Development of Transport Systems for Dedicated Service Provision Using Packet Transport Technologies

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Abstract

To date, NTT has been providing high-quality dedicated services such as analog and high-speed digital services on its time division multiplexing network. NTT has also been shifting its relay networks to packet transport networks in conjunction with the shift to the Next Generation Network. This article introduces a new packet transport multiplexing adapter for dedicated service provisioning on packet transport networks using circuit emulation technologies.

Keywords: dedicated service, leased line service, MPLS-TP, CEP

1. Introduction

Dedicated services such as analog and high-speed digital services differ from the best effort lines typical of the Internet, in that they are communications services designed to achieve high reliability and high quality (low latency, low error rates) by constantly allocating a fixed bandwidth to subscribers. There is still some demand for these services, especially services that are geared to corporate users.

For the link systems that perform the relay transmissions supporting these dedicated services, NTT laboratories have adopted synchronous digital hierarchy (SDH) based on time division multiplexing (TDM) technologies appropriate for multiplexing with fixed-rate lines and public networks. However, as Internet protocol (IP) services such as the Internet have spread, there has been a shift towards adopting packet transport technologies for link systems since these technologies have a high affinity with IP traffic. Packet transport technologies are connection-oriented transmission technologies with the same transmission quality as SDH and are based on Ethernet and multiprotocol label switching (MPLS) technologies. These technologies enable line and path administration functions, operations, administration and maintenance (OAM) functions, and protection functions similar to SDH.

With this background, the objective is to simplify the entire network by shifting from TDM technologies to packet transport technologies, even for dedicated service nodes. For this reason, NTT laboratories have applied MPLS-TP (transport profile), which is a packet transport technology, to develop the packet transport multiplexing adapter (PTM adapter) for dedicated services. This adapter is a new dedicated service node that will ensure the high quality and high reliability required for dedicated services. The PTM adapter is designed for migration from existing dedicated service networks to packet transport networks (**Fig. 1**).

An overview of the PTM adapter is shown in **Fig. 2**. It consists of three types of node: a relay node, subscriber node, and user-installed subscriber node, all of which can be connected to other link systems via Ethernet interfaces. These nodes also have clock

