Backbone Network for the Internet Era

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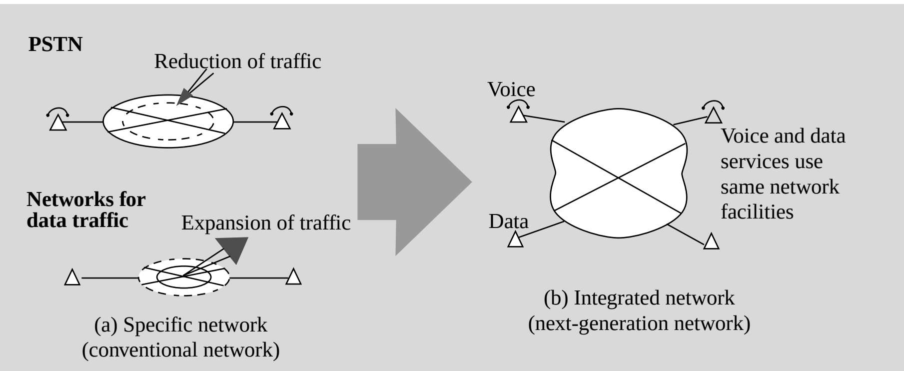
OVERVIEW: As a result of the sharp growth of the Internet, the volume of data traffic flowing into the network has increased considerably and mobile communications has expanded to a very large extent. The amount of data traffic is expected to exceed the amount of voice-based traffic of the conventional telephone network within just a few years. In addition, worldwide deregulation has made the domestic and overseas markets more competitive as new carriers enter the market and strategic alliances among established carriers are formed. Carriers will need to reduce the cost of their communication services and meet the diversified needs of subscribers if they are to survive. These environmental changes are forcing innovations in carrier network architecture. Node systems for next-generation backbone networks must be more reliable and faster and have a larger capacity than ever. Moreover, the systems must have a sufficient capacity for effectively processing both voice and data traffic. Hitachi has incorporated the latest technologies to provide backbone node systems suitable for next-generation networks with key components such as synchronous transfer mode/asynchronous transfer mode (STM/ATM) switches and optical devices.

INTRODUCTION

THE prevalence of the Internet and mobile communications is greatly changing the environment of communication networks. As the WWW (World Wide Web) becomes more familiar, the number of people using the Internet will increase sharply because it can be used to access a wide variety of information. The usage of mobile telephones is also expanding sharply, while the usage of conventional fixed telephone networks is reducing. These changes in volume and content of traffic flowing in communication networks are why networks should be changed from conventional voice-centric to voice-and-data-integrated for the next-generation networks shown in Fig. 1.

In addition, deregulation of protective policies in communication and progress of border-less society like the Internet has been allowing new carriers to enter the market and established carriers to form alliances. These environmental changes are causing intense competition among carriers, affecting costs and services provided (functions and customer support capabilities). For these reasons as well, carriers need to change the structure of networks to survive.

This paper provides an overview of carrier activities for constructing the next-generation backbone network and introduces node systems provided by Hitachi.



PSTN: public switched telephone network

Fig. 1— Change of Communication Network System.
Reconstruction of the carrier network is necessary because of changes in volume and content of traffic.

STEPS TOWARDS DEVELOPING THE NEXT-GENERATION BACKBONE NETWORK

Carrier networks are being made more data-traffic oriented. Owing to remarkable advances in today's optical communication technology and large-scale integrated circuit (LSI) technology, carriers are gaining the ability to construct effective networks to handle the growing amount of Internet traffic. Now, carriers are trying to change their networks by various approaches.

Standpoint in network innovation

(a) Established carriers

Established carriers have to develop new data services while they continue to provide conventional telephone network services, including fixed telephone, leased lines, packet, and ISDN (integrated services digital network) services. In other words, they must provide the services with step by step on demand, maintaining their existing network facilities on which they have already made an enormous investment.

(b) New carriers

New carriers can focus on constructing networks designated for data services that are expected to be major services in the future, since they do not have existing facilities related to conventional services.

