Development of 100-Gbit/s Packet Transport System

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Abstract

A rapid increase in the amount of Internet traffic is expected in the core network of the NTT Group due to the growing popularity of mobile and cloud services. NTT Network Service Systems Laboratories has developed a 100-Gbit/s packet transport system (100G-PTS) in order to increase the network capacity cost-effectively. Moreover, 100G-PTS also improves the operability and reliability of the transport system, which is expected to reduce operational expenditures. This article presents an overview of 100G-PTS and its technical features.

Keywords: 100G, digital coherent technology, MPLS-TP

1. Introduction

The trend of steadily increasing Internet traffic means that transport systems with higher capacity are required in the carrier network. To provide sufficient capacity economically, NTT Network Service Systems Laboratories has developed a next-generation optical transport system called a 100-Gbit/s packet transport system (100G-PTS) that makes it possible to deliver 100-Gbit/s high speed data traffic using digital coherent technology and also to accommodate data traffic efficiently using packet transport technology. The goals for this development, in addition to enhancing the capacity, are to improve the operability and reliability of the system by integrating the equipment in different layers and by simplifying the network, and to reduce power consumption in order to reduce the total operational expenditure (OPEX). In the near future, we will be able to further save costs of Layer-3 equipment such as relay routers by using 100G-PTS (**Fig. 1**). Thus, 100G-PTS will be our key system in the NTT Group.

2. Overview of 100G-PTS and its key technical features

There are three key technical features in 100G-PTS, which bring certain advantages, as follows (**Fig. 2**):

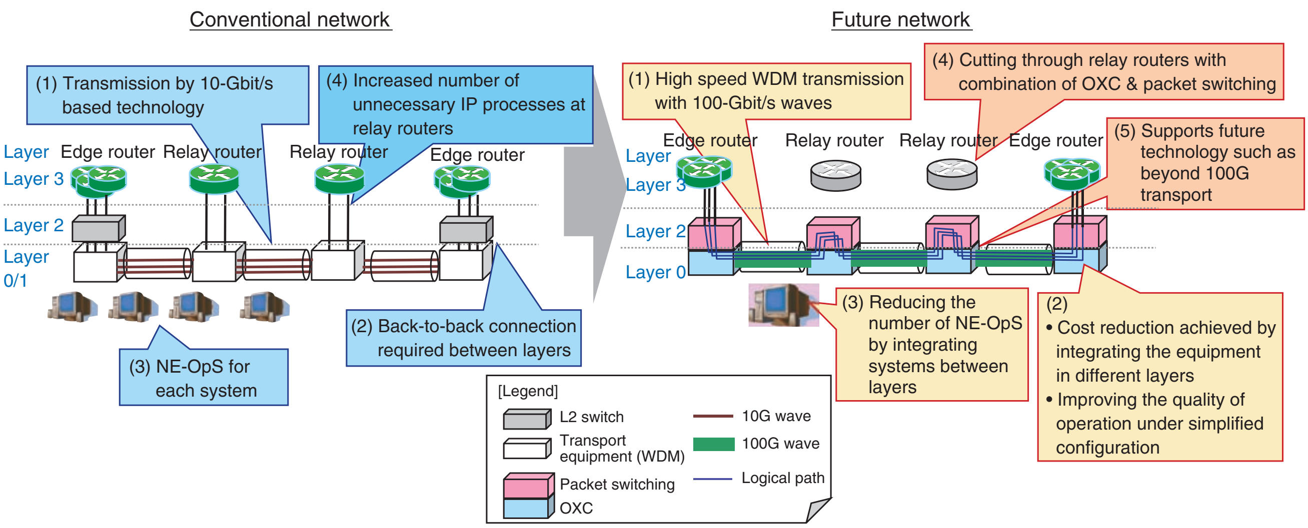
(1) Capacity enhancement by 100-Gbit/s digital coherent technology

(2) High operability and reliability by high performance optical switching technology that achieves compatibility between flexible bandwidth setting of the circuit and advanced operations, administration, and maintenance (OAM) functions through the use of MPLS-TP (Multi-Protocol Label Switch Transport Profile) technology