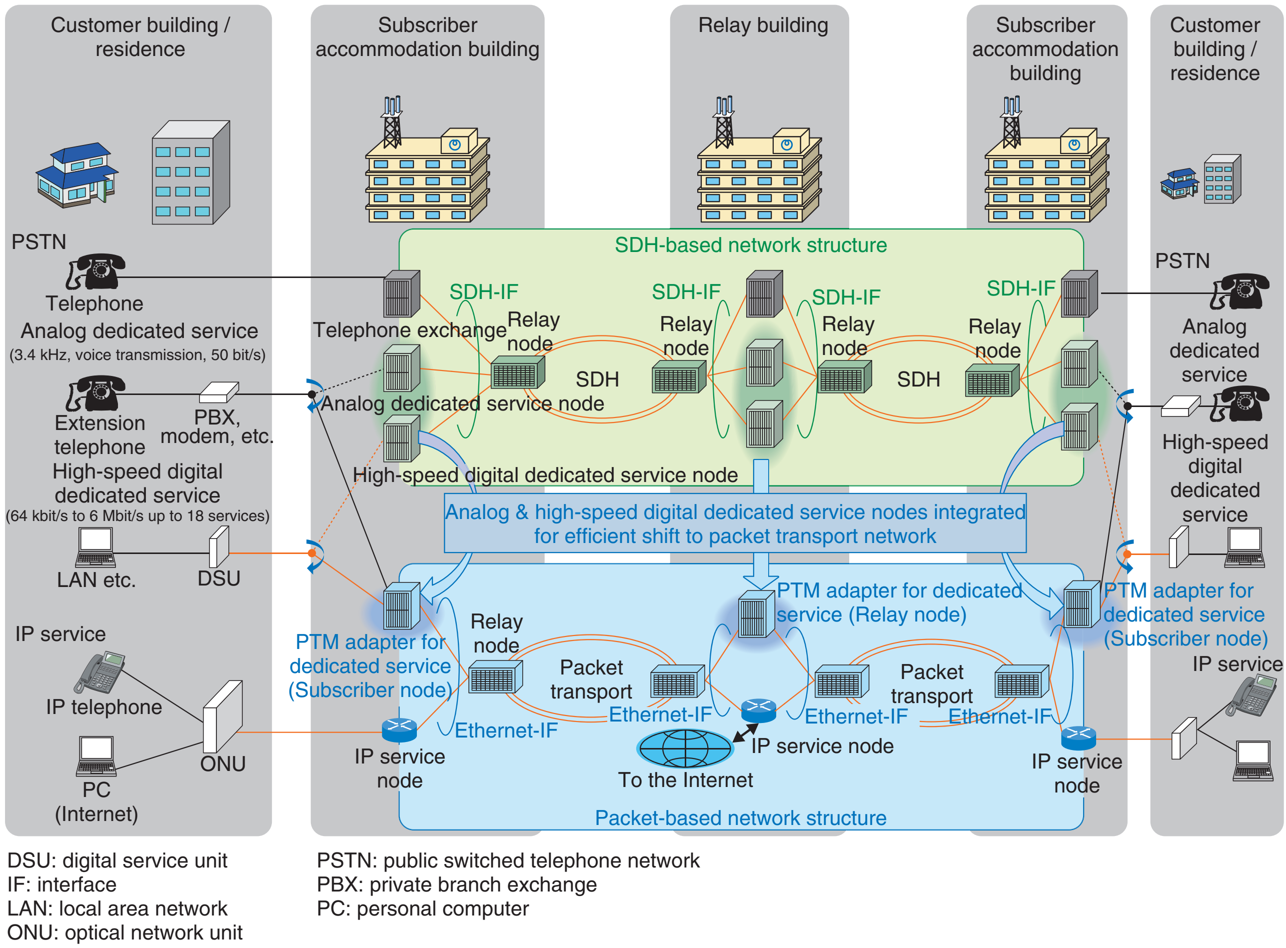


Fig. 1. Migration to packet transport networks with PTM adapter for dedicated service.

functions that enable synchronization with synchronous network clocks via a synchronization supply unit (SSU), monitoring and warning functions that are the same as existing equipment, test functions, and monitoring and control functions that enable switching control. Here, we describe some key elements in the development of these PTM adapters.

2. Migration issues

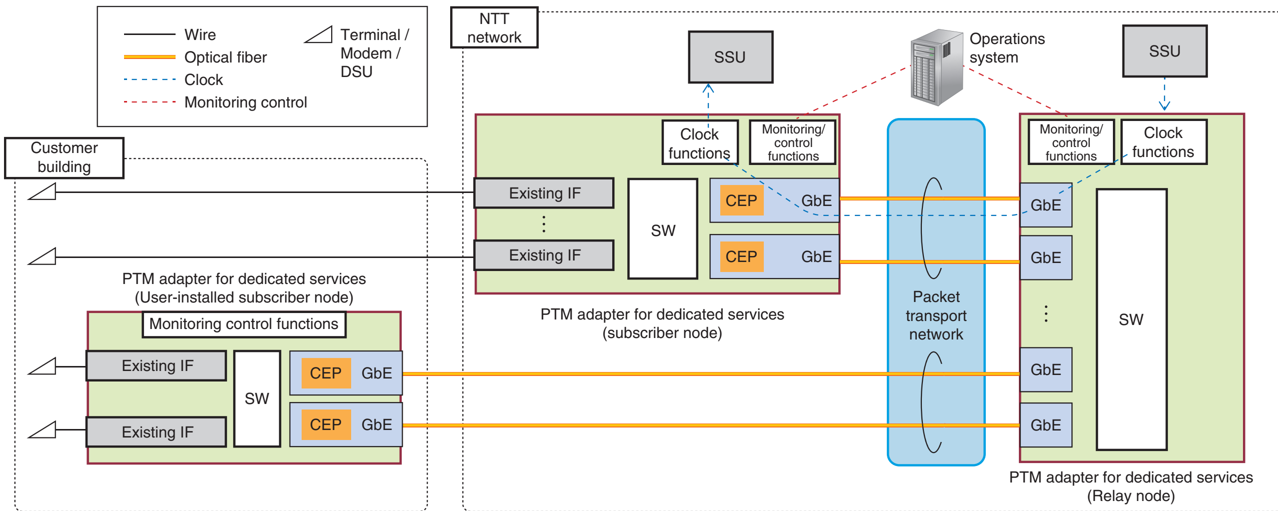
We describe here three migration-related issues that occurred with the PTM adapter.