Approaches to innovate in network architecture

Fig. 2 shows examples of next-generation backbone network architectures that use STM, ATM, or IP (Internet Protocol) layers to integrate various kinds of services.[1)]

(a) STM and ATM over SONET/SDH

In the architecture in Fig. 2 (a), STM and ATM are used as upper layers for such optical transmission systems as wavelength division multiplexing (WDM) and synchronous optical network (SONET)/ Synchronous Digital Hierarchy (SDH) systems, with integrating services on STM and ATM. In this architecture, the STM is intended for conventional services and the ATM is intended for new multimedia services. Mainly established carriers are planning to use this architecture.

(b) IP over SONET/SDH

In the architecture shown in Fig. 2 (b), IP is used as an upper layer for optical transmission systems (WDM and SONET/SDH systems), while integrating services on IP. New carriers are intending to use this architecture.

(c) IP over ATM

In the architecture shown in Fig. 2 (c), IP is used as an upper layer for ATM on optical transmission systems (WDM and SONET/SDH systems), while integrating services on IP. New carriers are intending to use this architecture.

For the architectures shown in Figs. 2 (b) and (c), the question of whether the ATM layer is used or not mainly depends on the policies of the carriers, that is, whether the carriers place a greater emphasis on quality of service (QoS), which the ATM provides, or on the cutting of overhead of the ATM cell to improve transmission efficiency.

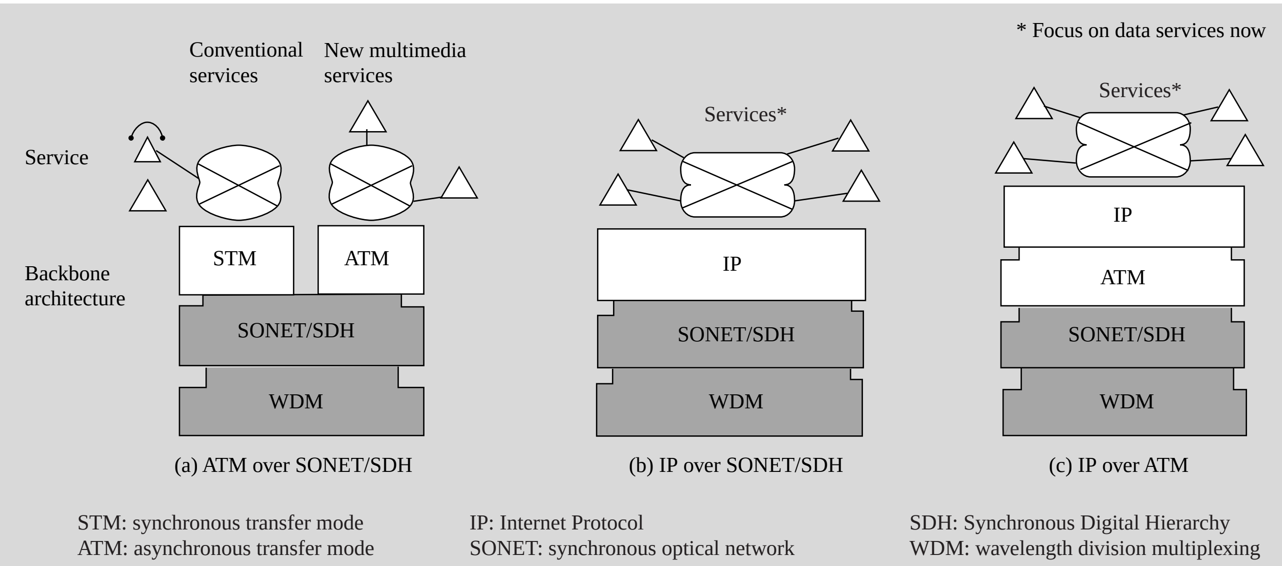


Fig. 2— Cases of Next-generation Backbone Network Architecture.
To integrate various kinds of services a backbone network uses STM or ATM or IP layer.

