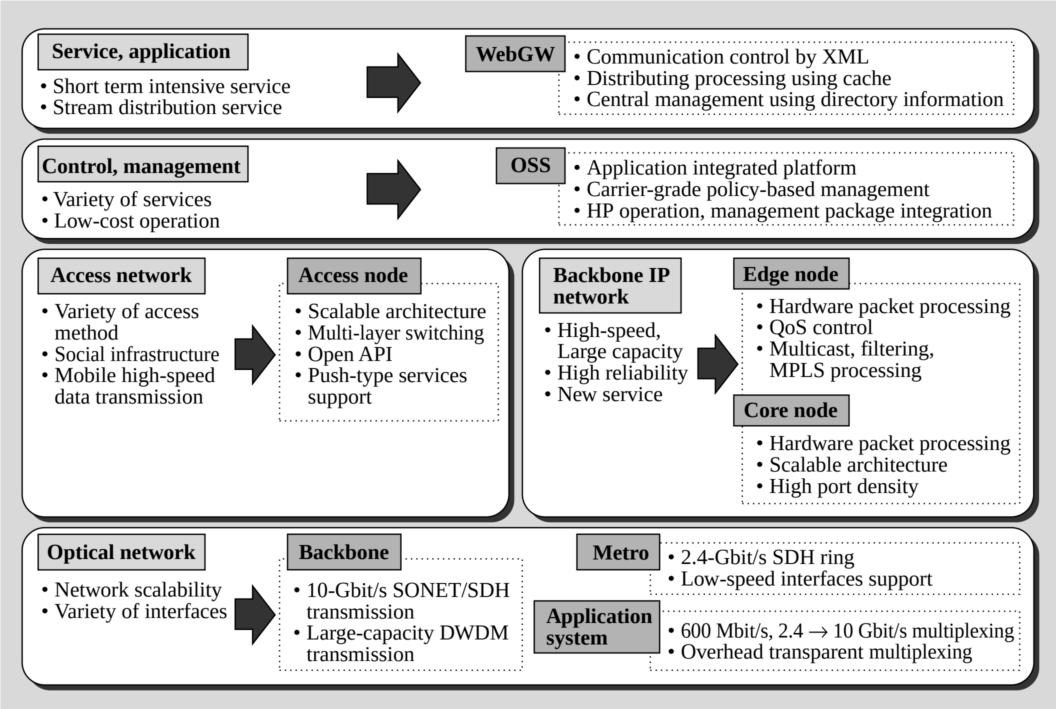

Fig. 1—Hitachi's Carrier Network Solutions.
Hitachi provides various carrier network solutions, covering backbone networks, access networks, and service and operation.

density for next-generation nodes with tera-bit capacity[2)].

(2) Optical Network

In an optical network, it is important to provide solutions for various requirements such as network scalability and support for various types of interfaces.

To meet these requirements for a backbone optical network, Hitachi provides a 10-Gbit/s SONET (synchronous optical network)/SDH (synchronous digital hierarchy) transmission system, the AMN5192 series, and a large-capacity DWDM (dense wavelength division multiplexing) system, the AMN6100 series. For metropolitan optical networks, Hitachi provides a 2.4-Gbit/s SDH system, the AMN5048 series, and a small-capacity DWDM system with various low-speed interfaces, the AMN601A and AMN601S series. These devices enable the configuration of a ring-type network.

Hitachi also provides a transparent transponder multiplexer system, the AMN4100 series, which multiplexes and transparently transmits the traffic of legacy 2.4-Gbit/s and 600-Mbit/s networks to the lines of 10-Gbit/s networks while keeping the operation information of the legacy networks as intact as it is.

Access Network

Since the IP network is becoming a social infrastructure, as mentioned above, high reliability is also required for the access system located at the entrance to the network. In addition, many functions such as media termination, user management, inter-working, and customizing are required, because various access methods and user requirements co-exist in the access network. To satisfy these requirements, we are developing a scalable access node architecture that uses a multi-layer-switching function. In this architecture, the open application programming interface (API) is used, facilitating the introduction of new services and customization for individual users.

For the mobile access network, high-speed data transmission and new contents-distribution services will come about in the near future. Hitachi is thus studying systems that can provide novel push-type services using high-speed data-transmission features in the mobile environment.

Service and Management

(1) Service

In the future, such Internet services as stock trading, ticket selling, and video and voice distribution are expected to grow drastically. To support these services, Hitachi proposes a solution using a novel active network technology. It distributes the processing of user requests by using cache data and enables quick responses to requests from a large number of users by using active network technology. It also provides functions that enable content providers to change service quality depending on the user or the characteristics of the data transmitted, by using the information on communication control added to the Web data.