2.1 Accommodation on the packet transport network

(1) Handling accommodation efficiency and latency

To accommodate dedicated services on the packet transport network, processing is required in order to packetize fixed-rate user line signals in each type of dedicated service at a set period and to restore packet signals as user line signals (depacketization). Furthermore, there are standard values for latency time in dedicated service networks that must be satisfied.

One cause of increased latency that occurs in the packetizing process is buffering latency due to waiting for user line signals to reach packet lengths of a certain size. For this reason, it is necessary to shorten the period of packetization and reduce the amount of buffering to achieve lower latency. However, a smaller packet size means there will be proportionally more packet headers, which lowers the accommodation efficiency. In contrast, lengthening the period of packetization lowers the proportion of headers and hence raises the accommodation efficiency, but it also increases the amount of buffering, which increases latency. Thus, to optimize accommodation efficiency and latency, it was necessary to design an optimal packetization period.



Main items	Sub-items		Details
Nodes	Interface	Relay node	GbE (synchronous Ethernet, hitless switching, OAM)
		Subscriber node	GbE (CPE, synchronous Ethernet, hitless switching, OAM)
			Existing interface (analog dedicated service, high-speed digital dedicated service, line testing)
	Clock		Receiver (64+8 kHz, 64+8 kHz + 0.4 kHz), Receiver (6312 MHz)
	Switch		Per line
	Monitoring control functions		Alert output, testing control, switching control
Operations system	Monitoring control functions		Implementation management, alert management, path settings, testing control, switching control

CEP: circuit emulation over packet
GbE: gigabit Ethernet
SW: switch

Fig. 2. Overview and main specifications of PTM adapter for dedicated services.

In depacketizing, a cause of increased latency lies in the process of absorbing fluctuations in packet delay that occur on packet transport networks. Because user line signals are at a fixed rate, it is not possible to normally restore user line signals if there are fluctuations in packet latency. Hence, it is necessary to absorb packet latency fluctuations by buffering packets. If the size of the buffer for absorbing packet latency fluctuations is small, it is possible to reduce latency, but it is not possible to normally restore packets with large latencies as user line signals. In contrast, if the size of the buffer for absorbing packet latency fluctuations is large, it is possible to normally restore packets as user line signals, although the latency becomes large. For this reason, it is necessary to gain a sufficient understanding of latency fluctuation on packet transport networks so that an optimum buffer size can be set to absorb these fluctuations.

(2) Handling clock frequency transmissions

To handle fixed-rate user signals synchronized with clock frequencies in dedicated systems, it is necessary to ensure that the clock frequencies of each device match. However, because Ethernet is an asynchronous system, clock frequencies at the sending and receiving ends are not synchronized, and frequency deviations up to ±100 ppm occur at the sending and receiving ends. These frequency deviations cause misalignment in packetization and depacketization periods which accumulate and make it impossible to reproduce user line signals, and thus make it impossible to ensure quality of dedicated services. For this reason, clock frequencies must be transmitted via Ethernet.

2.2 High efficiency, high accommodation, energy saving

As new service items were added to dedicated service nodes, new equipment had to be developed, which created issues with installation space and accommodation efficiency. Hence, there are demands to accommodate multiple service items in single pieces of equipment to achieve greater efficiency and reduce space requirements. Lower power consumption has also become a requirement with the increased demand for greater energy saving in recent years.

