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OBS FOR GENNEXT OPTICAL NETWORKS

Anand Kishore Raju*, Anshuk Chakraborty, Pradeep kumar Bhojania*****
Department of Computer science and Engineering, NIT, Durgapur
*raaju.nitdgp, **anshuk.nitdgp, ***pradeep.nitdgp@gmail.com

Abstract -The current Internet is suffering from its own success. As the number of users on the Internet and the variety of applications transported are growing steadily at high rate, the available bandwidth as well as the besteffort paradigm is facing limits. Ubiquitous and frequent congestion situations restrict the use of new timecritical applications like IP telephony, video conferencing or online games. Thus, there is an increasing demand for both bandwidth and some sort of scalable quality of service (QoS) support too. In this paper we analyze the performance of various algorithms applied at the edge nodes of an OBS network, in terms of resulting loss at the core OBS node

I. INTRODUCTION

One evolutionary trend is towards the transport of IP directly over the photonic layer. Now, the big challenge is to make the optical layer – which currently usually employs static, circuit switched transmission pipes – more dynamic. However, we are confronted with two problems:

- There is no optical bit processing at high speed.
- There is no flexible optical buffering beyond fiber delay lines.

Therefore, an architecture for the future Internet should take advantage of photonic network properties. One possible solution in this domain is Optical Burst Switching (OBS), a concept combining advantages of the enormous bandwidth offered by Dense Wavelength Division Multiplexing (DWDM) links and, the statistical multiplexing gain offered by optical packet switching networks. In this paper, we study the performance of various burst assembly algorithms applied at the edge nodes of an OBS network, in terms of resulting loss at the core OBS node. The burst assembly algorithms taken for investigation are pure time based, pure burst threshold based and mixed time & threshold based. Based on analytical and simulation results, we establish that the loss of packets can be minimized by modifying the existing burst assembly algorithms. The tests were carried out in Network Simulator (ns2) and its OBS extension, developed at DAWN Lab (University of Maryland) to simulate our OBS scenarios.

II. NEED FOR OBS

Currently deployed networks consist of pointtopoint DWDM links.This means that at each switching point, the optical signal is converted to electrical form, and the processing and forwarding is done in the electrical domain. This is known as an OpticalElectronic (O/E) conversion. When the signal is passed to the outgoing port, it is again converted and modulated onto the fiber as an optical signal (ElectronicOptical or E/O). Such a switching point is said to perform O/E/O conversion (opticalelectronicoptical).

In such a network, all communication is limited by the capabilities of the electronics in the system. Once the optical signal is converted into an electronic signal, some form of processing unit must examine the data and decide to which output fiber and wavelength the data must be forwarded. The data must then be remodulated onto the optical carrier. All of these steps involve significant delays enforced by the limitations of electronic processing speed. It is complicated by the fact that the full data payload of the incoming signal must be read and stored before being forwarded. In a packet switch (or router) the burden of the electronics is increased because the forwarding decision must be made for each packet at each hop and it is an expensive operation. Variable length packets must also be buffered at the router, requiring large amounts of electronic memory and sophisticated buffer management algorithms.

A question comes to mind at this point: Can we achieve high switching throughput if an optical switching technology is used? In other words, can we use optical technologies in the switch fabric, instead of electronic technologies? There currently exist numerous candidate technologies which could be used to switch data in the optical domain without need for converting the payload data into the electronic domain. They have their own advantages and limitations, some of which are significantly different to those found in the electronic domain. Principally, the state of the art in optical processing is currently embryonic, and so complicated control algorithms must be implemented in electronics still { thus at least the control information (e.g. packet headers) must still be converted to electronic form for processing). Secondly, optical buffering technologies do not yet exist beyond simple delays or recirculating loops, which poses problems when contention for limited outgoing transmission resources is experienced.
Given that we have available a number of optical switching technologies, how can we use the advantages of these technologies and overcome their drawbacks to achieve high throughput optical switches? How can we build a transport network out of such switches to provide service guarantees to the diverse applications expected in the next generation networks?We aim to find some answers to these questions. The specific focus of our study is on Optical Burst Switching (OBS) as a compromise between the demands of forecast traffic (which mandate the statistical sharing of packet switching) and the realities of optical technologies (for which circuit switching is much easier to implement).

III. OBS: EXPLAINED

Optical burst switching (OBS) is a natural way to support realtime multimedia traffic in the Internet which is often selfsimilar or bursty and requires low latency. It is especially economic and efficient for providing highend users or applications with sessions having a high bitrate, low latency and short duration upon their requests.

