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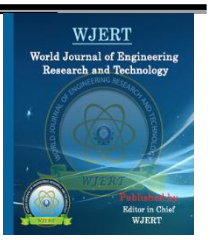

ANALYSIS OF TRAFFIC CONTROL IN WAVELENGTH DIVISION MULTIPLEXING (WDM) ROUTING

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ABSTRACT

In WDM routing we analyze the all self-routing and optical traffic control of WDM optical packets in a cascaded two-node all-optical Data Vortex switching node. In the experiment, WDM optical packets are successfully routed while maintaining a BER of 10^{-10} or better. The WDM optical networks give reliability and unprecedented for message transfer among the nodes. All-to-all routing is a fundamental routing problem in such networks and has been well studied on single hop WDM networks. The number of wavelengths to optimize the all-to-all routing on the single hop structure typically is very large. One way to reduce the number of wavelengths is to use -hop routing, in which each routing path consists of segments and each segment is assigned a different wavelength, where usually is a small constant. Because of the complexity of design and analysis for such a routing problem, only few papers discussed and proposed all-to-all routing by 2 hops. However, the proposed algorithms are usually exceeding complicated even for ring topologies. Often, an ad hoc approach is employed to deal with each individual Topology. The system reliability of a connection is determined by the number of different risks associated with the path. We study the most reliable routing for WDM networks with arbitrary risk distribution in this paper. Firstly we consider on the minimum risk single path (MRSP) problem, in which a single most reliable path is to be established between a given source-destination pair. To solve MRSP, a simple label-setting (Simple-LS) algorithm is proposed by iteratively setting every node with a diminishing path-risk set (i.e. the label of a

node). We then extend Simple-LS to find up to K lowest risk paths in each iteration, called K-path LS algorithm.

INTRODUCTION

The technique of Data Vortex routing suggested for the optical packet switching approaches the challenges like as absence of robust optical buffers and the viewpoint of routing structure, the contention resolution from a simple routing logic. So far, several researches[1-3] have been reported. In this technique we analyze the all-optical traffic control and self-routing of WDM encoded optical packets carrying 40 GB/s payload signal in a cascaded two-node all-optical Data Vortex node by all-optical header processing which is different from the electro-optic header processing used at the previous reported researches.

Structure of all-optical Data Vortex switching node

Fig.1. Schematic of the Data Vortex topology with A = 5,H = 4,C = 3 Routing tours are seen from the top and the side The proposed all-optical Data Vortex switch node[4] is shown in Fig. 1, which consists of two MZI-SOAs. The upper and lower MZI-SOA acts as an AND optical logic gate and an 1×2 optical switch, respectively. In an optical packet, a WDM scheme is used to carry the payload and header of an optical packet. In a WDM packet encoding scheme, each wavelength channel carries a single header bit on a time slot, and each node in a Data Vortex router decodes a specific header bit in a binary tree fashion.

If a WDM encoded optical packet comes into the proposed switch node, a portion of the signal is tapped into the upper MZI-SOA. Then the specific header signal is extracted by the passive optical band pass filter for the header processing. The upper MZI-SOA performs a header processing by the extracted header and the control signal from inner node and gives a routing signal for the lower MZI-SOA. This routing signal controls the switching function of the lower MZI-SOA gate.

When users subscribe services of an optical WDM mesh network that faces various potential risks (such as duct/cable-cut and equipment defects), connection reliability is one of the most important concerns. Although routing plays a critical role in determining connection reliability, limited research efforts are dedicated to studying reliability-aware routing in WDM mesh networks. Assume the reliability of a connection is determined by the path risk number, i.e. the number of distinct risks associated with the path. We study the most reliable routing for WDM networks with arbitrary risk distribution in this paper. We focus on two routing problems, min-risk single path (MRSP), and most reliable path pair (MRPP).

WDM optical networks can be classified into two categories: switch-less (also called broadcast-and-select) and switched. Each of these can further be classified as either single-hop (also called all-optical) or multi-hop network structure. If we talk about the switch-less networks, we can see the transmission from each node is broadcast to all other nodes in the network. At each node, the desired signal is extracted from all the broadcast signals. The switch-less networks are practically important since the whole network can be constructed out of passive optical components, which are reliable and easy to operate. There are many limitation of switch-less networks those are extended to wide area networks.

Indeed, it has been proved in that switch-less networks require a large number of wavelengths even for simple traffic patterns. Therefore, optical switches are required to build large scale networks. A switched optical network consists of nodes interconnected by point-to-point optic communication links. Each fiber-optic link supports a given number of wavelengths. Switches at each node direct their input signals to one or more output links. Each link consists of a pair of unidirectional links. In this paper we analyzed the such switched network in which signals from different applications may travel on the same communication link into a node and then exit along different outgoing links. The only constraint is that any two paths in the network sharing a common optical link must be assigned with different wavelengths. In switched networks it is allowed to “reuse wavelengths”, thus, achieving a dramatic reduction on the number of required wavelengths with respect to switch-less networks.