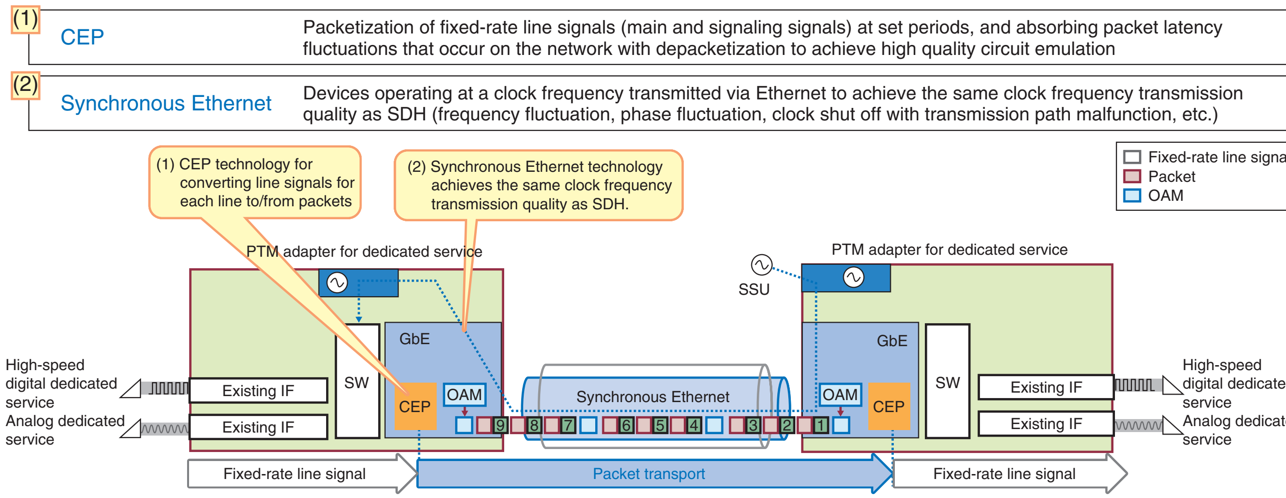


Fig. 3. Synchronous circuit emulation technology.

2.3 Improved maintenance operability and reliability

When new dedicated service nodes are migrated to a system, the existing dedicated service nodes adopting the conventional SDH technology must coexist with the PTM adapters until all the circuits are migrated to the newly installed nodes. Hence, from the viewpoint of maintenance operations, it is necessary to seamlessly carry out circuit testing and alarm monitoring from the same control terminal without operators having to identify which equipment is SDH-based and which is PTM-based.

Furthermore, service continuity is also required for handling dedicated services. Hence, hitless switching functions are required so that services are not affected during maintenance work and failures.

3. Technical issues

Here, we explain some technical points regarding these technologies.

3.1 Synchronous circuit emulation technologies

Synchronous circuit emulation technologies are used to achieve a level of communications quality similar to conventional dedicated services (latency, bit error rate). They consist of circuit emulation over packet (CEP) and synchronous Ethernet technologies. An overview of synchronous circuit emulation technologies is shown in **Fig. 3**.

CEP technologies are specified by the Internet Engineering Task Force (IETF) RFC5086 [1]. They convert fixed-rate line signals (including signaling signals) into packet signals. With transmission, fixed-rate line signals are packetized at 1–2 ms intervals and can be accommodated on the packet transport network by conversely depacketizing them upon reception.

Moreover, the PTM adapter is equipped with the following functions for packetizing and depacketizing. First, the PTM adapter can satisfy the latency requirement specified by dedicated services by setting optimal packetization periods for each service item. This also reduces the facility costs by improving the accommodation efficiency. Second, high-quality circuit emulation has been achieved by absorbing latency fluctuations that occur in the depacketization process. We have designed the optimal buffer size by simulating and measuring the expected maximum value on packet latency fluctuations with high accuracy, which is specified by dedicated services. We have also reduced the buffer size for latency fluctuations by depacketizing at an optimized timing with statistical processing. As a result, we have reduced the network latency.

Synchronous Ethernet technology is technology specified by the Telecommunication Standardization Sector of the International Telecommunication Union (ITU-T) in Recommendation G.8261 [2] for transmitting clock frequencies between devices via the physical layer of the Ethernet. After a reference clock frequency is generated in an oscillator in the transmitting device by using the clock frequency signal that was input, frequencies are converted to gigabit Ethernet

