A congestion alleviated scheme in optical burst switching network

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An optical burst switching (OBS) network platform is established with a ring topology of three nodes. A congestion alleviated scheme using advanced token protocol and wavelength tunable receivers is demonstrated to optimize the network platform. Experimental results testify that this scheme can resist collision at the level of 0.1% congestion rate.

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With the advantages of flexibility and practicability, optical burst switching (OBS) is a compromised approach between optical circuit switching (OCS) and Optical Packet Switching (OPS)[1]. Many research works such as network protocol, node designment, burst assembly algorithm, and so on have been done in the fields of OBS network[2−5]. But there are still some puzzled points under discovery. Network congestion caused by burst confliction is such an urgent problem in OBS research field[6,7]. In order to resolve this problem, researches were carried out on three aspects: time delay line in time domain, deflection route in space domain, and wavelength converter in wavelength domain[8−10]. In this letter, we design a congestion alleviated scheme by using optical wavelength converter combined with advanced control protocol.

We construct an OBS network platform with three nodes interconnected by fiber link in ring topology as Fig. 1 shows. Every node connects to three Gigabit Ethernets (GBEs). Data from source GBE is sent to the ring through its connected node. Then the destination node can get data from the ring.

In OBS network, there are two kinds of burst packets: burst control packet (BCP) and burst data packet (BDP), which transmit control information and data information respectively. In our platform, wavelength division multiplexing (WDM) technology is used to transmit seven wavelengths simultaneously. One wavelength carries BCP and others carry BDP. Each GBE occupies one wavelength as its home wavelength for sending data.

In our OBS ring network, every node acts as a source node, intermediate node, and destination node. Figure 2 shows the node configuration. When data stream arrives, the control wavelength is intercepted and transformed to electronic signal. The control information is decoded subsequently. The bursts whose destination is the local node are dropped. The bursts are disassembled and switched to their destination GBEs.

In transmission part, packets from three GBEs are switched to three queues according to their destination addresses. Packets in one queue are transmitted back to other Ethernet connecting to this node. The other two queues connect to assembly module. In assembly module, packets are assembled into BDP and BCP. BCP is transmitted in control wavelength. For every node, there are two home wavelengths to transmit BDP to other two nodes on the OBS ring respectively. In order to transmit the local BDPs, the two home wavelengths are cut down firstly and then the local BDPs are transmitted in the two home wavelengths respectively according to their destination nodes. Along the whole OBS ring, BDP is transmitted in all optical domain while BCP is converted to electronic signal at every node it passes through.

How to control congestion is an important issue in OBS network. Some control protocols such as just-enough-time (JET) and just-in-time (JIT) have been utilized

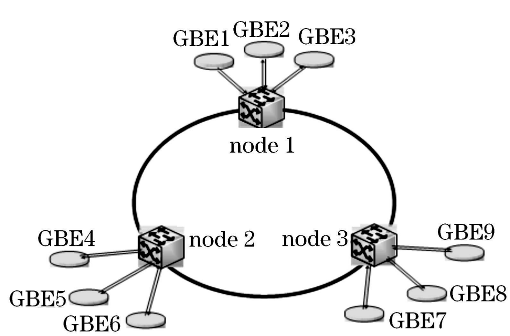

Fig. 1. Topology of OBS ring network platform.

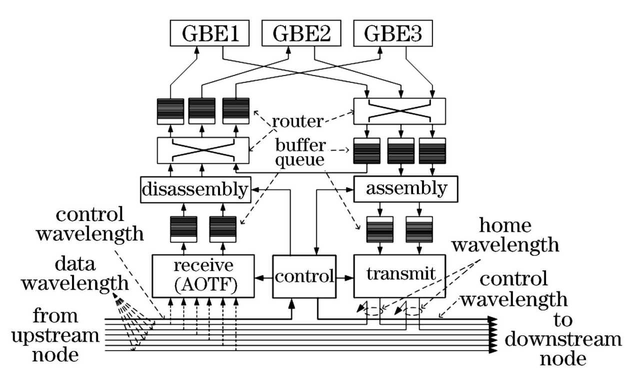

Fig. 2. Node structure of OBS ring network platform.

in OBS networks[11−14]. But these protocols are not effective enough to resist congestion. In our platform, we designed a burst congestion alleviated scheme which combined token protocol with optical wavelength tunable receiver.

As we know, token protocol is a packet-loss-free control protocol. Here we adopted an advanced token protocol to improve network usage efficiency. In traditional token protocol case, node can transmit data only when it catches the token around the ring. Then BCP and BDP can be sent in turn. After a time slot equals to the sum of offset-time and the time of BDP transmitting, the token will be released for next using. Here the offset-time stands for the time between BCP sent and BDP sent. It can be described by Fig. 3(a). As to our token protocol case, token can be released just at the end of T_{BDP} after BCP sent, T_{BDP} stands for the time of BDP transmitting as Fig. 3(b) shows. As a result, the efficiency of token is increased, and the capability of network is improved. The detailed differences between traditional token protocol and advanced token protocol used in this paper can be clearly understood from Fig. 4.

In this OBS network platform, a fixed transmitter and tunable receiver (FTTR) mechanism is employed[15]. Every source node has two home wavelengths to carry BDPs. BDPs with the same source and destination will transmit on the same wavelength. This program is called fixed transmitting. At destination node, an acousto-optical tunable filter (AOTF) is adopted to realize tunable receiving. AOTF can tune its receiving wavelength from one to another in a short time and download data

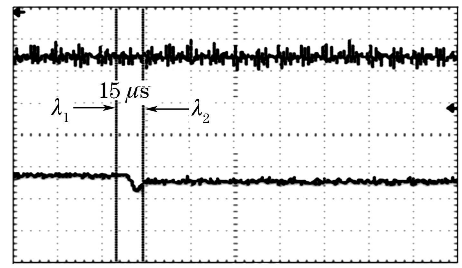

Fig. 5. Tuning time of AOTF.

carried by the wavelength. The tuning-time can be shortened to 15 μs, as shown in Fig. 5. Because AOTF is used in receiving module, the destination node can receive data carried by any wavelength along the ring. Collision in destination node can thus be reduced.