Photonic packet switching has emerged as an attractive way to overcome the electronic bottleneck in today’s fast growing communication and computing systems.[1] These type of systems have the more bandwidth, issues such as processing, buffering, scalability, and latency remain the key design challenges for the switching network elements. A new architecture called the Data Vortex was, thus, proposed that is uniquely free of optical buffers and enables simple routing logic for large scale low latency packet switch fabrics.[2] The hierarchical system employs a synchronous timing and distributed control signaling to avoid packet contention and to achieve simplicity, scalability, and high throughput. This type of system provides the use of a wavelength-header-encoding technique to minimize the routing function and switching latency. In this letter, we demonstrate experimentally the control mechanism between two fully functional routing nodes of the Data Vortex. In addition, the techniques of wavelength-division-multiplexing (WDM)-encoded header bits and wavelength-filtering recovery are also shown within the test bed.

A schematic of the Data Vortex architecture is shown in Fig. 1. The switch fabric size is defined by the following parameters and corresponding to the number of routing nodes lying along the “angle” and “height” dimension, respectively. The number of cylinders, scales as. Packets are processed synchronously within the switch fabric in a parallel manner. Within each time slot, every packet progresses by one angle forward either along the solid line toward the same cylinder or along the dashed line toward the inner cylinder. C=log2 (H)+1

Dual Layer WDM Routing

There has been a paradigm shift in computer processor design. Due to design complexity and limits arising from thermal dissipation at both package and system levels, processor performance growth via clock rate increases has stalled. Instead, more parallelism is utilized in the designs to continue the performance scaling. Many-core processors have become commonplace today. Parallelism based performance scaling requires integration of more components, functional units, cores, memory, interconnects, etc., onto a limited yieldable reticle, which is enabled by Moore’s Law scaling. Unfortunately, Moore’s Law scaling is nearing its end because of both physics and cost reasons and several groups are working to implement “more than Moore”. Therefore, continued scaling of the processor performance will inevitably and increasingly rely on hybrid integrated macro-packages.[1] Various approaches have been proposed to build hybrid packages, among which is one promising concept called the “macro chip”[2] that truly breaks the reticle limit by close integration of arrays of chips while simultaneously providing optical communication density between chips far superior to that afforded by conventional waveguide or fiber packaging techniques.

Point-to-point wavelength division multiplexing (WDM) networking was recently proposed[3] to interconnect the chips in a macro chip system. Silicon photonics enabled low-power optical interconnects offers large aggregated bandwidth and high bandwidth density with low communication latency, effectively making the macro chip a contiguous piece of large silicon with unprecedented bisection bandwidth and processing power in one package.

Related Work

All-to-all routing on a single hop model has been studied for rings, tori, meshes, hypercubes, and trees of rings.[2,4,6] Beauquieer[2] told about the number of wavelengths needed in a -

dimensional torus with nodes in each dimension is at most when is even. Bermond et al.[5,6] showed that the number of wavelengths needed in a ring of nodes and in a hypercube of nodes is . Schroder et al.[4] considered some special product graphs with the following results. When is odd, the number of wavelengths needed in a torus is when; the number of wavelengths needed in a torus or mesh with and is or. Beauquier[2] showed that the number of wavelengths needed for a -dimensional torus with nodes in each dimension is either or no greater than depending on whether or not is even, the number of wavelengths needed for a -dimensional mesh with nodes in each dimension is either if is even, or no more than otherwise. Narayanan et al. considered all-to-all routing for a family of chordal rings of degree 4 by presenting an approximation algorithm that requires only 1.013 times the theoretic optimal bound. Zhang and Qiao addressedthe problem of scheduling all-to-all personalized connections in WDM rings. For a given number of wavelengths and a number of transceivers per node, they showed the lower bound on the schedule length, which is a function of the parameters and. They also presented a scheduling algorithm for the problem, which delivers a solution.

EXPERIMENT AND RESULT

The experiment setup shown in Fig.2 consists of two parts: the optical packet generator and the cascaded all-optical Data Vortex node. In the packet generator, a 10 GB/s mode locking laser (λ_p=1560nm) carrying the payload data is optically multiplexed to 40Gb/s to generate the optical payload. Two header channels (λ_2=1552.3nm and λ_3=1553.1nm) are combined with the 40Gb/s optical payload to compose the input optical packet sequence. This optical packet and the control signal (λ_1= 1552.5nm) are applied separately to the node-1. In the switching nodes, the each optical packet in the input packet sequence is routed separately according to the traffic control signal and the extracted header information.

The routing results. In node-1, the initial input sequence has the data set of “101101 100011 110011 001100 000000”. As mentioned previously, a portion of the input packet is tapped and sent to the upper MZI-SOA for the header processing. In node-1, the wavelength of the band pass filter is set to the same as the header channel 1 (λ_2=1552.3nm). The extracted header signal interacts with the traffic control signal according to the AND logic operation. The output routing signal has only “on” bits when both header and control bit are simultaneously “on”. The input packet signal heading to the lower MZI-SOA was routed to either the SOUTH or the EAST output port in accordance with these routing bits. The optical packets switched to the EAST are sent to the input port of node-2 and are routed according to the header channel 2 (λ_3=1553.1nm) and the traffic control generated from node-1 in the same way at node-1. In this experiment we analyze the that WDM optical packets are successfully routed the signal while maintaining a bit-error rate of 10^{-10} or better for every node.

