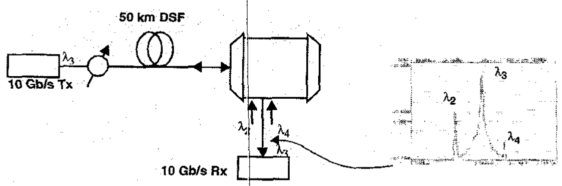


**TuR1 Fig. 3.** Experimental setup to evaluate the impact of backward-propagating light on the performance of the WADM. The optical spectrum is taken when the BER of the 10-Gbit/s signal is around $10^{-9}$.

has no effect on the BER performance of the signal channel as shown in Fig. 2. Note that the WDM-MUX is not symmetric[6] and the cross talk from $\lambda_2$ and $\lambda_4$ are not equal. To study whether bidirectional WADM requires more cross talk rejection, further measurements show that if all channels propagate in the same direction, the cross talk from adjacent channels is smaller than $-25$ dB.

In conclusion, an eight-wavelength bidirectional WADM with 80-Gbit/s capacity is proposed and studied. The WADM includes wavelength add/drop capability in both directions using multilayer interference-filter-based wavelength demultiplexers. It is shown that the backward-propagating light does not induce a power penalty.

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## TuR2 6:00pm

### Multi node demonstration of a multihop wavelength-routed all-optical packet-switched network

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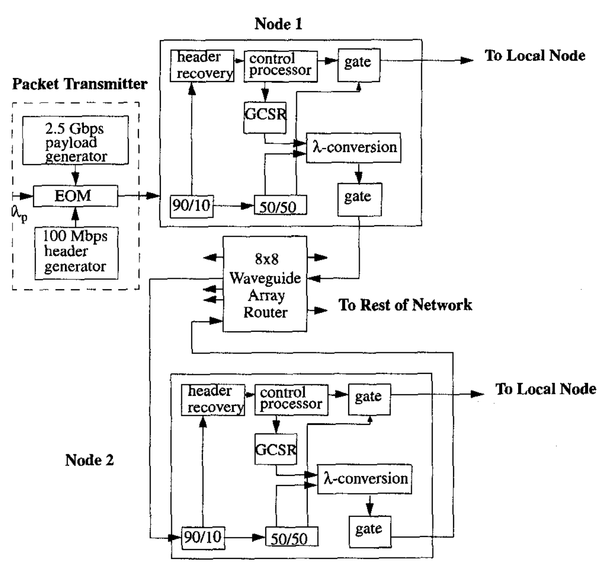
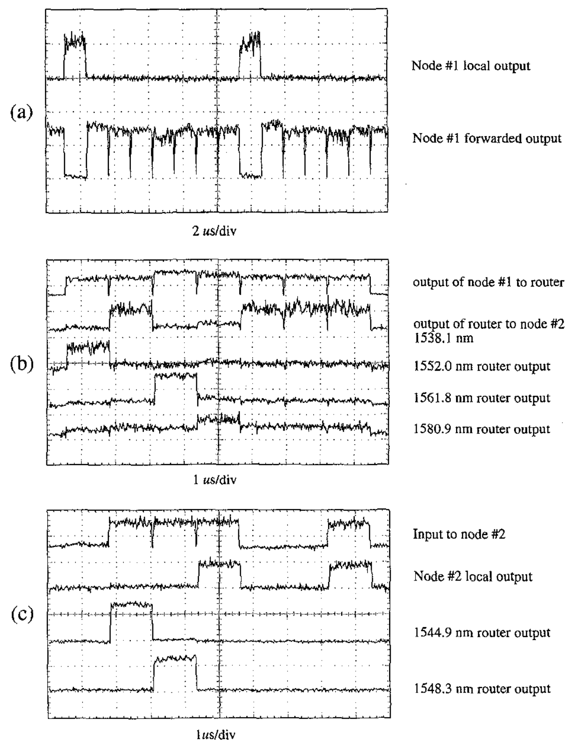
Multihop wavelength-routed all-optical packet networks can provide scalable data-rate and format-independent transport layers for packet-based communications. Single network interface nodes have been demonstrated that are capable of processing headers and either switching packets to a local host or forwarding them to a remote node.[1,2] In these demonstrations, subcarrier multiplexed packet headers were combined with the baseband payloads[3] and wavelength conversion was utilized to forward packets to another node. The node described in Ref. 1 is designed to operate with an interconnect that is based on the waveguide-grating array router.