Technical Requirements for the Next-generation Backbone Network

(a) Effective processing of the increasing amount of Internet data traffic

The network must be a gigabit-class (terabit-class within a few years) high-speed communication network with large capacity, high reliability and low construction cost. It must be realized step by step on demand, for example, based on the increment of subscribers, the volume of multimedia information flowing in the network, and the need for real-time communication.

Because of advances in optical technology, equipment that can handle multiplexing and transmission at speeds of 1 Tbit/s is coming closer to reality, and research is now advancing in optical switching and optical cross-connecting.

(b) Unified processing for multiple services

The network must ensure the QoS effectively, thereby meeting respective services. For example, to secure real-time voice communication, the delay time of processing must be low. As for file transfer, warrant of no data transmission error and data throughput must be realized.

The network must accommodate unified processing for multiple services and operation, and management (account, reliability, operation and maintenance) as well.

In addition, the network must implement scalability of capacity, and be able to accommodate add-ons such as additions of services easily.

HITACHI PRODUCTS FOR NEXT-GENERATION BACKBONE NETWORK

The following paragraphs introduce Hitachi products suitable for the switching node system, and multiplexer and transmission node system meeting the requirements mentioned above.

Switching Node

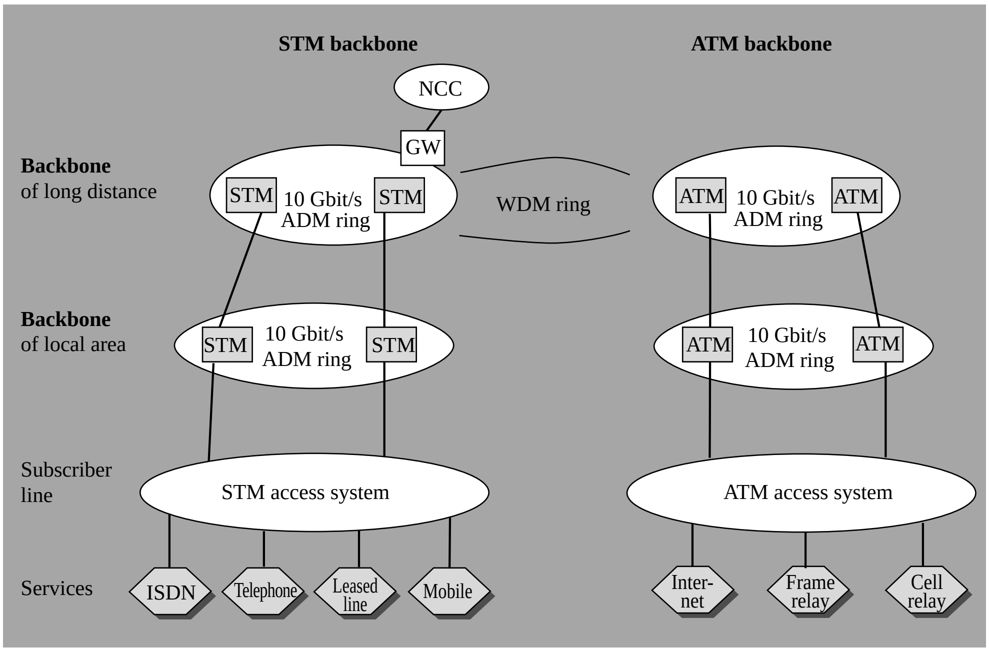
IP router

So far, advancements in IP router technology has focused on improving transmission speed for enterprise networks. For carrier networks, however, the router must satisfy the requirements for network scalability, guaranteed communication (QoS, low delay), and carrier-class functions like account, reliability, and maintenance.

Papers [2)] in this issue specifically describe Hitachi's activities in the field of IP routers.

