Component Technologies and Packet-Optical Integrated Transport Systems to Support Core Networks

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Abstract

Accompanied by the rapid increase in mobile communications traffic in recent years, there has been an increasing demand for larger capacity core network systems to support the backbone system. It is also regarded as important that the various costs such as CAPEX and OPEX are suppressed and that the network features a highly reliable resistance to disastrous events.

This paper introduces NEC's component technologies and the latest network systems for building high-capacity, high-reliability optical networks as well as discussing future prospects.

Keywords

packet-optical integration, digital coherence, CDC-ROADM, MPLS-TP, SDN

1. Introduction

In enabling practical coherent detection by using digital signal processing, digital coherent detection is attracting attention as a solution for achieving high capacity in core network systems. R&D and practical applications are currently actively being implemented as a result.

Furthermore, multilayer-integrated transport (packet-optical integrated transport) composed of WDM (L0), OTN (L1) and packet (L2) is also attracting attention as a suitable technology for achieving highly reliable network systems. Its implementation is also helping to suppress CAPEX (capital expenditure) and OPEX (operating expenditure).

This paper introduces NEC's component technologies for building high-capacity, high-reliability optical networks and also the SpectralWave DW7000 Packet-Optical Transport System that incorporates these components.

2. Configuration of Packet-Optical Transport

The configuration of packet-optical transport is shown in Fig. 1. The system comprises a packet switching section and an optical switching section.

Integration of the packet switching and optical switching sections makes it possible to monitor the network consistently. The flexible conversion of the wavelengths of client signals that have been input from a WDM system having multiple transmission paths and the application of the CDC (Colorless, Directionless, and Contentionless) function enables routing control and directs the transmission path as required. The system enables multilayer path selection from L0 to L2, thereby enabling the construction of an economical and

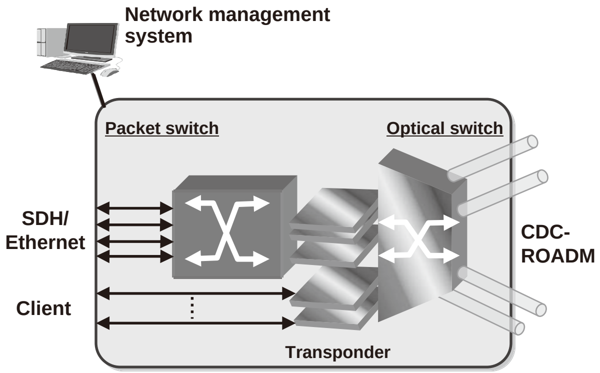

Fig. 1 Packet-optical integrated transport system.

flexible network that achieves optimization of network resources.

3. Component Technologies that Feature High Capacity and High Reliability

(1) Digital coherent technology

The digital coherent technology that is effective in achieving large capacity digital signal processing, which has already been put to practical use in the wireless field is now applied in optical fiber communications. The technology uses digital processing in the electrical domain to correct the phase noise that has hitherto been an issue of conventional coherent optical communications systems. It also compensates for the waveform distortion that occurs in transmission lines during WDM transmission.

(2) LO selection (patent pending)

When received WDM signals are to be connected to a transponder, an optical filter such as an AWG (Arrayed Waveguide Grating) device is usually necessary. However, reception of the required signals is possible without the optical filter when the local oscillator (LO) light inside the transponder is set at the required receiving wavelength and coherent detection is performed. The principle of this process is shown in Fig. 2. Optimization of the LO selection makes it possible to reduce both power consumption and footprint by approximately 50% compared to that of the optical filter.

Moreover, in superchannel transmission where multicarrier signals are overlapped in a single frequency range, the LO selection can potentially be an extremely effective technology for receiving specific carrier signals due to its achievement of larger capacity. NEC was successful in initiating R&D in this technology in advance of competing companies and has succeeded in its practical application.

(3) CDC-ROADM technology

As a result of the CDC-ROADM (Colorless Directionless Contentionless-Reconfigurable Optical Add/Drop Multiplexer) function, switching of optical paths for multiple routes is possible without being restricted by conditions other than that of the input/output interface (non-blocking). As shown in Fig. 3, this technology makes possible flexible construction of optical paths by sharing the transponder group for multiple routes.

