4K Uncompressed Streaming over Colored Optical Packet Switching Network

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Abstract

A field trial of 4K uncompressed streaming over 80 (8λ x 10) Gbps colored optical packet switching network with SOA based broadcast-and-select switch and stacked optical-code (OC) label processing is reviewed.

Introduction

"4K" motion pictures (3840x2048 pixels), which is 4 times pixel counts of high-definition (HD), are promising imaging technology for digital cinema, computer visualization, and medical applications. Uncompressed streaming of 4K motion pictures requires about 6 Gbps but enables us to share the image over networks with lossless quality in real-time manner. The feasibility of 4K uncompressed streaming over IP network has been demonstrated in these years [1]. Because of its high bandwidth, real-time point-to-multipoint transmission with high-speed switching capability of uncompressed 6Gbps 4k motion pictures still remains a challenge.

Optical packet switching (OPS) is a very attractive technology to realize such high bandwidth, low latency, and fine granularity for high-performance computer networks. Recently, many different OPS schemes have been developed to route and forward IP packets directly in the optical domain [2-4]. However, it is difficult to realize OPS system because practical optical buffers are not available. Recently, we have proposed and demonstrated the multicast-capable variable bandwidth colored packet switching using the semiconductor optical amplifier (SOA) based broadcast-and-select switch and the stacked optical-code (OC) label processing [5]. It enables to reduce the latency and simplify the control of complicate switching, scheduling and optical buffering because its payload time length is fixed. On the other hand, one real issue is how to connect such high-speed OPS networks and current networks based on Internet protocol (IP) technology. To provide the effective scheme and the device accommodating IP packets into over-40-Gbit/s optical packets in network edge nodes, the layer-3 IP switches (called as IP-OP or OP-IP converters) as interfaces between 80 Gbit/s OPS networks and 10 Gbit/s Ethernet (10GbE) have been developed [3].

In this paper, we introduce a field trial of 4K uncompressed streaming over multicast-capable 80 (8λ x 10) Gbps colored optical packet switching network using SOA based broadcast-and-select switch and stacked OC-label processing.

Architecture of Multicast-Capable Colored Optical Packet Switching Network

Figure 1 shows the multicast-capable colored optical packet switching network using SOA based broadcast-and-select switch and stacked OC-label processing. The switching node mainly consists of optical switches and optical label processor (Fig.1a). In the optical switch, the broadcast-and-select architecture is adopted using SOA switch array [6]. This architecture is suitable for optical multicasting. In addition, it takes advantage of the gain of the SOA switches to compensate the optical signal losses due to the power splitting. Figure 1b shows a configuration of colored optical packet format. It consists of the fixed-length colored payload bundling several WDM links and the stacked OC-label. It enables to reduce the latency and simplify the control of contention resolution as compared with variable length packets. Colored packets are forwarded based on the routing information that the stacked OC-label has [7]. The stacked OC-label recognition is simultaneously achieved by the optical correlation using a multi-port decoder [8]. The stacked OC-label is also suitable for optical multicasting.

Demonstration

Figure 2 shows the setup of 4K uncompressed streaming over a multicast-capable colored optical packet switching network. 4 uncompressed HDTV-IP Gateways (XG-2s) [9] connected with a 4K playback system generate 6.4 Gbps 4K streaming data (1.6Gbps for each XG-2). The Ethernet frame length is 2,220 byte. For traffic monitoring, a PC-based server generates another 1.6 Gbps streaming data. These 8-Gbps signals are transmitted through 10Gbps virtual local area network (VLAN) of JGN2 plus [10] from Digital Media and Content, Keio University (DMC) to NICT.

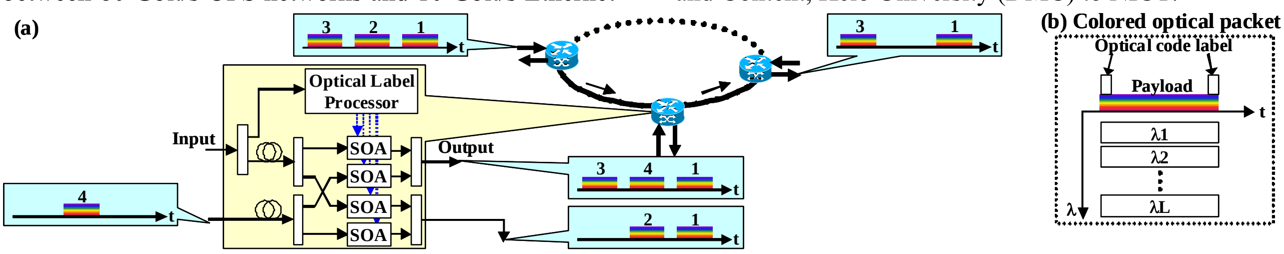

Fig. 1. Architecture of multicast-capable colored optical packet switching network.