(3) Cost reduction by integration of both optical (Layer-0) and packet switching (Layer-2) in a single system

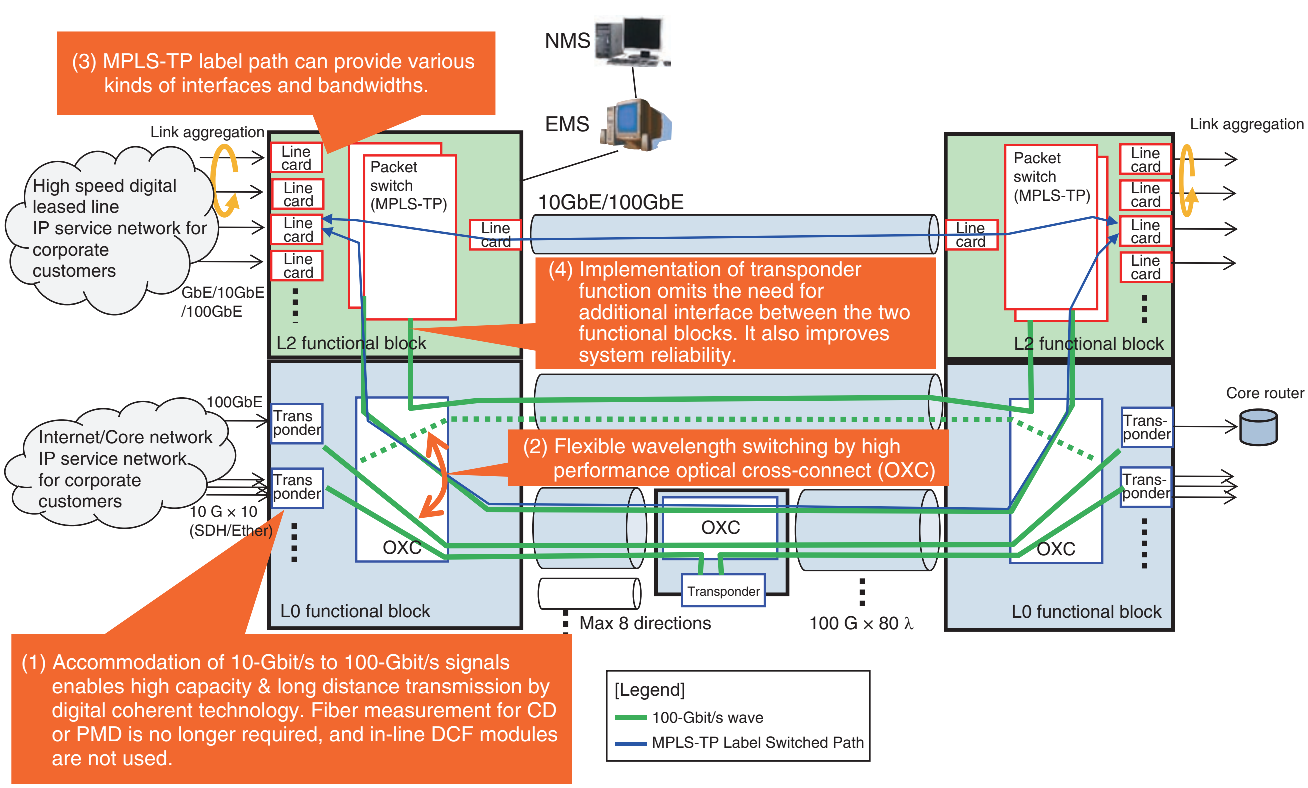
2.1 100-Gbit/s transmission with digital coherent technology*

* Digital coherent technology: Technology that uses high speed digital signal processing (DSP). It can drastically mitigate the limitations of transmission distance due to optical waveform distortion through the optical fiber cable.



NE-OpS: network element operation system
OXC: optical cross-connect

Fig. 1. Advantages of integrating layers in transport network.