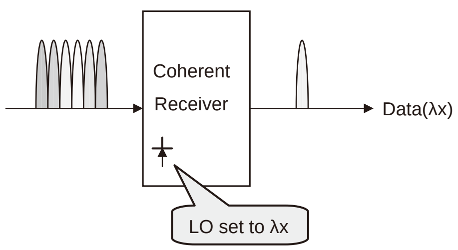

Fig. 2 Principle of LO selection.

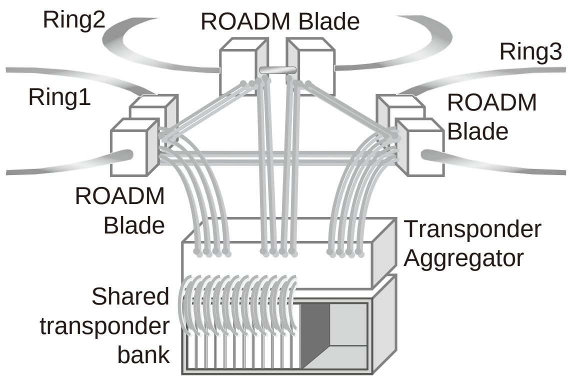

Fig. 3 CDC-ROADM.

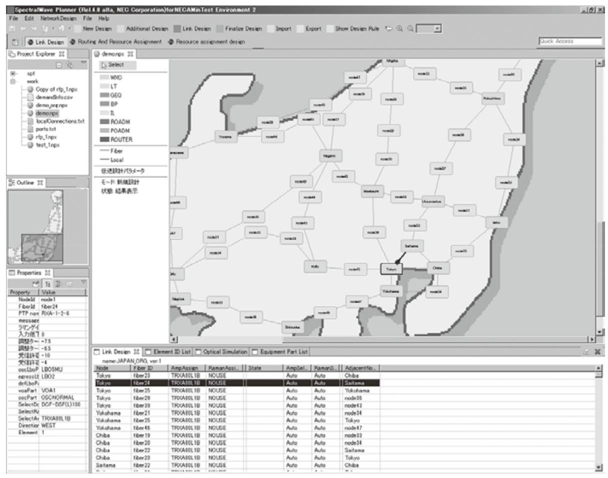

Fig. 4 Example of multilayer design.

(4) MPLS-TP technology

This solution uses MPLS-TP for the transport protocol in the packet switching section and allows MPLS-TP LSP with endpoints A and Z to be set for any desired route. Moreover, by using the OAM function's failure detection capability as a switching trigger, the solution enables high-speed path switching in less than 50 ms, which is equivalent to that of an SDH (Synchronous Digital Hierarchy) network.

(5) Multilayer design technology

In order to design a network with high efficiency and high reliability, it is required to create optimum system configuration in multilayers from L0 to L2. An optimum multilayer network can be achieved by taking consideration of the economic efficiency derived from cost simulation. Reliability is supported by setting different routes for the lines in a protective configuration and backup lines (third route switching) when a major disaster occurs.

Fig. 4 shows an example of multilayer design that takes account of these factors.

4. Features of the SpectralWave DW700

By applying the above-mentioned component technologies, the SpectralWave DW7000 achieves packet-optical integrated transport at the world's highest level.

The main specifications are shown in Table below, and the external appearance of the system is depicted in Photo.

Table Main specifications.

Classification	Item		Specification
Optical switch section	Maximum number of wavelengths		C-band (96 wavelength), L-band (88 wavelength)
	Maximum number of lines		8 lines
	WDM interface		Digital coherent, DP-QPSK
		PMD (Polarization-Mode Dispersion) tolerance	Maximum tolerance DGD 100 ps
		CD (Chromatic Dispersion) tolerance	50,000 ps/nm
Packet switch section	Management/monitoring technology		Ethernet OAM, MPLS-TP OAM
	Format		Ethernet frame (IEEE802.1D, Q, ad, ah) MPLS frame
		VLAN	• IEEE802.1Q VLAN-Tag • IEEE802.1ad S-Tag • IEEE802.1ah B-Tag Insertion/deletion/relocation of above
		MPLS	Label Push, PoP, SWAP
	Protection		G.8131 (MPLS-TP Linear Protection) Revertive/Bi-directional Non-revertive/

