To Analyze the Performance of Optical Burst Switched Networks for Energy Savings

Suresh Pandian. V, Arjun Kumar. C. R, Karpagarajesh. G

***Abstract*— In this paper we propose a multi-path selection approach to minimize the energy consumption of the optical core network, especially OBS. The wavelength routed paths may have to forgo minimum distance paths and choose a path which is at a larger distance. This tends to degrade the QoS like BER and delay. Given the service requirement conditions, we propose to select the paths such that the overall energy consumed by the optical network decreases and at the same time maintain the service threshold conditions. By using an efficient optical control management mechanism, network nodes (WRN) can be set to ON or OFF states. We have developed a simple mathematical model which is used for the calculation of blocking probability of an OBS network.**

***Index Terms*— Anycast, OBS network, BER, Protocols.**

I. INTRODUCTION

The development of faster communication links is likely to contribute to the demand for faster computers, which is likely to increase energy consumption. In addition computer networks at present, require additional power- demanding equipment, such as servers, amplifiers, routers, filters, storage devices and communication links. These communication components consume significant amounts of energy. With the ever-increasing demand for bandwidth, these communication components tend to increase and hence energy efficiency is an important issue.

In a wavelength-routed optical network spanning a large geographical area. Mainly optical cross connect switch (OXC) used in the wavelength routed node (WRN). The optical cross connect (OXC) provides switched pass-through path for express traffic that does not terminate at the node and an interface for dropping and adding optical signals at the node. The express traffic can be switched from any input to any output fiber. To expand the network capacity, energy consumption in the optical network is an important concerning for the networking industries.

We consider the performance impact when wavelength conversion is used, describes the standard implementations of wavelength routing or optical circuit switching. The main reason is that performance of the electronic equipment used in this optical-to-electrical-to-optical (O/E/O) conversion process is strongly dependent on the data rate and protocol. To overcome these limitations, the concept of all optical switching was explored. Two approaches to this concept are optical burst switching (OBS) and optical packet switching (OPS) The wavelength routed paths may have to forgo minimum distance paths and choose a path which is at a larger distance. This tends to degrade the QoS like BER and delay. To determine the performance of various proposed OBS approaches include factors such as burst assembly methodologies, scheme for reserving bandwidth over a lightpath. Burst scheduling procedure, and network resources contention resolution when two or more burst from different edge routers try to leave the same switch output port simultaneously.

In this paper to propose a multi path selection approach to minimize the energy consumption of the optical network, especially OBS has several distinctive features: OBS was conceived to provide an efficient solution for high speed *bursty* traffic over WDM network. Traffic is considered as being *bursty*, if there are long idle times between the busy periods in which a large number of packets arrive from the users. The packets are aggregate in the ingress (entry) node, for a very short duration of time. This allows that packets, have the same constraints (e.g., the same destination address and maybe, the same QoS requirements) are sent together as a burst of data. There are two advantages to OBS. First, it offers the high bandwidth and packet-sized granularity of optical packet switched networks without the need for complex optical buffering. Second, it provide the better energy efficiency overhead that is characteristics of wavelength-routed networks. Thus the performance characteristics of OBS lie between those of a wavelength-routed network and optical packet-switched networks. In the OBS network concept, a collection of optical burst switches are interconnected with WDM links to form the central core of the network. Devices called edge router collect traffic flows from various sources at the periphery of a WDM network. The basic structure of an optical burst switching (OBS), the flows then are sorted into different classes according to their destination address and grouped into variable-sized elementary switching units called *bursts*. The characteristics of an edge router play a critical role in an OBS system, since the overall network performance depends on how a burst is assembled based on particular types of traffic statistics.

Before a burst is transmitted, the edge router generates a control packet and sends it to the destination to set up a lightpath for this burst. As the control packet travels towards the destination, each optical burst switch along the lightpath reads the burst size and arrival time from the control packet. Then, in advance of the burst arrival, the burst switch schedules an appropriate time period on a wavelength that the next lightpath segment will use to carry the burst. This reservation for the arriving burst is called *burst scheduling*.