DCF: dispersion compensating fiber
EMS: element management system
L0: Layer-0
L2: Layer-2
NMS: network management system
SDH: synchronous digital hierarchy

Fig. 2. 100G-PTS key technical features.

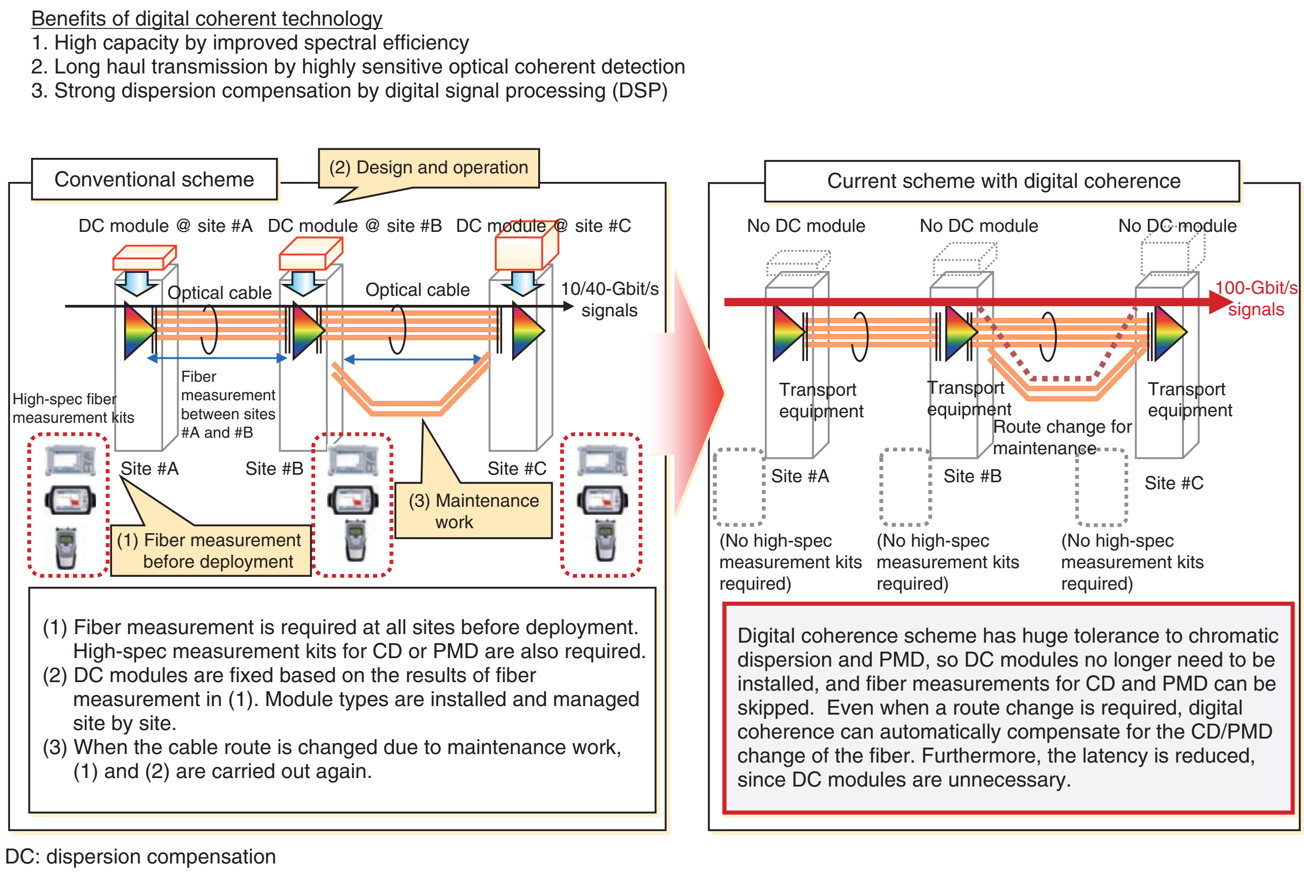


Fig. 3. Benefits of digital coherent technology.