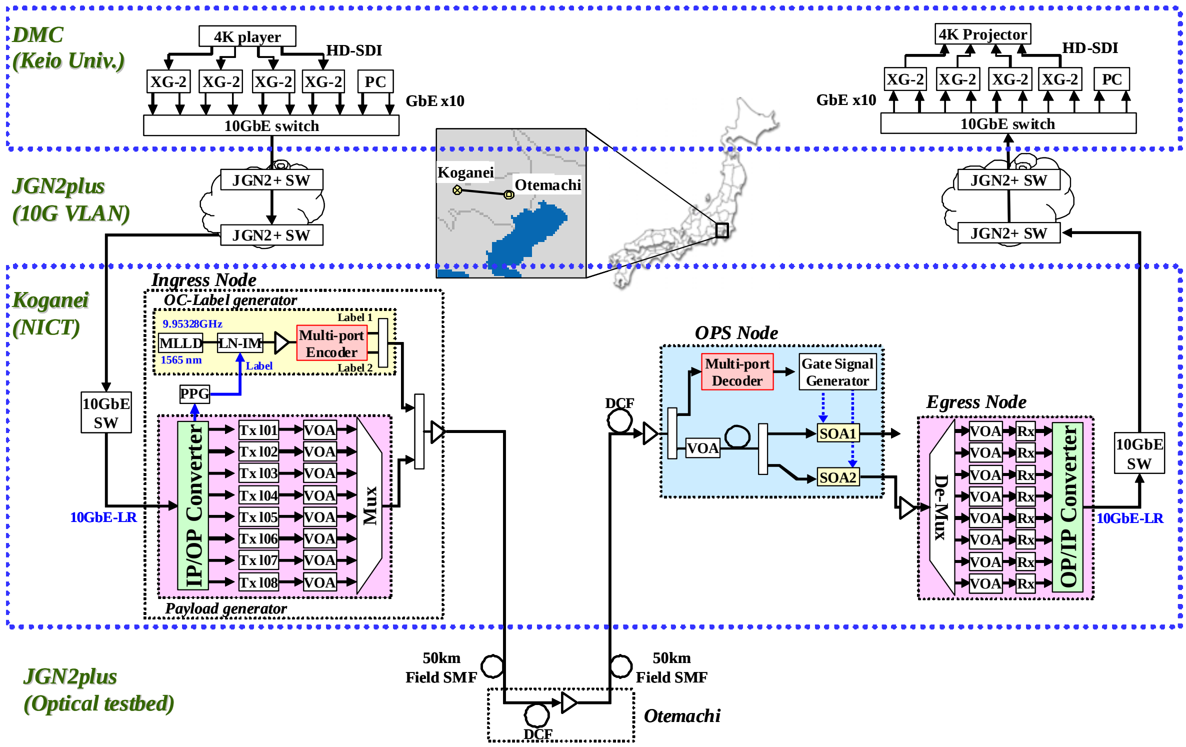

Fig. 2. Demonstration setup.

At the ingress node, the IP-OP converter divides IP packets over 10GbE frames to eight segments and generates stacked OC-label selection signal from the IP address after header processing using look-up table. Using the label selection signal and the multi-port optical encoder, 16-chip (200 Gchip/s) phase shift keying (PSK) optical codes are generated. By combining optical codes from two optical encoder outputs, the stacked OC label is generated. On the other hand, eight-segmented 10 Gbps Ethernet frames in the IP-OP converter are converted into 8-channel 10 Gbps non-return-to-zero (NRZ) format optical signals at different wavelengths (λ01: 1541.35 nm - λ08: 1558.17 nm at 300 GHz spacing) by burst-mode transmitter. The data rate of an optical payload is 80 (8λ x 10) Gbps and the payload length in time is one eighth of original 10 GbE frames. The generated packets are then launched into 100-km field single mode fiber (SMF), which is part of JGN2 plus installed in Tokyo metro area. In OPS node, these packets are divided and launched into two lines: the multi-port optical decoder and the optical switch. The control signal from the gate signal generator according to the decoder correlation output determines the state of the optical switch to either drop or pass through or add the optical packet. In the SOA, input optical packets are passed through and dropped according to the control signal. At the egress node, each optical packet is demultiplexed into 8-wavelength channels and received by 8-channel array burst-mode 3R-receivers. In the OP/IP converter, received packet payloads are recombined and converted into IP packets on 10GbE frame. These 10GbE frames are returned thorough 10G VLAN of JGN2 plus from NICT to DMC again. In DMC, 4 XG-2s receive 4K streaming signal from network and regenerate 4K video signal. The video signal is screened by a 4K projector. Finally, we measure the frame loss rate by the PC-based server.

The detail results of this demonstration will be presented on site. In addition, we discuss key issues in streaming over OPS system.

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