OBS uses oneway reservation so that a burst of user data (e.g. IP packets) can be sent without having to have a dedicated wavelength path a priori. Instead, a control (setup) packet is sent first to reserve the wavelength channel, which is followed by the burst after an offset time. In this way, OBS not only avoids the long endtoend setup delay, but also increases the utilization of the ultrahigh speed optical channels for variablebitrate services. In addition, by taking advantage of the limited opaqueness of the control packet, OBS may also facilitate adaptive routing for fault (and congestion) tolerance, as well as provide support for prioritybased routing (e.g. flowlevel IP switching) and limited multicasting. By combining the best of the coarsegrained optical circuit switching (e.g. via wavelength routing) and the finegrained optical packet/cell switching while avoiding their shortcomings, OBS can potentially realize the vision of building a flexible, efficient and bandwidthabundant fiberoptic network infrastructure capable of providing ubiquitous services to IP and other existing (e.g. ATM) and future protocols.

Optical switching paradigms	Bandwidth utilisation	Latency (setup)	Optical Buffer	Proc./Sync. Overhead (per unit data)	Adaptivity (traffic&fault)
Circuit	Low	High	Not Required	Low	Low
Packet/Cell	High	Low	Required	High	High
OBS	High	Low	Not Required	Low	High

Comparative study of Optical Switching Paradigms:

IV. OBS TERMINOLOGIES

Optical Burst Switching (OBS) is a switching concept which lies between optical circuit switching and optical packet switching. Firstly, a dynamic optical network is provided by the interconnection of optical cross connects. These optical cross connects (OXC) usually consist switches based on 2D or 3D Micro electro Mechanical mirrors MEMS which reflect light coming into the switch at an incoming port to a particular outgoing port. The granularity of this type of switching is at a fibre, waveband (a band of wavelengths) or at a wavelength level. The finest granularity offered by an OXC is at a wavelength level. Therefore this type of switching is appropriate for provisioning light paths from one node to another for different clients/ services

Optical Burst Switching operates at the subwavelength level and is designed to better improve the utilization of wavelengths by rapid setup and teardown of the wavelength/light path for incoming bursts. In OBS, incoming traffic from clients at the edge of the network are aggregated at the ingress of the network according to a particular parameter class of service and quality of service. Therefore, at the OBS edge router, different queues represent the various destinations or class of services. Therefore based on the assembly/aggregation algorithm, packets are assembled into bursts using either a time based or threshold based aggregation algorithm. In some implementations, Aggregation is based on a Hybrid of Timer and Threshold. From the aggregation of packets, a burst is created and this is the granularity that is handled in OBS.

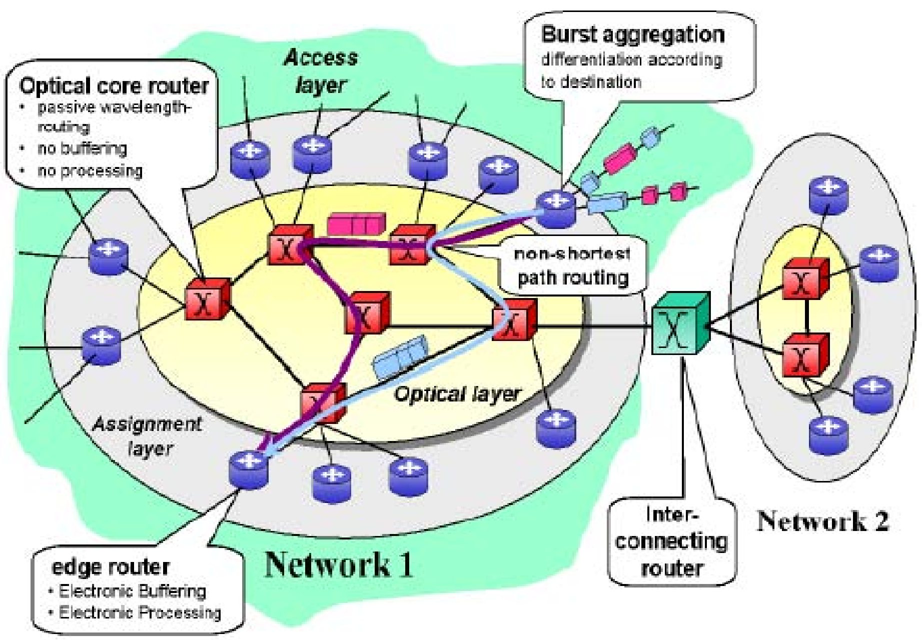
Also important about OBS is the fact that the required electrical processing is decoupled from the Optical process. Therefore the burst header generated at the edge of the network is sent on a separate control channel which could be a designated outofband control wavelength. At each switch the control channel is converted to the electrical domain for the electrical processing of the header information. The header information precedes the burst by a set amount known as an offset time. Therefore, giving enough time for the switch resources to be made available prior to the arrival of the burst. Different reservation protocols have been proposed and their efficacy studied and published in numerous research publications. Obviously the signaling and reservation protocols depend of the network architecture, node capability, network topology and level of network connectivity. The reservation process has implications on the performance of OBS due to the buffering requirements at the edge. The oneway signaling paradigm obviously introduces a higher level of blocking in the network as connections are not usually guaranteed prior to burst release. Again numerous proposals have sought to improve these issues.

