MEMS SWITCHES FOR USING IN OPTICAL BURST SWITCHING NETWORKS

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1. Optical Burst Switching Networks

With growing demands of Internet Protocol (IP) services for transmission capacity and speed, the Optical Burst Switching (OBS) presents the solution for future high-speed Wavelength Division Multiplexing (WDM) optical networks. OBS is a technology for transmitting large amounts of data bursts through a transparent optical switching network [1].

An OBS network consists of the edge nodes and the core nodes interconnected with each other with WDM links. Two types of edge nodes are differentiated in OBS network, the ingress (core) and the egress (destination) edge nodes that are based on interface of the classical IP network and the OBS network [1-3].

Ingress edge nodes electronically assembly several incoming IP packets with the same destination into constant or variable length optical bursts, which stay in optical domain until they arrive to the egress edge node. To each optical burst a header is generated necessary to correct the switching structure setting in every core node, through which the burst will be passing. Just before the burst is transported, the control header is sent, to inform all the core nodes along the road about the burst arrival. The control header is sent through the independent channel, which is on a different wavelength as transferred optical burst (out-of-band signaling). In each core node, the control header is converted by optical-electronic-optical (O/E/O) conversion, due to not available all optical control circuits. On the basis of information contained in the control header the setting of switching structure in core node is made and processed in control circuit. The information contains the time delay between control header and optical burst (referred to as offset), size of the optical burst, required output port, incoming wavelength. Then the new header for transmitting burst is generated. This header is again sent from the core node in advance of the optical burst. This repeats until the optical burst does not arrive to the egress edge node. The purpose of the egress edge node is to disassembly the optical burst in a condition that has been set before entering into the edge node [1-9].

To successfully transmit bursts over OBS network and reach destination node, resource reservation schemes have to be implemented to allocate resources and configure optical switches for that burst at each node. According to the way of resource reservation, resource reservation schemes may be classified into two main classes: one-way reservation and two-way reservation. OBS networks use mainly reservation schemes with one-way reservation. A number of one-way resource reservation schemes have been proposed for OBS, including Tell-And-Go (TAG), Just-In-Time (JIT), Enhanced Just-In-Time (E-JIT), Enhanced Just-In-Time Plus (E-JIT^{+}), Just-In-Time Plus (JIT^{+}), Just-Enough-Time (JET), Horizon, JumpStart [1-9].

2. MEMS technology

Switching technologies play a major role in resources reservation. In switches it is required to convert incoming control header of optical burst, followed by processing and switching to required output port. Currently, several switching technologies are available but micro-electro-mechanical system (MEMS) based switches are the most widely used. This switching technology allows us to build the cost-effective and high-capacity optical cross-connect [1].

Optical MEMS switches can be categorized into three groups: MEMS switches using micromirror, MEMS switches using membranes, MEMS switches using plane moving waveguides. The first two groups represent free space switches, because they use space as transmission medium. The last group represents waveguide switches that require moving certain parts of the switch once functioning. Most of the optical MEMS switches use micromirrors, which can be divided into two groups, namely, 2 dimensional MEMS (2D MEMS) and 3 dimensional MEMS (3D MEMS) [10-11].

2D MEMS technology can deliver a range of applications including medium-sized and large optical cross-connects, wavelength selective optical cross-connects, wavelength add-drop multiplexing, optical service monitoring, and optical protection switching. MEMS technology is an important key to ensuring reliability and flexibility of a network [10-11].

3. Results

The model of OBS network is created using OMNeT++ simulation environment. The created OBS network model is based on network models presented in [12-14]. OBS network model is composed of two compound modules: edge nodes and core nodes interconnected by optical fibers. The OBS network model contains 4 core nodes and 8 edge nodes that are interconnected by optical fibers (see Fig.1). The cross-connects are used as OBS core nodes with MEMS switching technologies. 2D MEMS switches were selected due to their properties, especially switching time. 2D MEMS switches have also been chosen because they provide the small energy consumption, since in the present is effort to achieve low energy consumption in the interest of protecting the environment – due to the problem that is denoted as "green network" in optical network. The switching time of each 2D MEMS switch is 10 ms. Reservation schemes JIT and Horizon are implemented in OBS network model. JIT reservation scheme is used as example resource reservation scheme with immediate reservation. Horizon reservation scheme is used as example resource reservation scheme with delayed reservation.

