Optical Switching and Networking 12 (2014) 45–55

Contents lists available at ScienceDirect

Optical Switching and Networking

journal homepage: www.elsevier.com/locate/osn

An irregularly slotted ring scheme for contention-free optical burst switching ☆

Junling Yuan [a,b], Xianwei Zhou [a], Jianping Wang [a], Xuhong Li [c], Fuhong Lin [a,*]

[a] *School of Computer and Communication Engineering, University of Science and Technology Beijing, Beijing, China*
[b] *School of Computer and Communication Engineering, Zhengzhou University of Light Industry, Zhengzhou, Henan, China*
[c] *School of Science, Zhongyuan University of Technology, Zhengzhou, Henan, China*

ARTICLE INFO

Article history:
Received 29 March 2013
Received in revised form
9 September 2013
Accepted 2 January 2014
Available online 13 January 2014

Keywords:
Optical burst switching
OBS
Ring network
Contention free

ABSTRACT

Optical burst switching (OBS) is a promising way to efficiently use the massive bandwidth in wavelength division multiplexing (WDM) networks. However, the problem of contention between bursts is hard to be solved in OBS networks with general topology. For that reason, the conception of contention-free OBS ring is proposed. In recent years, several OBS ring schemes have been designed. According to the number of transceivers installed at each node, the schemes can be roughly divided into two classes: single-transceiver schemes and multi-transceivers schemes. Among which, multi-transceivers schemes are more efficient than single-transceiver ones. There are two existing multi-transceivers schemes, LightRing and SWING, yet both of them have disadvantages. The LightRing scheme has a high queuing delay and needs large buffers, while the SWING scheme not only needs a large number of fiber delay lines but also has a specific requirement to the girth of the ring. In this paper, we design another multi-transceivers OBS ring scheme named irregularly slotted OBS ring (IS-OBS-Ring). In the IS-OBS-Ring scheme, all data wavelengths are slotted and slots on different wavelengths are not synchronously but irregularly distributed. Simulation results show that the performance of IS-OBS-Ring is further better than the LightRing scheme and similar to the SWING scheme. However, the IS-OBS-Ring scheme can overcome the disadvantages of both the LightRing scheme and the SWING scheme.

1. Introduction

Because of the existence of electronic processing bottleneck in electronically switched optical networks, all-optical switching technology is extensively researched in recent years. Several all-optical switching technologies have been proposed, such as optical circuit switching (OCS), optical packet switching (OPS), and optical burst switching (OBS) [1]. Among them, optical burst switching is a promising one to be used in the next generation optical networks.

The conception of optical burst switching is raised by Qiao and Yoo in 1999 [2]. In a general OBS network, data burst and control information are transferred by disparate channels. A data burst is assembled by packets coming from access network first; and then a control packet (or say burst header packet) is generated and transmitted to the control channel to reserve resource for the data burst; after a predetermined offset time, the data burst is sent out on the data channel.

OBS technology has many advantages. Since OBS is based on statistically multiplexing technology, the channel efficiency is greatly improved compared with OCS. As several packets are encapsulated into a burst and controlled by one control

☆ This work is supported by the National Science Foundation of China Nos. 61170225 and 61202079, and the National 863 program of China No. 2012AA121604.

* Corresponding author.
E-mail address: dr.lin.bjtu@139.com (F. Lin).

1573-4277/$ - see front matter © 2014 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.osn.2014.01.002

packet, the number of control packets in an OBS network is much less than in an OPS network.

OBS technology has a serious defect either: bursts would be sent out whether or not the requested resources are successfully reserved, thus they may contend with each other at intermediate nodes. Several contention resolving measures have been proposed, such as wavelength converter (WC), fiber delay line (FDL), and deflection routing (DR) [3]. Although each of them can reduce contentions to a certain extent, none of them can completely avoid the occurrence of contentions.

To avoid contentions in OBS technology, some of the researchers divert their attention from general topology to ring topology and propose the conception of OBS ring. By choosing an appropriate access control protocol, bursts can be transferred in an OBS ring without any contentions.