To select the paths such that the overall energy consumed by the optical network decreases and at the same time maintain the service threshold conditions.

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By using an efficient optical control management mechanism, network nodes (WRN) can be set to *ON* or *OFF* states. During the *OFF* cycle the nodes, to adopt a *sleep mode* and cutting down the traffic routed through them proposed solution for burst-assembly algorithm include formatting a burst based on a fixed assembly time, a fixed burst length, or hybrid time/burst-length method. The main parameters are a maximum assembly time threshold T, a maximum burst length B, and a minimum burst length Bmin. When the incoming packet flow is low, the threshold T time ensures that a packet is not deployed too long in the assembly queue. When the incoming packet flow is high, the upper limit B on the burst size also limits packet delay times by restricting the time needed to assembly a burst. Otherwise, if the burst size is not limited, long assembly times could result during heavy incoming traffic load. If the assembled burst length is smaller than Bmin by the time burst is scheduled to be transmitted, padding bits are added bring the length to Bmin. In this network, need to develop an efficient control plane and associate algorithm for the implementation of Energy-Aware Optical networks (EAON).

II. NETWORK SIMULATION MODEL

A. Network architecture

Fig. 1 shows the architecture for multicast-optical cross connect using splitter and adder switch. The WRN consists of the EDFA, multiplexer, demultiplexer, and wavelength cross connection switch (XCS). WRN can also have functionality to add/drop channels, a fixed optical add/drop multiplexer is simply referred to as an OADM. In general, because of the nature of the services provided, changes in add/drop configuration for a long-haul network occur less frequently than in a metro network where there tends to be a high turnover rate in service request and in wavelengths being transported. The fiber in line followed to the EDFA, the EDFA on the input side to compensates exactly for the signal attenuation along the input fiber and tap losses. An output side, the EDFA compensates exactly for the loss at cross connect switch (XCS). These optical cross-connect (XCS) switches sit at junction in ring and mesh networks that are interconnected through many hundreds of optical fibers each carrying dozens of wavelength channels. At such a junction an XCS can dynamically route, set up, and take down very high-capacity lightpaths.

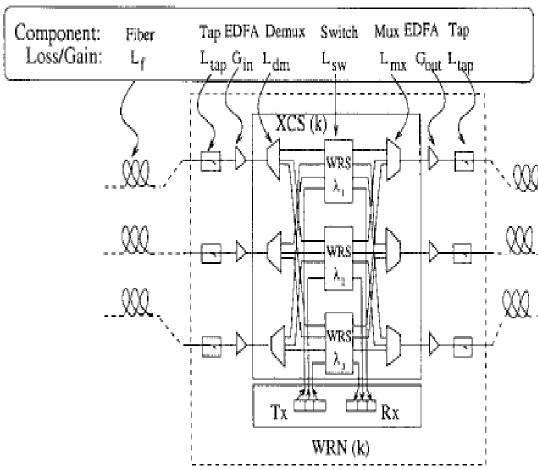


Fig.1 Architecture of wavelength routed node (WRN)

To visualize the operation of an XCS, that uses a switching matrix for directing the incoming wavelengths that arrive on a series of M inputs fibers. The switch matrix can operate electrically or optically, that is, it can switch the incoming signals in either the electric or the optical domain. Each of the M input fibers carriers N wavelengths, any or all of which can be added or dropped at a node. The M output lines, each carrying separate wavelength, are fed into a wavelength multiplexer to form a single aggregate output stream. An optical amplifier to boost the signal level tor transmission over the trunk fiber normally follows this. When channels having the same wavelength but travelling on different input fibers enter the XCS and need to be switched simultaneously to the same output fiber. This could be resolved by assigning a fixed wavelength to each optical path throughput the network, or by dropping one of the incoming channels at the node and retransmitting it at another wavelength. However, in the first case, wavelength reuse and network scalability (expandability) are reduced, and in the second case the add/drop flexibility of the XCS is lot. These blocking characteristics can be eliminated by using conversion at any output of the XCS, as shown for the following example.