In this paper, we present what we believe to be the first experimental demonstration of a multinode WDM multihop packet network interconnected with an arrayed-waveguide router. Each node has the full functionality to route packets with subcarrier multiplexed headers and perform fast wavelength translation between four wavelengths and space switching between a local host and an 8 × 8 waveguide-grating array router. Packets consist of a 3050 bit payload at 2.5 Gbps and a 122-bit NRZ header at 100 Mbps multiplexed on a 3-GHz subcarrier. Our demonstration incorporates several new performance enhancing subsystems, which previous demonstrations lacked. These enhancements include fast, uniform wavelength-conversion-switching performed using a novel current injection circuit in combination with a four-section wavelength tunable GCSR laser[4,5] yielding wavelength switching times under 4 ns for all wavelengths required by the node. Simultaneous wavelength conversion of subcarrier multiplexed packet headers and baseband payload via cross gain saturation in semiconductor optical amplifiers is shown to preserve the header through multiple all-optical hops. We have also implemented a different header recovery technique on each node: coherent RF heterodyning as in Ref. 1 on one node and incoherent RF detection using a fast Schottky barrier diode on the other. The second approach simplifies the header recovery subsystem and alleviates the need for frequency and phase synchronization of subcarrier sources. Additionally, because incoherent detection acts only on the prescence or absence of a subcarrier and not on its phase, this scheme is indifferent to pattern inversions produced by cross gain saturation-based wavelength conversion.

The multinode experiment consists of a packet transmitter and two fully functional space/wavelength routing nodes interconnected by an 8 × 8 waveguide-grating array router as shown in Fig. 1. The 1556-nm packet transmitter generates packets of 1.22-μs duration with a 30-ns guard band at each end. 10% of the input signal to each node is tapped for header detection and recovery. Header recovery at node #1 is performed by beating the converted signal with a 3.0-GHz LO followed by a low pass filter and at node #2 by using a microwave square law detector. An ECL



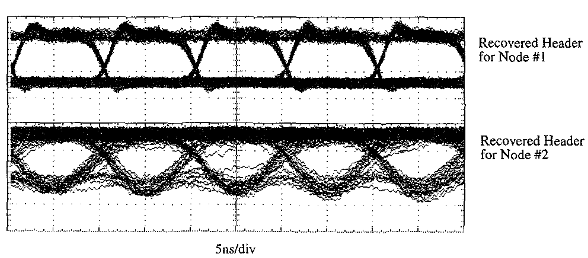

**TuR2 Fig. 1.** Block diagram of multinode experiment.




**TuR2 Fig. 2.** (a) Local and remote output of node #1; (b) Input to and output from the router due to forwarded packets from node #1; (c) Input to node #2 and routed packets from node #2.

routing processor at node #1 maps the recovered header to one of two modulator states (local or remote) and one of four possible wavelengths (1538.1 nm, 1552.0 nm, 1561.8 nm, and 1580.9 nm) at the packet rate. Node #2 has the same functionality as node #1, except that mapping to 1544.9 nm and 1548.3 nm is shown for the second hop.

The four conversion wavelengths are obtained by changing the current in the coupler tuning section of a four-section tunable laser. A novel pre-distortion pulse-shaping circuit is used to decrease the wavelength conversion times and reduce the variance across different source/destination wavelength pairs. The payload and subcarrier multiplexed header are converted to the tunable laser wavelength via cross gain saturation in a semiconductor optical amplifier. Optical modulators are used to gate packets to the local host and to the wavelength-routed network. The remote modulator is open only for the duration of a packet and is closed otherwise, including those times when no packets are being received, in order to prevent unwanted signals from leaking into the network. Demonstration of routing through the first and second nodes is




**TuR2 Fig. 3.** Eye diagrams of recovered headers at node #1 and node #2.

shown in Fig. 2. Eye diagrams for the recovered header bits are shown in Fig. 3.

In summary, we believe we have demonstrated multihop wavelength-routed all-optical packet switching over multiple nodes for the first time. The experiment demonstrated space and wavelength switching through a waveguide-grating array router.

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**TuR3 6:15pm**

## Experimental demonstration of penalty-free optical cross-connect cascade with multiwavelength transmission over 1000-km standard fiber

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An optical cross-connect (OXC) architecture was proposed[1] to implement high-capacity transparent wavelength-division multiplexing (WDM) optical transport networks. A laboratory demonstrator was built to assess the feasibility of this concept.[2] We report here a penalty-free cascade experiment of three 4 × 4, eight-channel OXCs operated at 2.5 Gbit/s including WDM transmission over 1001-km nondispersion-shifted fiber.

The experimental setup is described in Fig. 1. The OXC includes three major switching stages: (1) a multiwavelength space-switching stage, based on clamped-gain semiconductor optical amplifier gates,[3] (2) a tunable wavelength selection stage, based on commercial Fabry-Perot filters under loop control, and (3) an all-optical wavelength conversion stage, using carrier depletion techniques in semiconductor optical amplifiers (SOAs). Two of the converters are based on cross-gain modulation effect (XGM), while the third one is a new Mach-Zehnder Interferometer converter (MZI-WC) based on cross-phase modulation.[4]

In addition, a single-pump double-stage fluoride fiber amplifier is inserted on both sides of the optical filter, to adjust the input optical power to the MZI-WC, and also to cancel wavelength- and path-related power fluctuations before or in the first stages of the OXC.

Three paths through the OXC are fully equipped, in addition to local add-drop ports. The losses are representative of a 4 × 4 eight-wavelength node. One of the output ports is looped back to one of the