Fig. 1 is the general construction of OBS ring. In an OBS ring, all the links are wavelength division multiplexed (WDM) and one of the wavelengths is specified as control channel, just like in ordinary OBS networks. At each node, a pair of frequency-fixed transceiver is assigned to the control channel to receive and transmit control packets; and each control packet is processed in electronic domain. The remainder wavelengths are used as data wavelengths to transfer data bursts; the bursts are transferred and processed by all-optical style.

Several OBS ring schemes have been proposed in recent years. According to the number of transceivers for data wavelengths installed at each node, the existing OBS ring schemes can be divided into two classes: single-transceiver schemes and multi-transceivers schemes. Single-transceiver schemes are cost-saving while multi-transceivers schemes are efficient. In this paper, we will propose a new multi-transceivers OBS ring scheme. The proposed scheme is as efficient as other multi-transceivers schemes; meanwhile, it can overcome the disadvantages of other multi-transceivers schemes.

The remainder of this paper is organized as follows. The related works are briefly summarized in Section 2. The proposed irregularly slotted OBS ring scheme is introduced in detail in Section 3. In Section 4, the performance of the scheme is investigated. Lastly, a brief conclusion is drawn in Section 5.

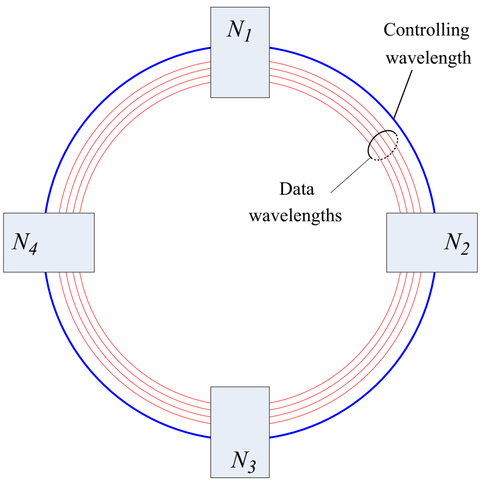

Fig. 1. The general construction of OBS ring.

2. Related works

In this section, we briefly introduce the existing OBS ring schemes. In the following description, we always record the number of nodes as N and the number of data wavelengths as W (besides a control wavelength).

2.1. Single-transceiver schemes

In single-transceiver OBS ring schemes, only one pair of transceiver is installed at each node. The main differences among distinct schemes lie in two aspects: one is the type of transceiver for data wavelengths; the other is the relation between N and W.

2.1.1. Dedicated transmission wavelength scheme

In 2003, Xu et al. proposed the first OBS ring scheme [4]. In their scheme, the number of data wavelengths is required to equal the number of nodes, i.e., $W=N$. Each node is assigned a dedicated data wavelength (the *home wavelength*) to transmit data. At each node a frequency-fixed transmitter and a frequency-tunable receiver are provided for data wavelengths. The fixed transmitter is fixed at the home wavelength of the node for transmitting bursts to other nodes; the tunable receiver can tune to all the data wavelengths to receive bursts from other nodes.

Since only one receiver is provided for each node, contention for the receiver maybe occurs if several other nodes is simultaneously transmitting bursts to the same node. Fortunately, artfully designed access control protocol can avoid the collision. Five access control protocols are given for this scheme, but only two of them are contention-free: round-robin with tokens (RR/Token) and round-robin with acknowledgement (RR/ACK). The RR/ACK protocol has a high queuing delay and low channel efficiency; whereas the RR/Token protocol is well-performed. In the RR/Token protocol, each node has one and only one token; a node can transmit burst to another node only when it is holding the token of the latter.

2.1.2. Dedicated reception wavelength scheme

In 2004, Arakawa et al. proposed another OBS ring scheme [5], which is just “symmetrical” to the scheme of Xu et al. The scheme also requires $W=N$ and each node owns a *home wavelength*. The difference is that the home wavelength is not for transmitting data but for receiving data. At each node, a tunable transmitter and a fixed receiver are equipped for data wavelengths. The fixed receiver is fixed at the home wavelength of the node to receive data from other nodes. The tunable transmitter can tune to all the data wavelengths to transmit data to other nodes. They proposed two access control protocols: upstream prioritized switching (UPS) and earliest arrival prioritized switching (EAPS). However, neither protocol is contention-free.