B. Energy per bit

In this section we calculate the energy required to transmit an optical bit across an WRN shown in Fig. 1. The WRN can have the function of add/drop channels, using the transmitter and receiver shown in Fig. 1 Energy is defined as the product of power consumed and time. An optical add/drop multiplexer (OADM) is a device which allows the insertion or extraction of one or wavelength from a fiber at a network node. There are two different types of energy associated with the optical networks,

1) To associated the energy with the transmission of one optical bit over fiber.
2) Energy consumed by a router (WRN) for switching an optical signal.

The average time to transmit 1 bit over a channel (fiber) is the inverse of the average bit rate (*B*). The energy associated with the transmission of 1 bit can be expressed as,

$$Ebit = PdTbit, \tag{1}$$

Where *Tbit* is the time to transmit one bit over the fiber (*Tbit* = 1/*B*), *Pd* is the power dissipated. Thus (1) denotes the energy consumption for one optical bit for a distance of *L* km. We assumed that a path is composed of transmitter, a number of in-line EDFAs, WRNs and a receiver, then *Pd* is given by,

$$Pd = P_{in}^{(Tx)} + P_{in}^{(EDFA)} + P_{in}^{(WRA)} + P_{in}^{(Rx)} \tag{2}$$

Where $P_{in}^{(Tx)}$, $P_{in}^{(EDFA)}$, $P_{in}^{(WRA)}$, $P_{in}^{(Rx)}$ are the total powers consumed by (or the power from the grid), the transmitter, EDFA, WRN, and receiver respectively. The energy per bit for an opticalcore WRN switch is approximately $E_{bit}^{(WRN)}$ = 10 nJ. Similarly the $E_{bit}^{(EDFA)}$ for an optical amplifier such as EDFA is about 0.1 nJ.

Thus we see that if an optical bit traverses H hops, with each hop consisting of k optical in-line amplifiers, and the total energy consumed due to WRN and EDFAs is ,

$$(H+1)\, E_{bit}^{(WRN)} + kH E_{bit}^{(EDFA)} \quad (H>1) \qquad (3)$$

We calculate the energy per bit required to transmit an optical bit across the WRN based on the network architecture given in [5]. The energy per bit consumed for a given source-destination pair (s,d) is given by

$$Ebit(s,d) = (P_{in}^{(Tx)} + P_{in}^{(Rx)})Tbit + \sum_{\forall i \in R} Ki\, E_{bit}^{(EDFA)} + (H+1)E_{bit}^{(WRN)} \qquad (4)$$

Where R is the shortest-path route for (s,d).

III. ENERGY EFFICIENCY ROUTING (EER) ALGORITHM

In this paper we propose a cluster based architecture, the nodes of the optical backbone networks are divided into disjoint sets. Each group consists of more than one node to form a single cluster. These clusters can be set to adopt a sleep mode initiated by the optical control plane (OCP). During the sleep mode of the cluster, the connectivity of the network decreases and hence there could be more request dropped. In order to decrease the request drops by using an *anycasting* communication paradigm. Anycasting allows the flexibility of selecting a destination from a desired set of destinations. If a destination cannot be reached due to its intermediate node belonging to a cluster in an OFF state (i.e., sleep mode), then using anycasting, the next available destination can be chosed. An anycast request can be denoted by (s, Ds), where s is the source node and Ds ($m = |Ds|$) are the probable destination candidates for the source node s. In anycasting, the chosen destination can be at a longer distance, increasing the bit-error-rate (BER) and the propagation delay. It is necessary to making the routing algorithm aware of the threshold conditions and decide on establishing a lightpath accordingly. We define a network element vector (NEV) which consists of information about the noise factor (relation between BER and noise factor is given in [5]) and propagation delay of the link (say i) as,

$$NEVi = [\eta i\ \tau i]^T$$

where ηi is the noise factor and τi the propagation delay for the link i respectively and T indicates the transpose. The threshold condition for a given request is denoted by $T^{(r)} = [\eta max, \tau max]^T$. The overall (NEV) for a request r is given by,

$$NVR^{(r)} = [\eta^r, \tau^r]^T = [\prod_{k=i}^{j} \eta k, \sum_{k=i}^{j} \tau k]^T$$