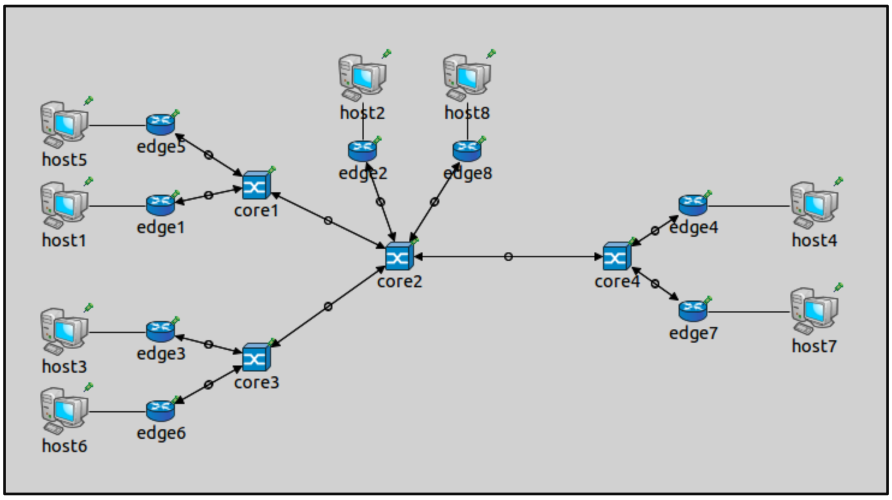

Fig.1: *The model of OBS network.*

Fig. 2 shows that blocking probability of data bursts decreases with increasing number of data channels and the performance of reservation schemes is very similar. The number of data channels in one optical fiber is shown in the range 1-24 because blocking probability of data bursts over 24 data channels was decreasing very slowly due to the heavy load of core node *Core2*. The delay between two consecutive data bursts was set to a large value in order in ms. At a lower value of load, the order in μs and ns, core nodes could not process incoming control header and switch data bursts due to short switching time.

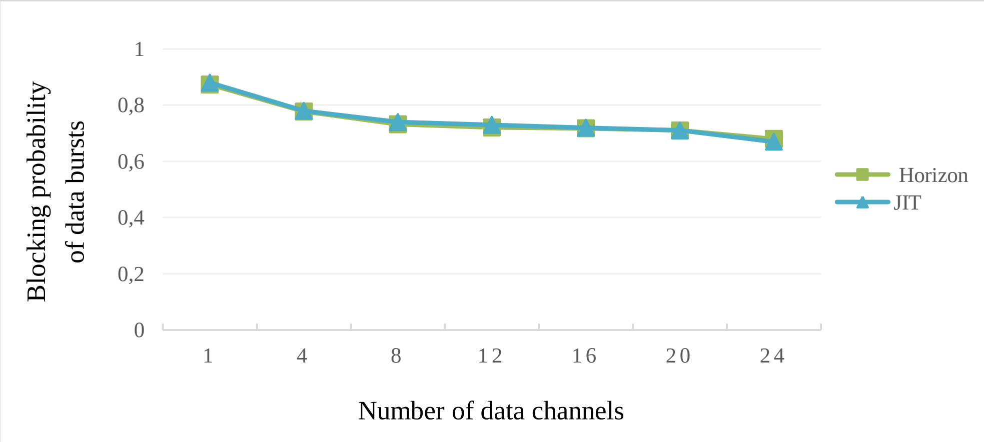

Fig.2: *Blocking probability of data bursts for JIT and Horizon reservation schemes with MEMS switching technology and average bursts length 8859 B.*

4. Conclusion

The simulation results show that the performance of reservation schemes is very similar. Blocking probability of data bursts by reservation schemes JIT and Horizon decreases with increasing number of data channels. The results also show that with MEMS switches and higher intensity of bursts arrivals, individual core nodes could not process incoming control headers and switch data bursts. So the switching technology plays important role in the resource reservation and is very important for future high-speed all optical networks. Future high-speed all optical networks will need more promising switching technologies; i.e. switching technologies with shorter switching time.

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