STM and ATM switching system

In the past, conventional networks were constructed for specific services and were independent of other services and networks. The systems used in these networks were designed specifically for certain



NCC: new common carrier
GW: gateway
STM: synchronous trasfer mode
ATM: asynchronous transfer mode
ISDN: integrated services digital network
ADM: add/drop multiplexer
WDM: wavelength division multiplexing

Fig. 3—Case of Service Integration by Next-generation STM/ATM Switching System.
In this case STM switching systems can accommodate the conventional telephone services (such as ISDN, telephone, leased lines), and ATM switching systems can accommodate a variety of data/multimedia services (such as Internet, cell relay).

network services. Next-generation STM and ATM systems, however, integrate various services economically, depending on the level of technical development of software and processors. Fig. 3 shows that STM switching systems can accommodate the conventional telephone services mentioned before and that ATM switching systems can accommodate a variety of data/multimedia services such as cell relay, frame relay, and Internet services.

(a) System architecture

STM and ATM switching systems are designed based on the concept of unified architecture.[3)] A building block approach has been adopted as a method common to both systems. In this method, hardware and software are composed of combinations of function blocks (FBs), depending on the needs. This building block approach gives the networks more adaptability and flexibility so that new systems and services can be easily added.

In hardware, as shown in Fig. 4 (a), the CPU (central processing unit) is designed as a common FB. This FB contributes to the development of a switching system and the reduction of system cost. Latest technologies can be easily adopted replacing FB unit.

In software, as shown in Fig. 4 (b), control functions used for such services as ISDN, ATM, and leased-line are designed as a common platform. This platform has made the design process more efficient.

(b) Application products

Those system architectures aforementioned are adopted for local switches and gateway switches as well. Hitachi has developed pager switching systems (radio switching systems) and gateway systems for carriers as application products. Fig. 5 shows Hitachi multimedia node system (HN8000) series as an example.

(c) Key component

Hitachi developed technologically advanced, large-capacity switches for its STM/ATM switching system. A non-blocking, high-multiplexing time division, 128-k channel × 128-k channel (64 kbit/s-channel conversion) switch block was developed for the STM switching system, while a 40-Gbit/s large capacity ATM switch block was developed for the ATM switching system.

Toward the era of broadband communication in the

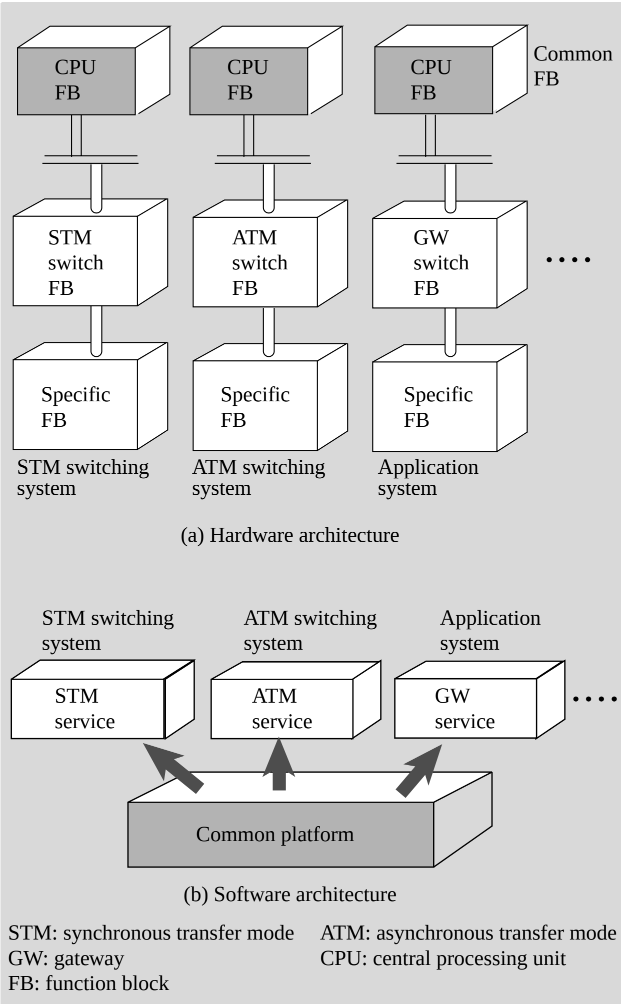


Fig. 4— Common Architecture of Next-generation STM/ATM Switching System.
The common platform and function block improve designing efficiency.