Optical burst switching has many flavours determined by the current available technologies such as the switching speed of available core optical switches. Most optical cross connects have switching times of the order of milliseconds but require tens of milliseconds to set up the switch and perform switching. New switch architectures and faster switches of the order of micro and nano second switching times can help to reduce the path setup overhead. Similarly, control plane signalling and reservation protocols implemented in hardware can help to speed up processing times by several clock cycles.

The initial phase of introducing optical burst switching would be based on an acknowledged reservation protocol i.e. twoway signaling: after burstification process, based on a forwarding table bursts of a particular destination are mapped to a wavelength. As the burst requests a path across the network, the request is sent on the control channel, at each switch, if it is possible to switch for the wavelength, the path is set up and an acknowledge signal is sent back to the ingress. The burst is then transmitted. Under this concept, the burst is held electronically at the edge and the bandwidth and path is guaranteed prior to transmission. This reduces the amount of bursts dropped. The effects of dropping bursts can be detrimental to a network as each burst is an amalgamation of IP packets which could be carrying keepalive messages between IP routers. If lost, the IP router would be forced to retransmit and reconverge.

Under this conventional OBS, a one way signaling concept as mentioned previously is used. The idea is to hold the burst at the edge for an offset period while the control header traverses across the network setting up the switches; the burst follows immediately without confirmation of burst setup. There is an increased likelihood for bursts to be dropped but contention resolution mechanisms can be used to ensure alternative resources are made available to the burst if the switch is blocked (being used by another burst for the incoming or outgoing switch port).

V. OBS ARCHITECTURE



VI. BURST ASSEMBLY ALGORITHMS

Sources are generally routers for internet access and sources send packets for various destinations. The edge switches maintain individual assembly queue for all other edgeswitches. Traffic, destined for a particular edge switch, are assembled in the same assembly queue and bursts are assembled according to one of the following Burst Assembly Algorithms (henceforth abbreviated as BAA)

A. Time based BAA: Packets, destined for same destination edge switch, are accumulated for a fixed duration of time T and sent as a burst to the edge scheduler.

a. 2. Burst Length based BAA: Packets destined for a particular edge node are assembled till a threshold burst length B is reached and forwarded to the edge scheduler for scheduling.

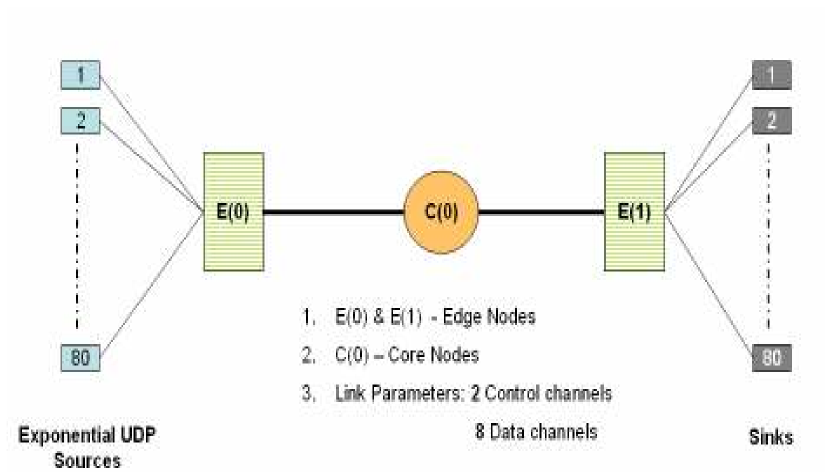
b. 3. Mixed BAA: Packets, destined for a particular edge node, are assembled as a burst till any of the above two thresholds (T or B, as mentioned above) are reached. Then the burst is forwarded to the edge scheduler for scheduling.