Since the noise factor and the delay are upper bounded by their respective thresholds, a lightpath can be established only when $\eta^r < \eta max$ and $\tau^r < \tau max$.

The pseudo code for the proposed energy efficient algorithm. The input to the algorithm is an anycast request where the source (s) and the destination set (Ds) are assigned from a uniformly distributed random variable. The network element vector (*NEV*) to initializ with noisefactor of unity and zero delay. Each anycast is request assigned threshold service parameters according to the service level agreement (SLA) of the application. The destination set *Ds* is sortly according to shortest path routing. The nearest destination is selected from the set and a route is calculated. If the links to all the intermediate nodes for *di* are available then the NEV for the route is calculated. If the QoS parameters violate the SLA then the request is dropped. If at least one of the intermediate node(s) belongs to a cluster which is in the OFF state, then a new destination is selected (*dj* , *j* 6= *i*).

IV. PERFORMANCE EVALUATION

Anycast is a network addressing and routing methodology in which datagram's from a single sender are routed to the topologically nearest node in a group of potential receiver, though it may be sent to many nodes. All identified by the same destination address, the addressing routes datagram's to a single member of a group of potential receivers that are all identified by the same destination address. This is called one-to-one-of-many association. On the Internet, anycast is usually implemented by using BGP to simultaneously announce the same destination IP address range from many different places on the internet. This result in packets addressed to destination addresses in this range being routed to the "nearest" point on the given destination IP address. In the past, anycast was suitable to connectionless protocols (built on UDP) rather than connection-oriented protocols, such as TCP that keeps their own state. However, the TCP anycast is now used. TCP anycast, there are cases where the receiver selected for any given source may change from time to time as optimal route change, any conversations that may be in progress at the time. To corrected for this issue, there have been proprietary advancements within custom IP stacks which allow for healing of stateful protocols where it is required. For this reason, generally anycast is used as a way to providing high availability and load balancing for stateless services such as access to replicate the data, for example; DNS service is a distributed service over multiple dispersed servers. Many emerging next-generation internet applications, such as high-performance scientific computing, videoconferencing, and multimedia are characterized by high bandwidth requirements. Multi-Source and Destination communication paradigms, the QoS requirements w.r.t delay and loss, high reliability and survivability requirements. In order to support these requirements, emerging networks must be able to managed resources in a flexible manner. This project investigates a service-oriented optical network architecture that is enabled by an underlying optical transport network capable of dynamic and agile resource allocation.

