A novel node architecture for all-optical switching networks

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A calibration switch architecture, suitable for prioritized packet transmission, uses significantly fewer optical switches and wavelength converters without compromising performance.

The explosion in the volume of electronic communication has resulted in an acute need for high-performance networks. Some promising all-optical switching networks (ASNs), such as optical burst-switched (OBS) and optical packet-switched networks, have been proposed to meet this need. ASNs use optical switches rather than optical-electrical-optical conversion to achieve transparent transmission. Since wavelength conversion (WC) and optical random access memory (RAM) are not readily available so far, contention will occur when two or more switching entities (e.g., packets, bursts) from different input ports need to be forwarded simultaneously on the same wavelength and output port.

Many methods for resolving such conflicts have been studied. The literature explores three dimensions of contention-resolution schemes (wavelength, time, and space) using wavelength conversion, fiber delay lines (FDLs), and deflection routing, respectively. Although wavelength conversion is a good method, the technology is not mature at present. FDLs and deflection routing increase data latency. Thus, under the current and foreseeable limitations of optical technology, ASN performance is mainly hampered at the network node by conflict over resources. To address this problem, we have developed a novel node architecture called a packet calibration switch.

Calking is the process of making seams tight. Packet calking means filling the gaps between switching entities by inserting Internet protocol (IP) packets. The basic function of a packet calibration switch is as follows. First, the node categorizes the traffic into two types, single-hop traffic and multihop traffic, based on whether it uses one or more physical links. Second, the node supports prioritized packet transmission, and the pass-by multihop traffic is always forwarded first. Third, newly added traffic can be aggregated if needed. Finally, single-hop traffic is calked into gaps in the multihop traffic for transmission.

An example of packet calibration switch architecture using OBS is shown in Figure 1. It has two important functions: edge aggregating and core switching. IP packets from the access interface are routed by the traffic sorter according to their destinations. If they are going to an adjacent node, the packet is queued in the single-hop queue. If not, it goes to a multihop queue. IP packets in multihop queues are assembled into bursts according to assembly algorithms. Bursts and single-hop IP packets are stored in the electronic RAM. If the node detects that a wavelength is idle for a specific time period, single-hop IP packets are aligned as a calking entity with a duration to fit the period. Figure 2 traces the calking process for four pass-by bursts, labeled 1 to 4, and two calking entities marked C₁ and C₂, respectively. Before the node transmits a calking entity, the node sends a calking control packet to inform the adjacent node.

We have developed and simulated five schemes in a four-node line network: calking, no calking, FDL, partial WC (PWC), and calking combined with PWC. We selected an assembly algorithm and made the following assumptions for the simu-
Figure 2. The calking process of an OBS node, showing four pass-by bursts (1–4) and two calking entities (C1 and C2). WC: Wavelength conversion. E/O: Electrical to optical.

Figure 3. This plot of drop probability versus offered load shows that packet calking decreases the probability of dropped packets. PWC: Partial wavelength conversion. FDL: Fiber delay line.

Figure 4. This plot of link utilization versus offered load demonstrates the 5~25% improvement with packet calking. BL: Bottleneck link. OL: Ordinary link.

This node architecture is suitable for prioritized packet transmission. It is more cost-effective than the existing node architectures because it requires many fewer optical switches and less WC to achieve nearly the same packet-dropping probability as the node configured with PWC. In addition, link utilization is improved. In the future, we will investigate the feasibility of packet calking and the technologies suitable for its application. At the same time, we plan to focus on burst mode optical transmission at high bit rates, which is still a subject of intensive research.

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References

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