VII. JUST ENOUGH TIME (JET) PROTOCOL

The most popular protocol for sending a burst is known as Just Enough Time (JET) protocol. 7. MODELING & SIMULATION

1. Topology Used:

protocol, after a burst is formed, a control packet (CP) is generated which contains information like duration. of burst, destination of the burst and expected departure time (termed as offset time) of the burst among many others. The offset time is necessary for configuration of the switches along the whole path as the OBS core switches are generally bufferless (or very limited buffer support with Fiber Delay Lines). The Control Packet is then immediately sent to the core over a designated control channel, dedicated for this purpose. The offset time is generally allocated by the edge scheduler which schedules the data burst over a free wavelength channel, to be sent after the offset time.Offsettime can be used to provide QoS support over OBS network



2. Parameters Involved:
Case(i):
For Conventional Burst Assembly algorithm:
Total channel capacity = 100GbpsPeak rate (sources) = 10Gbps
,Packet size = 10 kb
No. of packets in each burst = 100
Time taken to transmit each packet =10k/10Gbps =

1 s

Time taken to transmit each burst =100 X 1 s = 100 s
ON time = 10 s

OFF time = (Total Time – ON Time) = 100 – 10 = 90 s

Burstiness = 10 (recommended for OBS network)

Average Rate = ([ON Time]/[Total Time]) X [Peak Rate] = 1Gbps
Case (ii):
For making the existing Burst Assembly algorithm,

we introduced certain parameters, which are described below:For Time based BAA,
T = T – αT, T is the time threshold. α is given by

α = αnew αold

{α varies according to the loss advertised by the core. }

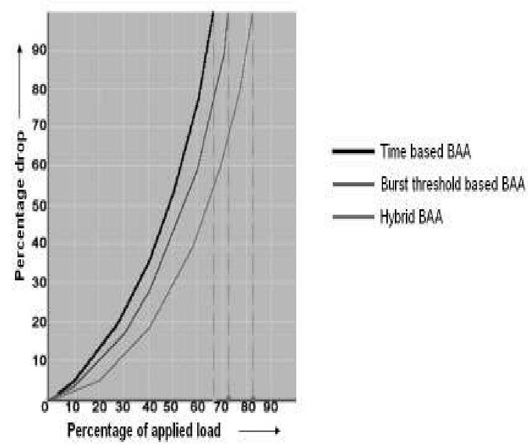
For Burst threshold based BAA,

B = B – αB

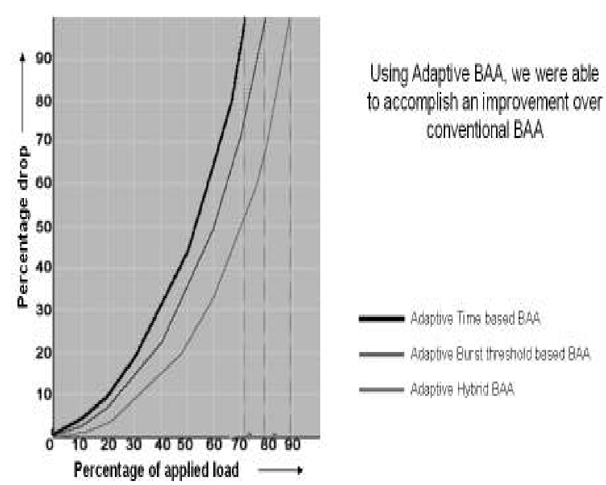
B is the burst threshold/length. For Mixed BAA, both time and burst length are varied simultaneously from

T = T – αT,
B = B – αB

3. TCL Scripting:
We used Network Simulator 2 (with OBS Extension) developed at DAWN labs, University of Maryland to simulate the above mentioned cases. The simlulator accepts TCL scripts as input.
4. Results:
Case (i): Using Conventional Burst Assembly Algorithms



Case (ii): Using Adaptive Burst Assembly Algorithms



5.Inference:
Based on simulation results, we establish that,

by modifying the burst assembly algorithm we can reduce packet loss in an OBS network.

CONCLUSION

The existing OBS networks are efficient. But our study establishes that, they can be improved further by tweaking the existing Burst Assembly Algorithms and incorporating adaptivity into them. It's already an established fact, that OBS is THE solution to cope with the astronomical demands of new networks. And we are taking it a step further by actually making the existing OBS paradigm more efficient. This will eliminate all problems of bandwidth shortage and traffic congestion.

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