(2) Operations Support System

As carrier IP networks become information infrastructures and business portals for enterprises, a variety of services must be provided at low cost. Furthermore, several customer requirements, such as rapid introduction of new services, service quality improvement, and low-cost service offering, must be satisfied. Satisfying them requires an operations support system (OSS) that provides total solutions covering not only network and service management but also new-service marketing support, customer services, and billing. Hitachi's IP-supported OSS has a reliable, high-performance application-integrated infrastructure and carrier-grade policy-based network management, along with the integration of Hewlett-Packard's advanced operation and management package. It thus provides solutions that support the rapid construction of such systems as provisioning, QoS guaranteed, and customer billing.

TOWARDS THE NEXT-GENERATION OPTICAL AND IP INTEGRATED NETWORK

Network Configuration

As Internet traffic volumes continue to increase, a node architecture is needed that can support tera-bit capacity switching. One candidate for the new node is an optical cross-connect system applying the optical and IP integrated network concept. In this concept, the large-capacity transfer function of an optical network node is controlled and operated using IP network technology.

An important issue in achieving an optical and IP integrated network is how to apply the simple high-speed transfer function of the optical network node to the IP network. We solve this issue by dividing the IP network into two parts, i.e., an access network and a backbone network. In this configuration, the core node of the backbone network provides the high-speed, large-capacity transfer function. The access nodes of the access network and the edge nodes of the backbone network provide such functions as subscriber termination, line concentration, and complicated service handling. In this architecture, the functions requiring complicated processing are executed only at the periphery of the network, so the high-speed, large-capacity core nodes become simple, and it becomes easy to apply an optical network node, such as an optical cross-connect system, to the core node of the backbone network.

Migration to Optical and IP Integrated Network

IP and optical networks are currently controlled and operated separately, so it is difficult to integrate both networks in one step. Therefore, we integrate them in two phases.

In the introduction phase, information on routing, signaling, and topology is distributed separately in each network, as it is now. A function to exchange routing information between networks is added to the interfaces between the networks, as shown in Fig. 2 (a). For instance, first a client IP node requests the IP address of an other client IP node connected to the optical network prior to path set-up. Then, the client IP node sends the set-up request to the optical network node, specifying the IP address of the destination node. This method minimizes the addition of functions and makes it possible for an IP network to use such optical network functions as on-demand optical-path set-up between IP network nodes.

In the mature phase, fully integrated networks will be available using multi-protocol lambda switching (MPλS)[3], which adds the optical wavelength to the MPLS label. Information including routing, signaling, and topology is distributed in both networks using IP-based protocols, and the paths between IP nodes are

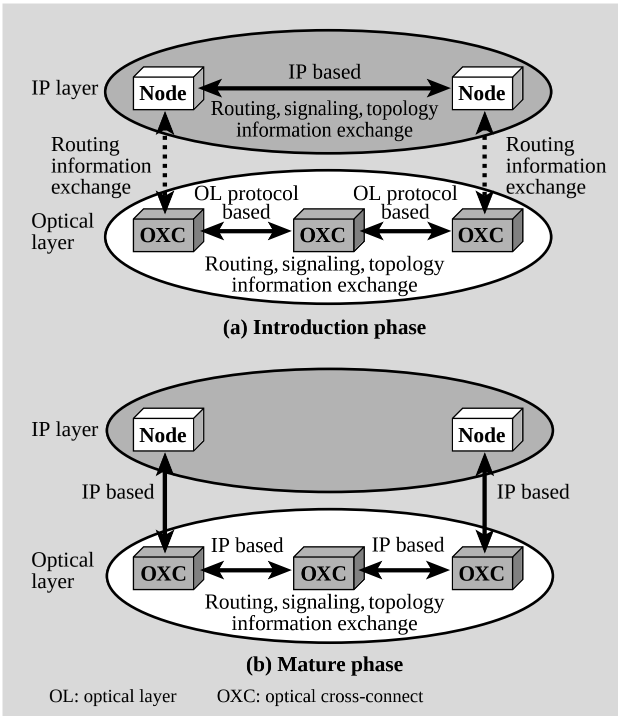

Fig. 2—Migration Scenario for Optical and IP Network Integration.
Hitachi proposes integrating optical and IP networks gradually to meet the need for expanded network capacity.