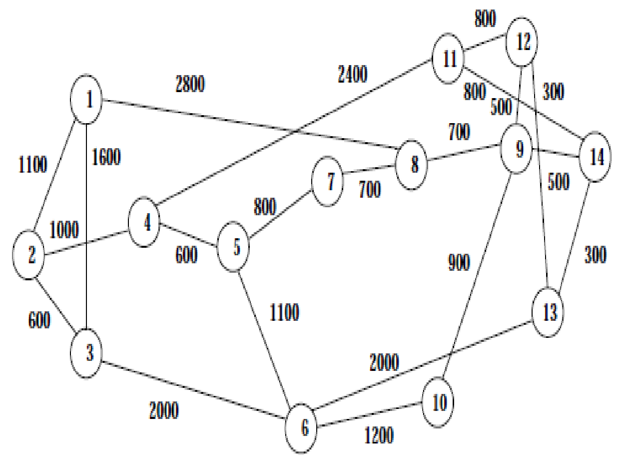


Fig.2 The National Science Foundation (NSF) Network

The NSF network consisting of 14 nodes and 21 bi-directional links as shown in fig. 2 for our simulation studies. The links, benefit from in Erbium Doped Amplifier (EDFA) placed 70 km. the source and candidate destination of a request are evenly distributed among all nodes in the network. Burst arrival follows passion process with an arrival rate of λ burst per sec. The length of the burst is exponentially distributed with expect service time of 1/μ secs. An optical transport layer provides the basic mechanisms for reserved resources, and an optical service layer builds a set of services over the basic optical transport layer. In the domain, specific problems to be addressed include (i) investigating mechanisms for supporting anycast communication services in optical networks, (ii) investigating mechanisms for providing survivability in such networks, and (iii) developing methods for supporting reliable transport in optical networks. To propose the activity will result in a framework and architecture for deploying a wide range of services in optical networks in order to support the requirements of the most demanding next-generation applications. The result in the development of new algorithms and protocols for implementing anycasting and providing reliable services, and will lead to the development of the analytical models for evaluating these algorithms and protocols.

V. PARAMETER USED FOR COMPUTATION OF EBIT

parameter	Value
Channel bit rate (B)	10 Gbps
Electronic Bandwidth (Be)	0.7B
Loss of Mux/Demux	4 Db
Gain of EDFA in OXC (Gin, Gout)	22 dB, 16 Db
Fiber Attenuation Co-efficient	0.3 dB/km
Switch element insertion loss	1 Db
Waveguide fiber coupling loss	1 dB
Tap loss (Ltap)	1 dB
Switch loss (Lsw)	$2\log_2 NLs$ + 4Lw dB (for a N×N switch)
Fiber loss (Lf)	0.2 dB/km
Number of fiber/links	2 (bi-directional)

VI. RESULTS

Optical networks are performed perfect energy efficient to determine the continuous wave performance of the switch. To shortest paths have been tested at the drive currents mentioned above. The optical burst switch has a net facet-to-facet gain of > 0 dB at 1555.5 nm for all used paths. The maximum gain of 2 dB being observed. The fiber coupling losses to be estimated 0.2 dB/km. Figure. 4 shows the facet-to-facet gain as a function of wavelength and on-chip output power for a number of used paths. The 1 dB on-chip output saturation powers range from -10 to -14 dBm for the majority of paths.

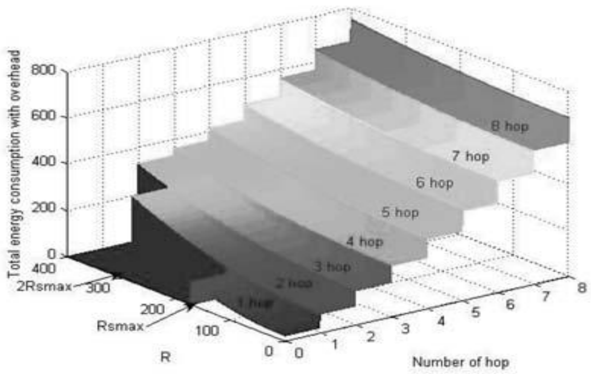
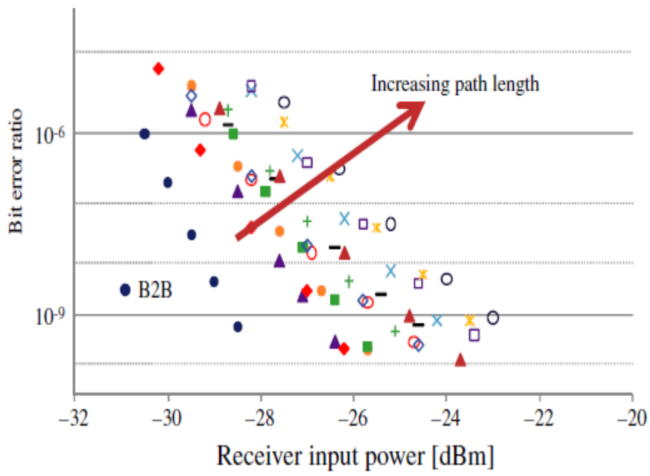


Fig. 3 energy consumption Vs number of hops.