Our burst congestion alleviated scheme contains both the advanced token protocol and optical wavelength tunable receiver. As described above, occupied time of token in each network node is decreased under the advanced token protocol. As a result, the network efficiency is increased while burst loss probability is increased too. On the other side, OBS ring network can resist burst loss remarkably when optical wavelength tunable receivers are adopted. Consider both the two factors, the increase of burst loss probability caused by advanced token protocol is less than the decrease caused by wavelength tunable receiver. When observing the whole network, congestion can be alleviated in term of end-to-end burst loss probability. Figures 6(a) and (b) give the simulation results under OBS ring network. Compared with traditional scheme, network efficiency and burst loss probability are all optimized under our scheme.

In order to testify this congestion alleviated scheme, we measured the tolerance performances of this OBS platform. In our experiment, file transfer protocol (FTP) server was located in one node of OBS network

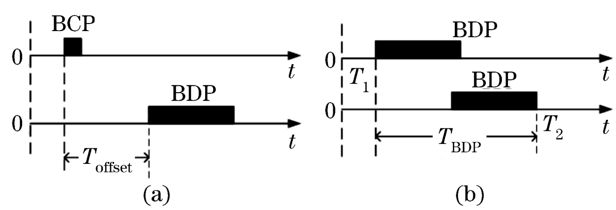

Fig. 3. (a) Offset time T_{offset}; (b) BDP transmitting time T_{BDP}.

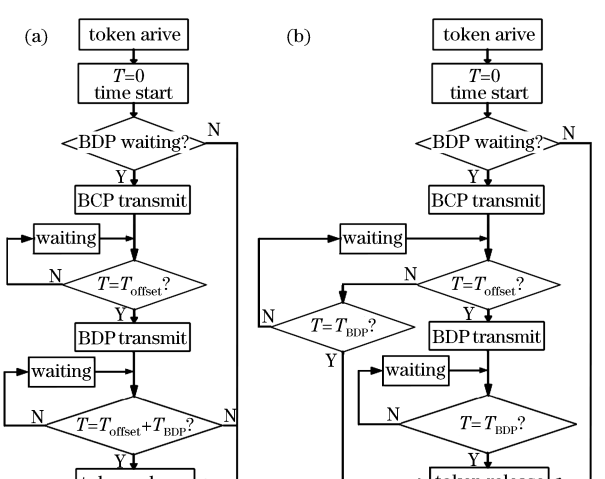

Fig. 4. (a) Traditional token protocol; (b) advanced token protocol.

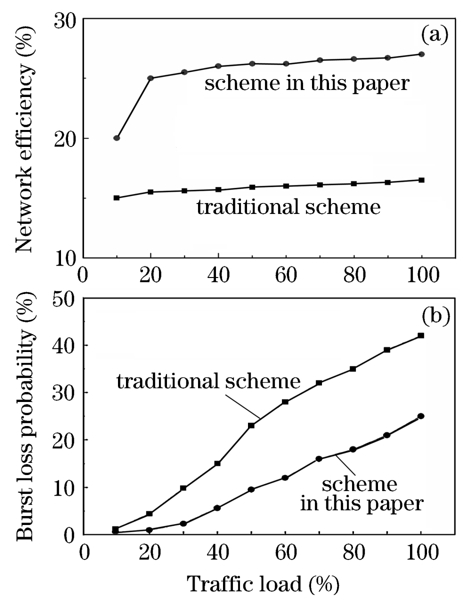

Fig. 6. (a) Network efficiency versus traffic load; (b) burst loss probability versus traffic load.

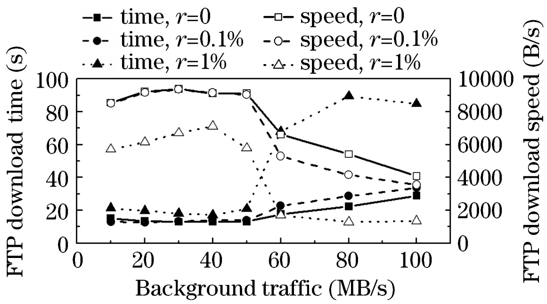

Fig. 7. FTP download experimental results. r: burst loss rate.

platform. FTP packets were transmitted through the OBS ring with background traffic. A client in other node of OBS network platform download these files. The average download speed and total download time of one FTP file was recorded.

The target of our experiment is to examine the network performance under different burst-loss rate. The experimental results are shown in Fig. 7. When the background traffic speed is lower than 50 MB/s, the average FTP download speeds under 0, 0.1%, and 1% burst-loss rates are almost at the same level. With the increase of background traffic, the average FTP download speed with 1% burst-loss rate reduces quickly, but the average FTP download speeds with 0 and 0.1% burst-loss rates still keep in a higher level. The same phenomena appear when considering the total download time of FTP file.

As we know, FTP transmission is based on transfer control protocol (TCP) which has its own requirements on network. Other application services based on TCP, such as telnet and e-mail, are also suitable to this scheme. For other services, we also have done some works on user datagram protocol (UDP) and hypertext transfer protocol (HTTP) services. They gave the same results as FTP service did.

This paper introduces a congestion alleviated scheme in OBS ring network platform using an advanced token protocol as control protocol and AOTF as tunable receiver. Experimental results prove that this scheme can resist the influence of burst collision below the level of 0.1% burst-loss rate and alleviate burst collision above this level.

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