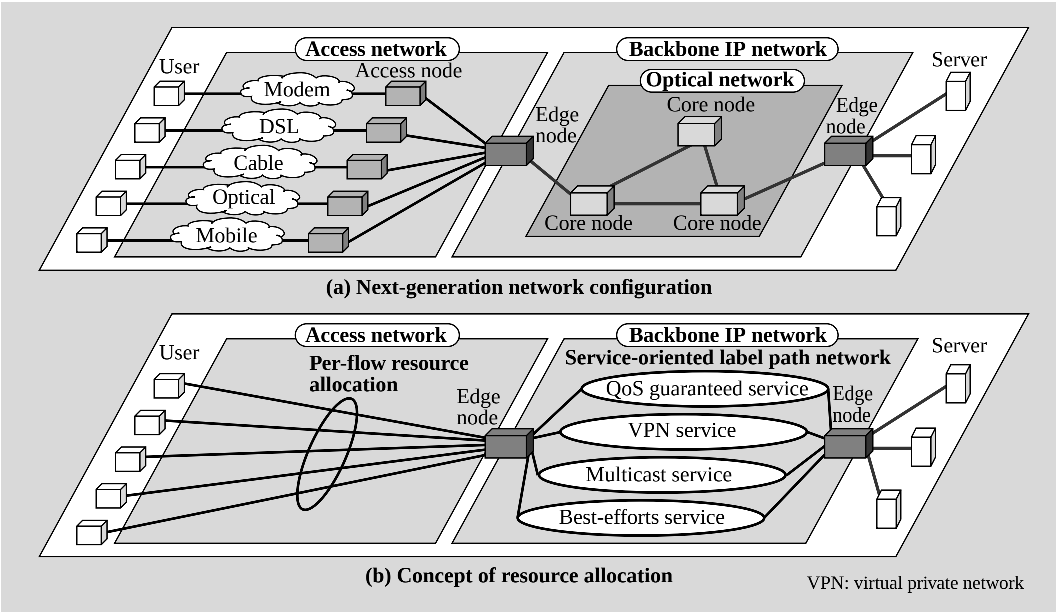

Fig. 3—Image of Next-generation IP Network.
The proposed next-generation optical and IP integrated network is configured with a backbone IP network and an access network.

set-up using this information [Fig. 2 (b)]. The routing information is distributed using an interior gateway protocol (IGP), e.g., open shortest path first, and the path set-up and bandwidth allocation are executed using MPLS. Although extension of the IGP and modification of both the management part and the path set-up part of the optical network nodes are required to provide the optical network topology to the IP network, doing so enables optimal resource allocation.

In this way, carriers can integrate their optical and IP networks gradually to meet the increasing need for IP network capacity. Fig. 3 shows an image of the next-generation IP network.

CONCLUSIONS

We have described Hitachi's carrier IP network solutions and discussed a network architecture for an optical and IP integrated network as well as its migration scenario. Other papers in this special issue describe Hitachi's network system and solutions.

Hitachi will continue to provide total solutions aimed at IP network evolution.

REFERENCES

(1) J. McQuillan, "What's Next for the Net," Next Generation Network '99 (Nov. 1999).

(2) I. Mimura et al., "Terabit Node for Next-generation IP Networks," *Hitachi Review* **49**, 155-158 (Dec. 2000) (this issue).

(3) J. Luciani et al., "IP over Optical Networks-A Framework," Internet Draft, draft-ip-optical-framework-00.txt (Mar. 2000).

ABOUT THE AUTHORS

Noboru Endo

Joined Hitachi, Ltd. in 1986, and now works in the Research and Development Group. He is currently engaged in research and development of network systems. Dr. Endo is a member of the Institute of Electronics, Information and Communication Engineers of Japan, the Information Processing Society of Japan, and the IEEE, and can be reached by e-mail at endoh@crl.hitachi.co.jp.

Morihito Miyagi

Joined Hitachi, Ltd. in 1989, and now works in the Research and Development Group. He is currently engaged in research and development of network systems. Mr. Miyagi is a member of the Institute of Electronics, Information and Communication Engineers of Japan, the Information Processing Society of Japan, and the IEEE, and can be reached by e-mail at miyagi@crl.hitachi.co.jp.

Tatsuo Kanetake

Joined Hitachi, Ltd. in 1989, and now works in the Research and Development Division, Hitachi America, Ltd. He is currently engaged in research and development of network systems. Dr. Kanetake is a member of the Optical Society of America and the IEEE, and can be reached by e-mail at tatsuo.kanetake@hitachi.com.

Akihiko Takase

Joined Hitachi, Ltd. in 1981, and now works in the Telecommunication & Information Infrastructure Systems. He is currently engaged in strategic business development. Dr. Takase is a member of the Institute of Electronics, Information and Communication Engineers of Japan, and the IEEE, and can be reached by e-mail at akihiko_takase@cm.tcd.hitachi.co.jp.