GMPLS-based High-speed Optical Slot Switching System
Using PLZT Ultra-high Speed Optical Switch for HDTV Contents Delivery Network

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Abstract: We design and implement a new high-speed HDTV content delivery network with GMPLS-based Optical Slot Switching system which consists of 10ns switching PLZT optical switch and Ethernet/Optical Slot protocol converter as edge router.

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1. Introduction

The IP traffic in the network increases rapidly by the speed-up of the access network and the spread of the P2P application in recent years, and the demand for the high-speed mass forwarding technology has risen. But present IP network is not suitable for bulk contents like HD (High Definition) files because of some reasons. First is backbone router bottleneck by sharing bandwidth. It causes data transfer slowly. Second, best effort communication doesn't support the bandwidth guarantee. Therefore, we design and implement new layered structural optical network architecture for HDTV contents delivery. The network consists of two layers, P2P application layer and OSS (Optical Slot Switching) [1] transport layer.

2. Layered Structural HDTV Contents Delivery Optical Network

2.1 P2P Application Layer

In the application layer, server suggests the pre-downloading peers and user will create peers for high-speed rich contents download. The contents which a user prefers to see are automatically pre-fetched by category matching method. A user machine automatically accesses to the HD contents server and discovers the peers which have already downloading contents. A user measures the performance of the peers and will set up the optical path which consists of several slots. Making P2P and pre-downloading by optical slot transfer realize the high-speed rich contents download.

2.2 Optical Transport Layer: Optical Slot Switching

Figure 1 shows our proposed OSS network and block diagram of protocol converter as the edge router. Upper P2P application layer finds the peer which has HD contents, the user creates optical slot path by GMPLS signaling. The OSS network consists of a control plane and a data plane, and it synchronizes the devices in the network. In this paper, we employ three techniques to realize the OSS network. These are PLZT optical switch, GMPLS (Generalized Multi-Protocol Label Switching) extension control protocol and Protocol Converter.

With conventional optical switches, it was very difficult to realize the OSS network because of its switching time. Slow switching causes large guard time between data transfer, and can not realize efficient content transfer. However, a high-speed optical switch was actively researched in recent years. Then, PLZT high speed optical switch was realized by Epiph Photonics Co., Ltd. (former Nozomi Photonics) in 2005 [2]-[4]. The PLZT optical switch enable to switch its output port with under 10 ns, and can improve the bandwidth utilization by reducing the guard time between data transfer unlike the conventional switches.

We extend the TDM-LSP (Time Division Multiplexing-Label Switched Path) scheme in RSVP-TE (Resource Reservation Protocol-Traffic Engineering)[5] and realize optical slot reservation. RSVP-TE is standardized as the GMPLS signaling protocol. Before data transfer, one node sends a PATH message to destination node to collect the slot used information between two nodes through the protocol converter (edge router) or several optical switches.
After receiving PATH message, destination node collects the desired slots and sends RESV message to source node to reserve desired number of slots. When destination node collects the desired slots, various types of scheduling can be selected. For example, in the case of DVD file transfer, a lot of slot will be assigned to user. The scheduling algorithm is under evaluating now.

We developed protocol converter as the edge router. Since data is transferred with data slot in proposed network, it is needed to accumulate the data and send with synchronous timing at edge router. In this paper, we would like to use the packet-capture accelerator manufactured by U10 Networks. The Ethernet data which comes asynchronously from input port are processed at Reconfigurable processor, and buffered into DRAM according to destination address of each packet as shown in lower part of figure 1. This protocol converter is taken synchronization with PLZT optical switch and sends a data slot synchronously which size is decided beforehand, which the sending period is "Slot".

3. Experiments

3.1 PLZT Optical Switch System with GMPLS-based Controller

In order to realize the proposed slot switching network, we developed a PLZT optical switch system with a GMPLS-based controller. Figure 3 shows the PLZT optical switch unit. The system consists of a control unit and an optical switch unit. The control unit is a Linux-based PC with GMPLS software, and is connected to the optical switch unit via a serial cable. The optical switch unit consists of a High-speed Driver, optical switch body and controller board. The controller board includes an FPGA that has a pair of 4000 pattern memory banks. It reads and writes the banks based on signals from the controller and sends the appropriate switching pattern signal to the high-speed driver. The high-speed driver sends switch signals to the switch body upon receiving signals from the controller board. The system can activate the switch by slot according to a RESV message from the GMPLS control plane.
3.2 Protocol Converter: Ethernet to Slot

We develop a protocol converter as the edge router between Ethernet-based IP network and OSS network. Figure 2 shows the board of protocol converter. In our implementation, a protocol converter takes switch timing synchronization with master PLZT optical switch.

On the other hand, we realize the frame, which consists of several slots. For example, if we reserve 1000 switching patterns on the memory bank of PLZT optical switch system, the frame size will be 1000 and 1000 switching patterns will be read cyclically. We call it “Cyclic Switching.” The switch system sends the synchronization signals to protocol converter every 1000 switching pattern. Thus, protocol converter takes synchronization with PLZT optical switch.

3.3 Experimental Network

Figure 4 shows the experimental network to implement OSS and fig.5 shows the picture of the experimental network. In the network, the number of slots in a frame and slot size can be changed as needed. There are three protocol converters, one PLZT optical switch and three users of one contents server and two clients. User B and C have preferences, and the server knows them. If the server obtains the contents which match to the user’s preferences, the server sends contents to appropriate user. The server sends the PATH message to the user and set up the optical slot path.

4. Conclusion

We have designed and implemented new layered structural optical network architecture for HDTV contents delivery. Upper P2P application layer realizes the contents delivery network which pre-fetches the contents by category matching method from contents server. Lower OSS layer consists of 10ns switching PLZT optical switch and Ethernet/Optical Slot protocol converter. By the experiment, we showed the system feasibility of our proposed network.

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