In the Fig.3, there is showed the result of routing with error control, from this figure we can say that error is controlled of every node in proper manner.

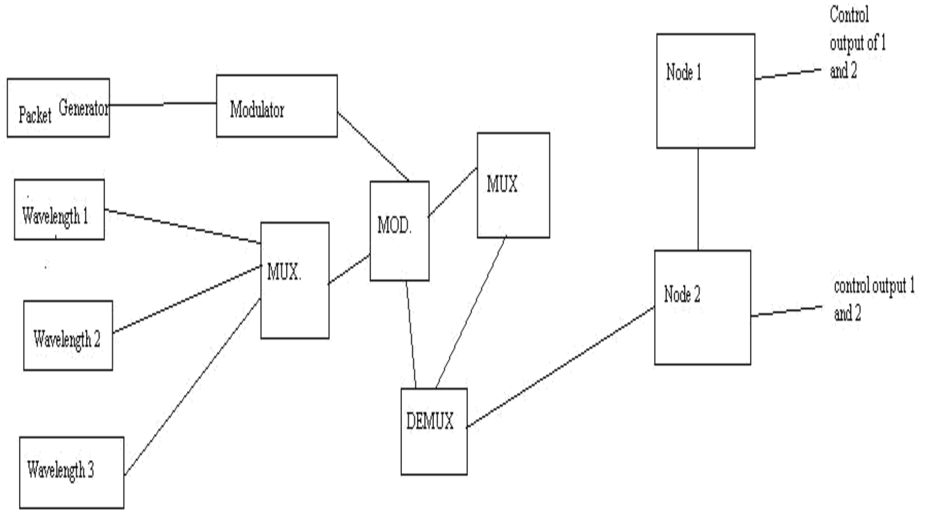
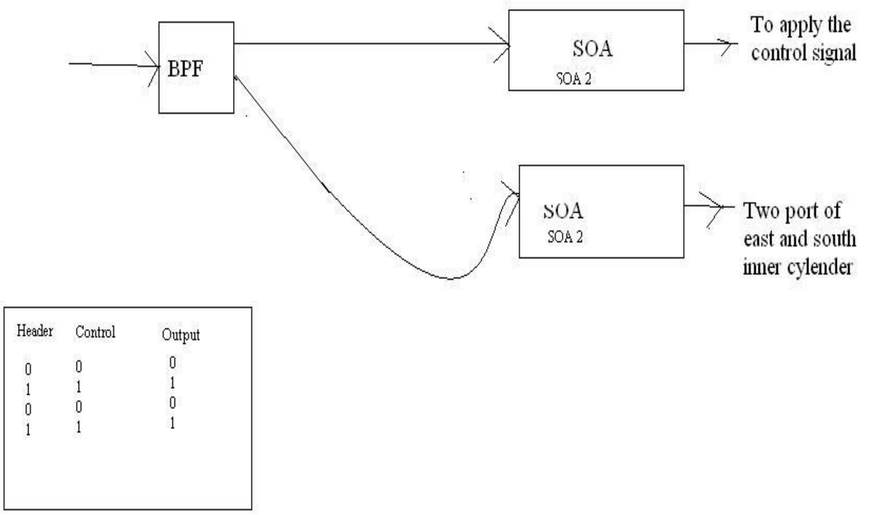


Fig. 1: Set-Up of Optical Data Vortex switch node employing MZI-SOAs.



Header	Control	Output
0	0	0
1	1	1
0	0	0
1	1	1

Fig. 2: Experiment setup for WDM routing and traffic control.

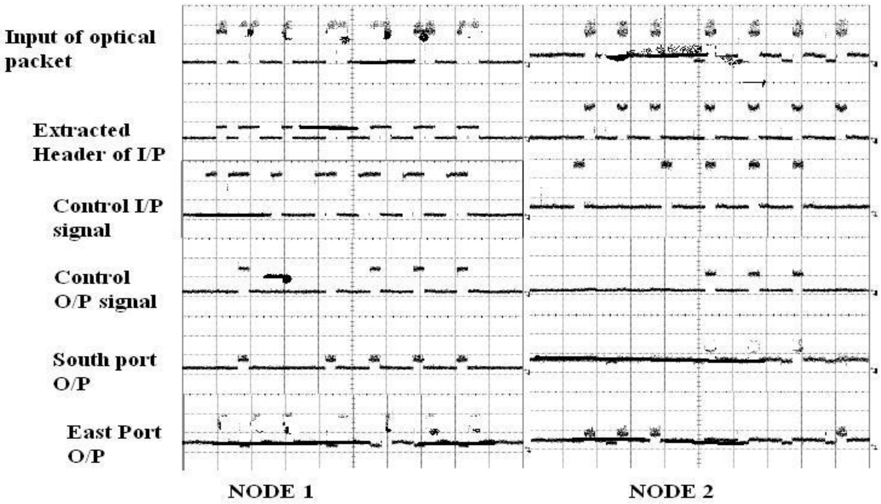


Fig. 3: Routing results at every node.

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