In conventional wavelength-division multiplexing (WDM) systems, the maximum speed is 10 Gbit/s or 40 Gbit/s per wavelength. However, using more 10/40-Gbit/s WDM equipment will not be sufficient to deal with the rapid increase in traffic, and therefore, a new transport system that can drastically enhance the capacity with higher speed data transmission is required. Digital coherent technology, which is a breakthrough technology in the industry, makes it possible to deliver 100-Gbit/s transmission per wavelength in 100G-PTS. 100G-PTS can achieve a maximum capacity of 8.0 Tbit/s by multiplexing 80 wavelengths of 100-Gbit/s signals.

To speed up the transmission rate (from 10/40 Gbit/s to 100 Gbit/s), spectral efficiency must be improved. We adopted a multi-level modulation/demodulation scheme that is widely used in the wireless communication field. However, long haul transmission still presented difficulties because multi-level modulation is sensitive to the noise generated inside the fiber during transmission. Polarization mode dispersion (PMD) and chromatic dispersion (CD) induced in the fiber are also factors that limit the transmission distance. The use of digital coherent technology resolved these difficulties, as its high speed digital signal processing (DSP) capability can compensate for or drastically mitigate distortion due to noise or PMD/CD during transmission.

Another major advantage of digital coherence is in deployment and operation (**Fig. 3**). In conventional systems, fiber measurements for loss, CD, and PMD need to be done using high-specification measurement kits before the installation work starts. On the basis of the results of such measurements, we have to install the appropriate CD compensation module site by site. Moreover, if the cable route is altered for maintenance purposes, we have to do the fiber measurements again for other fibers, which requires a lot of extra work. This is no longer necessary when using 100G-PTS with digital coherent technology, however, because CD and PMD can be generally compensated for by DSP. Thus, the measurement kits are no

