An Efficient Network Utilization Scheme for Optical Burst Switched Networks

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ABSTRACT

Optical Burst Switching (OBS) is one of the most important switching technologies for future IP over wavelength division multiplexing (WDM) networks. In OBS Network, the burst assembly technique is a challenging issue in the implementation of the system. Burst assembly influences burst characteristics, which negatively impacts network performance. In this article, the authors propose an efficient hybrid burst assembly approach, which is based on approximate queuing network model. To reduce the time complexity, an approximate queuing network model has been considered. Throughput performance has been investigated, taking into account both burst loss probability and time complexity. Simulation results have shown that the proposed hybrid approach based on variable burst length threshold and fixed maximum time limitation provides Simulation results have also shown a good trade-off between burst blocking performance and scheduling time.

Keywords: *Circuit Switching Networks, Data Flow Architecture, Decision Models, Information and Communication Technologies, Network Topology, Packet Switching Networks, Store-and-Forward Networks*

INTRODUCTION

With the rapid advancements in dense wavelength division multiplexing (DWDM) technology, it is possible to use 80–120 separate wavelengths on a single fiber, each supporting a data rate of more than 400 Gbits/s. Nevertheless, there is a relative marginally increase in the electronic processing speed, which means that data optically transmitted would be slowed down at each node if it is switched electronically. So, it is expected that IP packet can be transported directly over optical layer without any Optical to Electrical and Electrical to Optical (O/E/O) conversions. However, both currently existing switching paradigms, namely optical circuit switching (OCS) and optical packet switching (OPS) have inherent

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shortcomings to support bursty traffic. OCS has low bandwidth utilization because it has a large bandwidth provisioning timescale. An OPS has a good adaptation to the bursty traffic, however, it faces two major challenges:

- Lack of optical random access memory
- Stringent requirement for synchronization

Recently, optical burst switching (OBS) has been proposed as an emerging optical switching paradigm to take advantages of both OCS and OPS. OBS not only can provide improvements over wavelength routing in term of bandwidth efficiency but also eliminate O/E/O conversion at the switching node, which make it possible to use OBS as the switching paradigm in IP over WDM network. One way reservation is used by most of the conventional OBS protocols, where header is sent into a buffer-less switching network with a chosen offset time from the data to reserve the resource. But when the traffic load increases suddenly, the pre-chosen offset time will not be sufficient enough for the header to finish the resource reservation along the path. Since the switching network is assumed buffer-less, bursts may be dropped at any point along the path, if contention occurs, therefore this approach cannot provide required quality of service (QoS).OBS can be seen as a middle term solution towards all optical packet switching whose goal is to improve wavelength utilization and sharing by introducing a dynamic wavelength management. In OBS networks (as shown in Figure 1), data never leave the optical domain: for each data burst assembled at the network edge a reservation request is sent in advance as a separate control packet. There are two kinds of nodes: edge and core routers. The main function of edge nodes is the burst assembly: these nodes are the gateways between traditional "electrical" networks and high speed optical networks; they must collect IP datagram and assemble them into burst according to proper assembly algorithms. Core nodes, on the other hand, deal with optical data bursts and the related control packets. They have to set up on the fly internal optical paths for switching bursts and take them hop-by-hop closer to their final destination. In addition, the offset time allows the core router to be buffer-less, avoiding then the employment of optical memories, e.g. fiber delay lines, required on the contrary by optical packet switching. The control packet carries relevant forwarding information, as the next hop, the burst length and the offset time. It precedes the data burst by a basic offset time that is set to accommodate the non-zero electronic processing time inside the network and dynamically set up a wavelength path whenever large data flows are identified and need to traverse the network. Only the control packet is converted between optical and electronic domains, therefore is the only information delayed because of the conversion. The most used reservation protocol is Just-Enough-Time (JET) in OBS network (Chen et al., 2004). JET is a delayed reservation protocol which allows reserving a wavelength channel just for the burst duration, starting at the predicted burst arrival time. If the reservation is successful, the control packet is forwarded to the next node; otherwise the correspondent burst is blocked. The use of this reservation protocol doesn't allow to fully utilizing the bandwidth: in every channel there is portion of unused bandwidth between bursts that have made a reservation, called void. In order to get a good utilization of the available resources, an efficient reservation process is required. To this end, effective scheduling algorithms have to be developed (Yoo et al., 2000).An optical burst consists of assembled IP packets directed to the same destination address. Burst assembly process starts at the initial packet arrival and continues for the period of burst assembly time at an edge node in OBS networks. The length of burst assembly time is allowed to be fixed or variable according to the design of OBS nodes. "Burst buffering delay" occurs through the period between the arrival of initial IP packet and the transmission of a burst. The optical burst is buffered during the burst assembly process and it further waits for offset time after the burst is completed. Burst

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