Fig. 5— HN8000 Multimedia Node System.
Hitachi has developed pager switching system and gateway switching system for the carriers as application products.

near future, Hitachi is now working on a high-multiplexing time division, 256-k channel × 256-k channel switch block and a high-speed ATM switch block over 160 Gbit/s.

For its large-capacity ATM switch, Hitachi is utilizing its latest optical interconnecting technology, which enables high-speed and high-density multichannel connections, especially higher than that of electric wiring, between printed circuit boards (PCBs) and between units. Hitachi has developed high-speed and highly integrated, optical module technology (200 Mbit/s × 12 channel),[4] as well as products with a maximum capacity of 800 Mbit/s per channel.

Optical switching system

Although still in a research stage, Hitachi is working on an optical switching system as a next-generation terabit-class switching node and as a main node system in future all-optical networks. The development of an optical buffer memory is still an issue, and Hitachi is studying various possibilities such as a delay line using optical fiber and an optical semiconductor memory.

Hitachi has already completed fundamental technology for 40-Gbit/s optical switching system. It is now developing a prototype exchange with the capacity of 320 Gbit/s (10 Gbit/s × 32 wavelength channels).

Multiplexer and Transmission Node

With the progress of multimedia communication, the transmission speed and capacity of multiplexer and transmission nodes are being improved by incorporating optical device technologies such as laser diodes. Wavelength multiplexing in practical use can now be done for anywhere from 32 to 80 wavelength channels, and 100 to 200 channel wavelength multiplexing is in a research stage. The bit rate of a wavelength channel is now from 2.5 to 10 Gbit/s, and 40 Gbit/s in a research stage. Hitachi's products are described below, and its details including optical device technology are discussed in papers [5] in this issue.

SONET/SDH

Hitachi has developed 10-Gbit/s SONET/SDH transmission systems, utilizing its own latest optical devices and ultra-high-speed ICs.

As shown in Fig. 6 (a), there are two types of SONET/SDH systems. The first one is a point-to-point type system composed of line terminating equipment