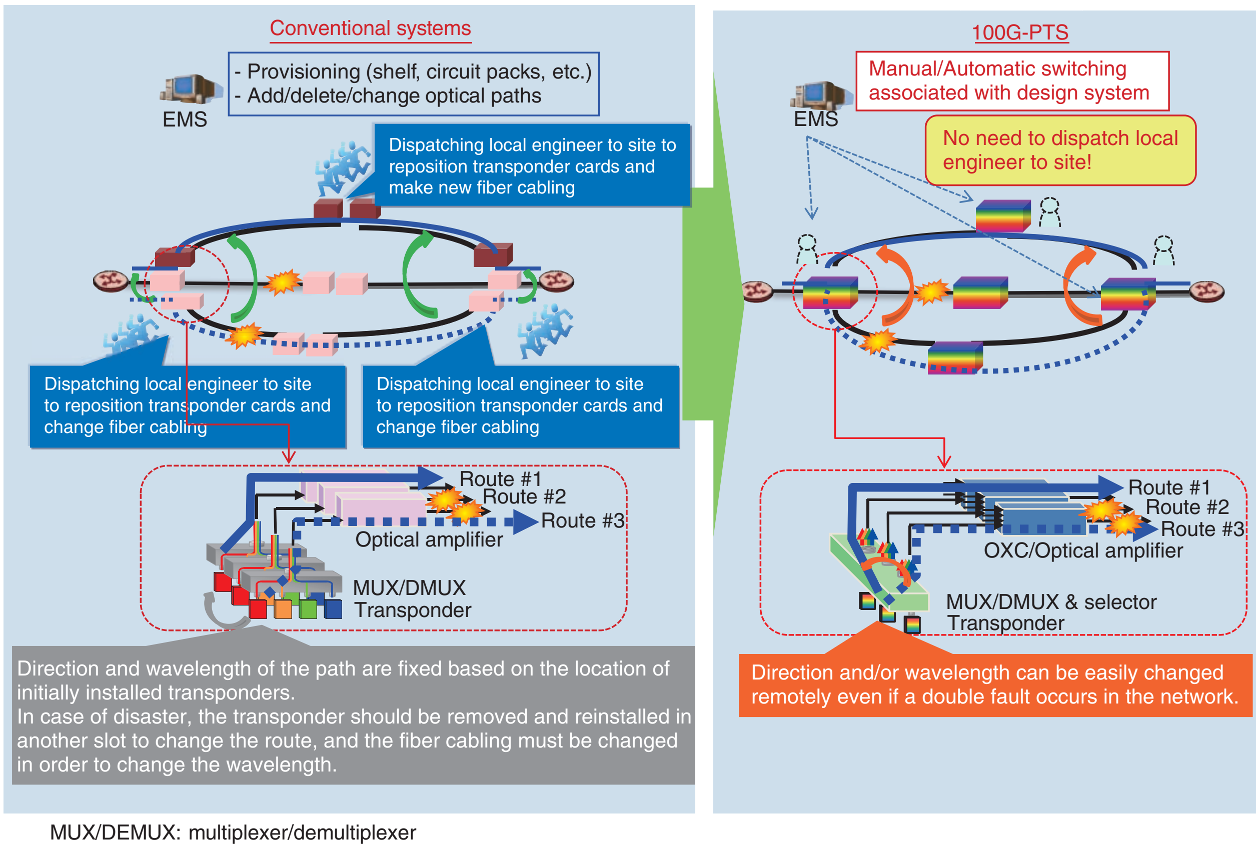


Fig. 4. Features of high performance optical switching technology.

longer needed, which reduces the OPEX for such work. Moreover, the delay of the system is improved because no CD module needs to be installed in 100G-PTS, which is an advantage for the carrier network.

2.2 High operability and reliability by high performance optical switching technology

In a WDM system, a transceiver called a transponder is necessary to generate the optical signal that is optimized in order to transmit signals a longer distance when it receives signals from external equipment such as service nodes. In conventional systems, the direction or wavelength of the path is fixed based on the position of the slot the transponder card is placed in. Therefore, when we have to change the route of the optical path or wavelength in the event of a disaster, we need to dispatch a local engineer to the site and manually change the slot in which the transponder card is placed. After that, we change the fiber connection and reconfigure the optical path via the network element operation system (NE-OpS) (**Fig. 4**). This requires a lot of planning for the route change. In 100G-PTS, on the other hand, we can remotely change the direction and/or wavelength via NE-OpS by using the high performance optical switch. Thus, we do not have to dispatch a local engineer to change the fiber connection and change the slots in which the transponder cards are placed, and this substantially reduces the OPEX of this task. A double fault case that might occur in a disaster is depicted in Fig. 4, in which we can repair a commercial circuit by switching to a third route remotely.

2.3 Compatibility between flexible bandwidth setting of the circuit and advanced OAM functions by MPLS-TP technology

In conventional systems, we have generally used the SDH (Synchronous Digital Hierarchy) format as an ITU-T (International Telecommunication Union Telecommunication Standardization Sector) standard to multiplex and accommodate legacy service traffic such as that from landlines or leased lines. In the SDH scheme, fixed time slots are allocated for each circuit/path, so the bandwidth is fully occupied even when