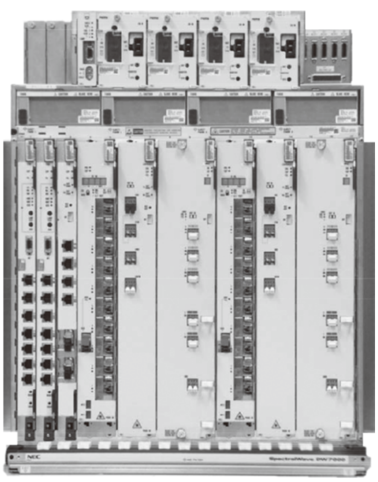

Photo External view of the SpectralWave DW7000.

5. Efforts for Future Expansion

Our aims to further increase the capacity of the DW7000 and to enhance its reliability are projected as follows.

(1) Large-capacity network

As part of our efforts for the R&D to increase network capacity, NEC has been collaborating with Verizon Communications of the United States and has set world records for the three consecutive years since 2011. The post-deadline paper (PDP5A4) of OFC/NFOEC reported in March 2013 that this collaborative effort succeeded in the field trial of 54 Tbs.

In support of the superchannel that is necessary to increase the capacity, the following two capabilities are important.

- Capability of coping with a flexible grid instead of a conventional fixed grid that supports only fixed signal wavelengths.
- Capability of optimizing the wavelength utilization efficiency by narrowing the spectrum when the variable format transponder that changes the modulation method according to the transmission distance (multi-value modulation of 8-QAM, 16-QAM, 64-QAM, etc.) is used, and of widening the spectrum when long-distance transmission is required.

The SpectralWave DW700 employs an architecture that can already handle with the above-mentioned two technologies.

(2) SDN

With the transport SDN system, CAPEX and OPEX can be reduced when the following measures are taken.

1) Automation/simplification of the management of the network control operation

2) Quick provision of virtual networks such as IP networks.

3) Increase in network usage efficiency

Furthermore, no router is required because a routing capability is incorporated in the transport SDN system. The routing capability achieved in the transport SDN system results in an advantage as described below.

4) Construction of a routerless network

Measures 4) can be expanded into the transport SDN system in combination with the existing SDN controller (SDN-C).

Fig. 5 shows how the transport SDN system is configured.

The SDN-C builds a virtual network by allocating network resources of the packet switching section based on an order to open the service. As shown in the example in Fig. 5, a virtual

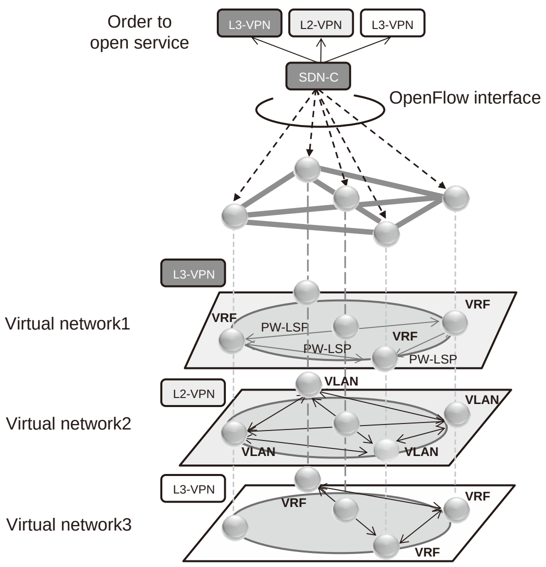

Fig. 5 Transport SDN system.

network can be configured in various layers including Ethernet (L2), IP (L3), and MPLS. As a result of the centralized configuration of the SDN-C's C-Plane function, the routing function can be provided throughout the integrated transport system. Thereby enabling a reduction in the number of routers and suppressing the OPEX (power consumption/management and operating costs) of the entire system.

6. Conclusion

Above we have discussed the large-capacity, high-reliability component technologies used in core transmission systems and have introduced the SpectralWave DW7000 Packet-Optical Integrated Transport System. We believe that compatibility with the superchannel and integrated control by SDN will enable the construction of networks of even larger capacity and of higher reliability.

* Ethernet is a registered trademark of Fuji Xerox Co., Ltd.
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