The figure shows 3 as, 3 dB spectral bandwidth of 91 nm. It should be noted that the many possible paths through this Close–tree switch fabric have different lengths and different numbers of waveguide crossings and TIR mirrors, so the different paths will experience slightly different optical gains and dynamic impairments which do not scale directly with the path lengths. The average power consumed for each request with varying network load is shown in the Fig. 4. This figure shows the power consumption for different choice of clusters in the sleep mode. When all the clusters are ON, there are no sleep modes, the energy consumption is high. In Fig. 4 we also show the request loss. A request loss can occur due to channel unavailability or because of the sleep mode.



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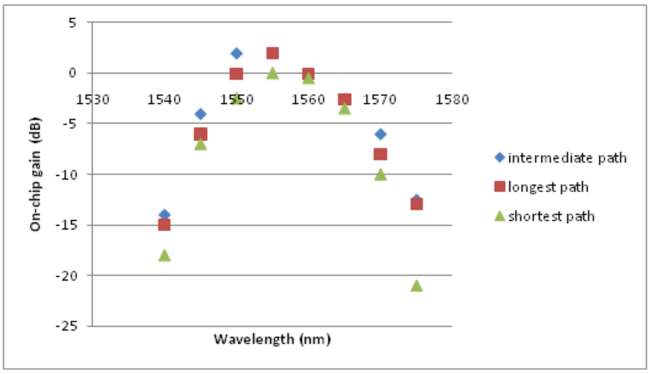

From Fig. 4c we observed that the power consumed for a given network load decreases, when the clusters are put into sleep mode. When all the clusters are OFF (ideally the complete network is in sleep mode), the blocking probability is very high (≈50%). This is because most of the calls have intermediate nodes that belong to the clusters in the OFF state. Only calls that are single hop exist in the network. Hence the average energy consumption is constant as observed in Fig.4a. In this paper we have discussed energy cost in the Internet, and also calculated the energy per bit consumed by the optical signal to traverse a wavelength routed network.

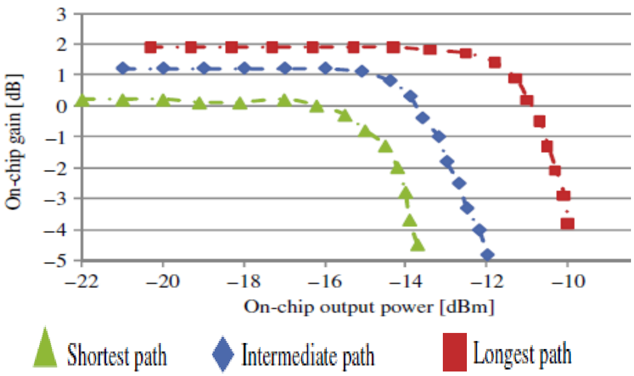

Fig. 4a, b, c Switch facet-to-facet gain as a function of wavelength, output power, input power for the shortest path, an longest path and intermediate path through the switch

Using an anycasting communication paradigm in clustered node architecture in an optical network, we show a decrease in the energy consumption. Sleep cycles for the WRN are proposed. This further of work can be extended to consider efficient traffic shaping techniques.

VII. CONCLUSION

In this paper we discussed the new energy efficient paradigms for optical burst switched network (OBS), with the number of high bandwidth application increased. This work can be designed, energy efficient optimized routing algorithm that combined the features of both an energy efficient routing algorithm and shortest distance routing algorithm thus the main factor that effect the proper working of optical burst switching Network. Since the algorithms for decreasing energy consumption and distance is also optimized so the proposed routing algorithm is cost effective. The proposed algorithm maintains a trade-off between energy consumption and the QoS.

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