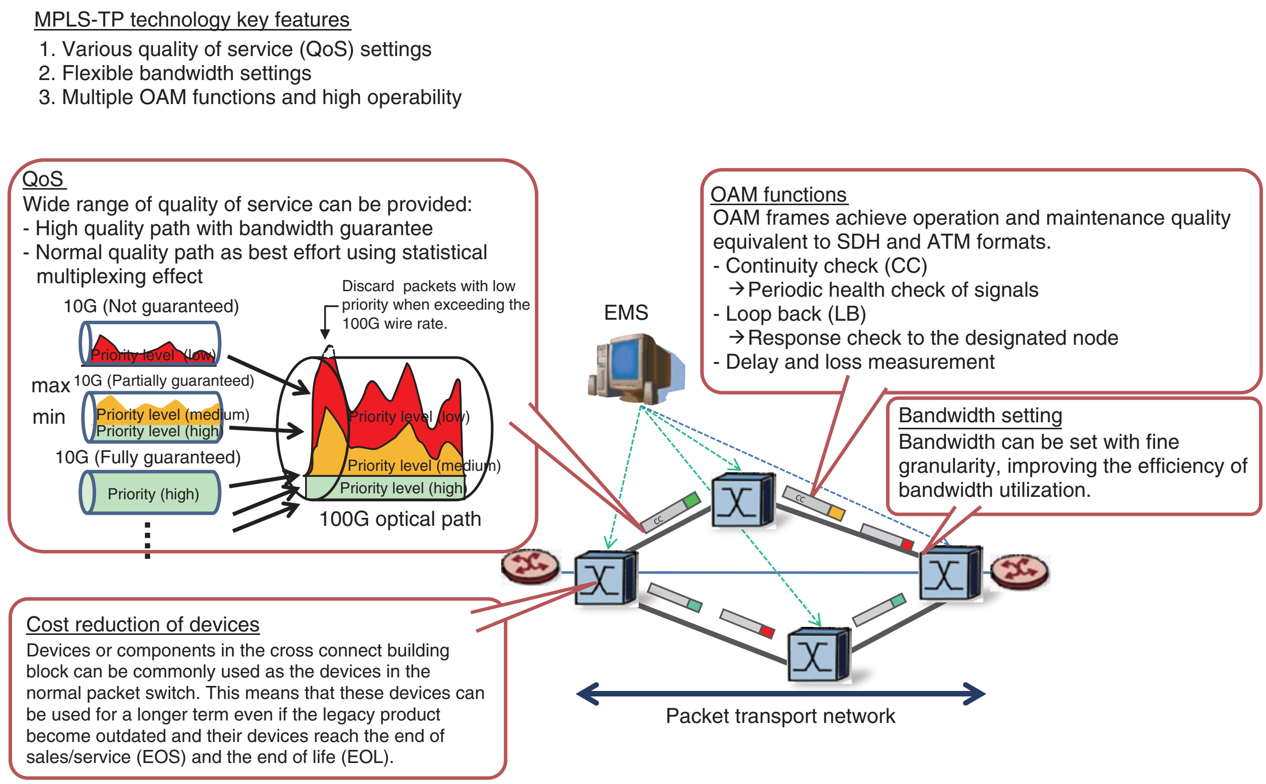


Fig. 5. Features of MPLS-TP technology.

there is no data traffic in the time slots.

In a packet system such as 100G-PTS, however, packets are generated only when there is some data traffic on the circuit. Additionally, we can set the path bandwidth with fine granularity by using packet multiplexing, and we can also set and manage an end-to-end label switched path (LSP) as well as set the SDH technology. When several LSPs are mapped onto the wavelength path, 100G-PTS can mix both types of LSPs (bandwidth guaranteed and non-bandwidth guaranteed) in order to effectively use the bandwidth. It can also configure the redundant LSP paths that achieve less than 50-ms protection switching, and moreover, it can provide hitless protection switching with no frame loss. Different types of protection paths are possible based on the operating conditions, so 100G-PTS assures high reliability of the network.

In terms of operation and maintenance, continuity check (CC) or loop back (LB) testing functions are available in 100G-PTS, which supports sufficient OAM functions to realize high quality operations and maintenance.

2.4 Cost reduction by integrating optical switching (in Layer-0) and packet switching (in Layer-2) in a single system

The equipment for WDM (as an optical transport system) and TDM (time-division multiplexing) (as an electrical MUX/DMUX (multiplex/demultiplex) switch) was generally released as separate units for transport systems, so an additional transponder was necessary to connect both pieces of equipment, and the cost was relatively higher. The 100G-PTS system can provide one system that combines the Layer-0 functional block (WDM) and Layer-2 functional block (packet switch), which reduces the interface cost by simplifying the connection between the two layers. It can also save the space needed for the equipment and the power consumption as well.