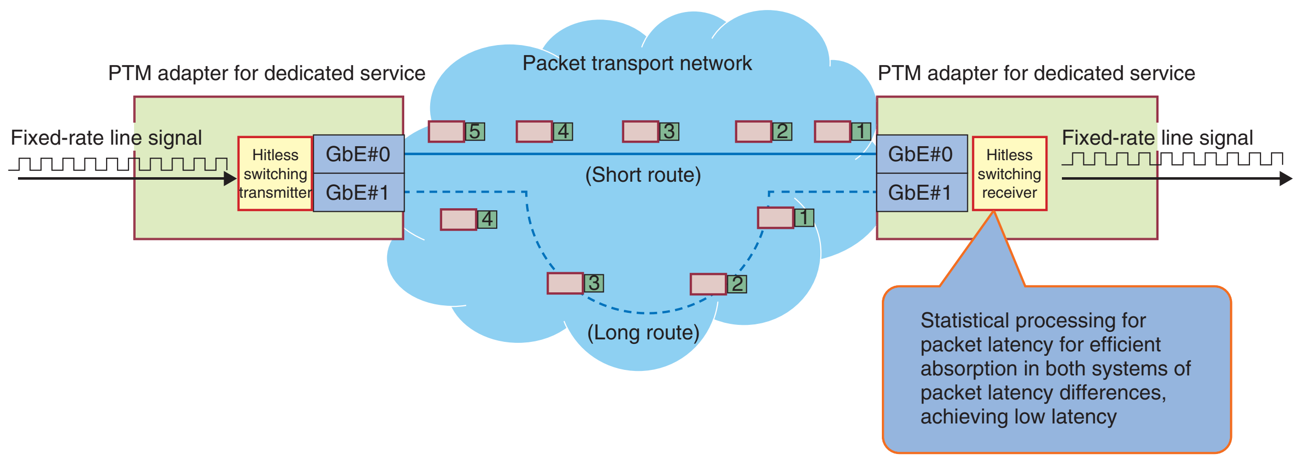


Fig. 4. Overview of hitless packet switching.

(GbE) signaling speeds to send Ethernet signals. The transmitting equipment clock signals are reproduced by extracting the clock timing from the received Ethernet signal (the rise timing of the bit string) in the receiving equipment. This technology enables each piece of equipment to operate with the transmitted clock frequency, even via Ethernet.

3.2 High efficiency, high accommodation, energy saving

We have made it possible to reduce the maximum power consumption to about one-third that of conventional systems for the maximum number of accommodations by integrating existing dedicated service nodes required for each service item with the PTM adapters. We have also made more effective use of existing facilities by making subscriber interface packages compatible with existing equipment. Furthermore, we have drastically reduced the amount of space required by making it possible to house circuits in one rack, whereas five racks were previously required.

3.3 Improving maintenance operability

With the PTM adapters, we have made it possible to achieve seamless alert monitoring and line testing functions for SDH and packet transport segments from the same terminal by sorting the details required for testing and by coordinating each layer for SDH segments and packet transport segments. In terms of alert monitoring in particular, we have optimized determination criteria so that the transport error occurrence thresholds would be the same level for SDH and packets because the packet transport system detects errors packet-by-packet and discards errored packets, whereas the conventional SDH system detects errors bit-by-bit. This gives maintenance teams improved maintenance capabilities by enabling them to confirm normal operations in batches without having to consider the individual technologies used in each segment.

Additionally, we applied hitless switching technology to the PTM adapters to improve service quality. The hitless switching technology is illustrated in **Fig. 4**. This technology adjusts latency for short and long paths and uses systems to select first-come packets.

Moreover, since latency fluctuation is an issue with packet transport networks, we have enabled hitless switching with lower latency than the conventional system by using technology that efficiently absorbs packet latency differences between both paths through the use of statistical processing for the latency of each packet.

4. Future development

This article described a PTM adapter for dedicated services developed by NTT Network Service Systems Laboratories.

Going forward, we aim to respond to customers seeking high quality and high reliability by developing Ethernet networks that satisfy the quality standards of dedicated services.

References

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https://www.itu.int/rec/T-REC-G.8261

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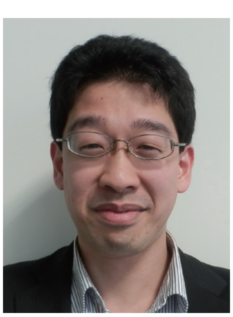

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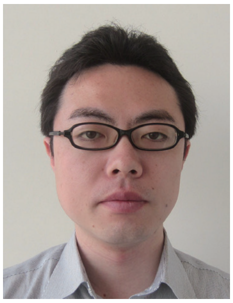

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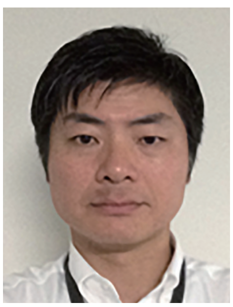

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