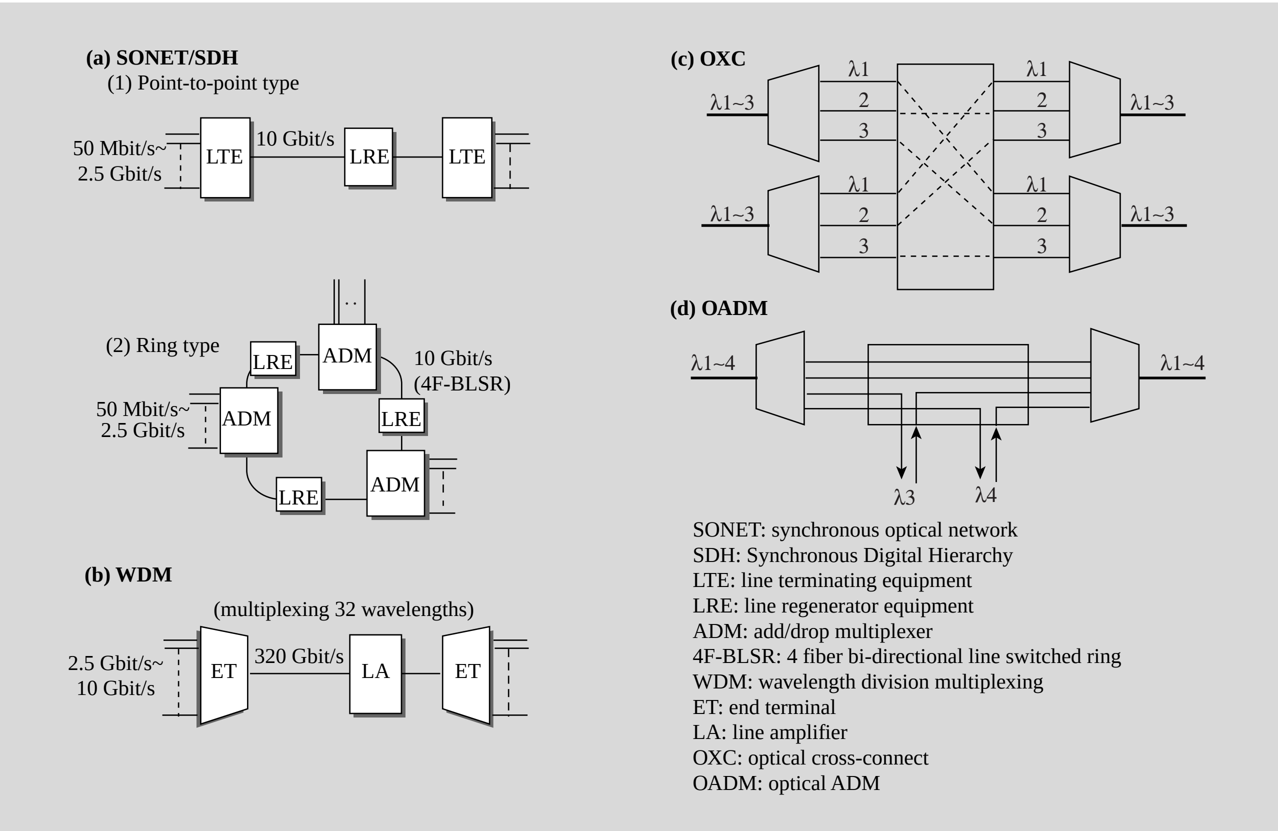


Fig. 6— Optical Transmission Node.

(LTE) and line regenerator equipment (LRE) used for long-distance hook off. The other one is a ring type system composed of add-drop multiplexers (ADMs) and LREs. Both types have a recovery function with prepared spare routes in case of fiber failure. To ensure high reliability of the network, LTE is configured with a working fiber to restoration fiber ratio of 1:1 to 3:1, and the ADM incorporates four-fiber bi-directional line switched ring (BLSR) technology.

Hitachi's SONET/SDH systems are being adopted as node systems for the next-generation backbone networks by carriers both in Japan and abroad.

WDM

As the same in SONET/SDH, utilizing optical device technology, Hitachi has succeeded in developing 320-Gbit/s WDM with 10 Gbit/s × 32 wavelength channels. This shows that terabit transmission is approaching a practical stage. The WDM system consists of end terminals (ETs) and line amplifiers (LAs) as shown in Fig. 6 (b). The system capacity can be upgraded from 160 Gbit/s to 320 Gbit/s even in the field.

OXC and OADM

Putting optical cross-connects (OXCs) and optical add-drop multiplexers (OADMs) to practical use is expected as backbone node systems with large capacity that could realize reliable terabit class optical networks with low implementation cost.

Fig. 6 (c) and (d) show methods of transmitting optical signals in both OXC and OADM. The OXC can easily change transmission routes for any wavelength (for every optical path) or for each optical fiber, as shown in Fig. 6 (c). The OADM adds or drops a specific wavelength from or to multiplexed wavelengths within optical rings, as shown in Fig. 6 (d).

A number of issues remain to be solved before the systems can be put into practical use, such as how to set preparatory routes, how to realize a high-speed optical switch for any wavelength. Hitachi has developed a prototype OXC/OADM and is now working on a feasibility test for putting it into practical use.

CONCLUSIONS

This paper described next-generation backbone network that domestic and foreign carriers are aiming at, and introduced products that Hitachi provides. Hitachi will continue to develop new products and technologies, providing total network solutions to our customers.

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