Because 100G-PTS supports many kinds of interfaces and a number of routes, it can be applied in various situations in the carrier network. For example, 100G-PTS can configure a multi-ring network, and it can also remotely switch to the third route in the event of a disaster, as shown in **Fig. 5**.

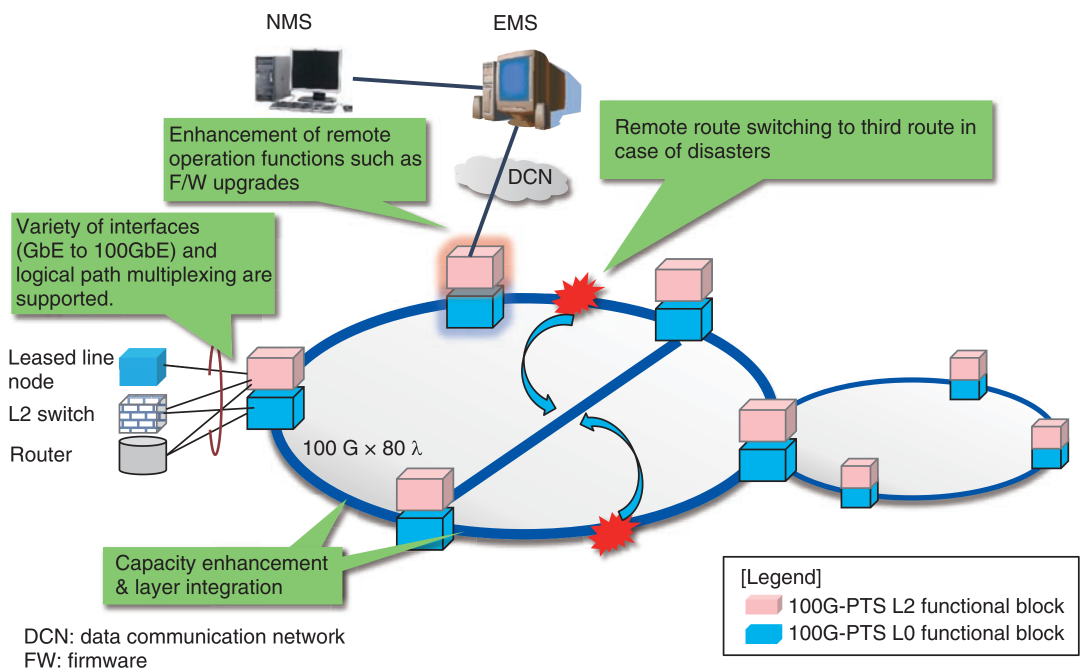


Fig. 6. Schematic of 100G-PTS network (summary).

3. Conclusion

Against the background of increasing demand for Internet traffic, NTT has developed 100G-PTS, which brings sufficient capacity and achieves high operability and reliability as summarized in **Fig. 6**. The demand for equipment that consumes less power has been growing in recent years because the rapidly increasing heat density (per rack) requires a powerful air cooling system, which drives up the cost of facilities. This in turn raises the CAPEX (capital expenditure)/OPEX. In the near future, we will focus on developing technology that can reduce the power consumption in 100G-PTS, and we will also continue to investigate further high performance technologies such as 400-Gbit/s transmission and SDN (software-defined networking).

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He received the B.S. in physics from Keio University, Tokyo, in 2001 and the M.A. in arts and sciences from the University of Tokyo in 2003. He joined NTT Network Service Systems Laboratories in 2003 and studied optical transmission systems. He also worked on the development project for optical transport systems. During 2011–2014, he was involved in international submarine cable projects at NTT Communications. He has been in his current position since July 2014 and is engaged in developing 100-Gbit/s packet transport systems (100G-PTS). He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE).

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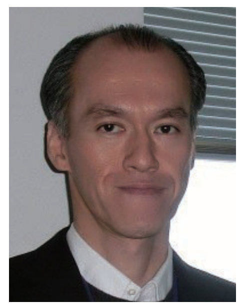

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