Performance analysis of multi-probability outputted model in a prioritized multi-classes traffic existed OBS network

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ABSTRACT

Optical burst switching (OBS) is a novel optical switching paradigm which could exploit the huge bandwidth of Dense Wavelength Division Multiplexing (DWDM) technology, and it is a typification of next generation full-optical switching technology. In this paper, the performance of multi-probability outputted model in a priorities traffic existed OBS network has been proposed and analyzed. Based on our proposed scheduling mechanism, the quality-of-service (QoS) of the OBS network has been supported.

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1. Introduction

Along with the explosive increment traffic in Internet, high-speed and ultra-broadband optical networks have been regarded as the solution for next generation communications. Nowadays, the transmission rate of single-wavelength optical channel in one fiber can reach hundred T level in backbone. But in core switching nodes, due to the lack of optical-memory and optical-logic, the "Electronic Bottleneck" problem still exists. Optical burst switching (OBS) is a novel optical switching technology that connects optical circuit switching to optical packet switching. It is the best solution for "Electronic Bottleneck" recently, and it has been regarded as a next generation IP over WDM optical transport networks [1–3].

A typical OBS network is composed of edge nodes, core nodes and WDM links. Edge nodes aggregate and encapsulate IP packets into optical data bursts based on their attributes, including destinations, priorities, etc., and at the same time, edge nodes create burst control packets (BCP) for each corresponding data burst. Core nodes as intermediate sites take charge of BCP process and data burst switching/forwarding full-optically. Under one-way reservation protocols, such as Just-Enough-Time (JET) [4–6], a BCP and its corresponding data burst apply an "out-of-band" signaling model to pass through the OBS core network.

In the core node blocking system of an OBS network, bursts may use large probability to select the output-port that has the short distance to a given destination, while may use small probability to select the output-port that has the long distance to the same destination. Such burst-outputted model has been proposed in some previous works, which has been called "Multi-Probability Outputted Model (MPOM)" [7,8]. The main benefit of MPOM is that, it can make the core node operating at a status more fit for the real networks operational scenario. In this paper, the performance of prioritized multi-classes traffic based MPOM in an OBS core node has been analyzed. High-classes data traffic protection mechanism has been established to support the QoS for the OBS network.

2. QoS supported MPOM application

In an OBS core node system, if several output-ports can reach to a same destination, control unit in the core node may use larger probability schedule bursts to the port that can lead to the shorter path to the destination than the port led to the longer path. Here, we may denote the former port as short-path-port (SPP), while we denote the latter port as long-path-port (LPP) [8]. Particularly, in a prioritized multi-classes traffic existed OBS network, QoS should be supported efficiently [9]. In the MPOM applied OBS core router, we propose a QoS guaranteed mechanism as follows:

(1) Same class degree bursts occupy SPP and idle port according to their arriving time.
(2) Higher class bursts have absolutely preemptive priority to select SPP over the lower class bursts.
(3) Higher class bursts have absolutely preemptive priority to occupy the idle port over the lower class bursts.

Based on the basic rules listed above, we give the output-ports selected procedure for multi-classes traffic in the OBS core node. Here, we set N as the output-port number of the given core router, M denotes the idle output-port number at a given moment, there

is the relationship of $0 \le M \le N$. We also set $i(1 \le i \le X)$ as the class degree of bursts, and we assign *Class*1 traffic as the highest priority class, while *ClassX* traffic as the lowest priority class in the OBS network. $D_j(j = 1,2,...,N)$ denotes the path distance between *NO.j* output-port to the destination. We assume that there is N paths leading to a given destination edge node. For simplification but not loss generality, we set $D_1 < D_2 < \cdots < D_N$. Thus, the basic procedure of QoS supported MPOM application could be implemented as follows:

if (there exist M idle output-ports ($0 \le M \le N$))
{
    if (the arriving bursts have the same priority class degree)
    {initialize the output-ports selected probabilities, then, apply MPOM to schedule the bursts}
    else if (there are differentiated priority classes for arriving bursts)
    {on the consideration of QoS support for priority classes traffic, high-class bursts will be given the high priority to select the output-port which can lead to the short path to the destination. In detail, referring to *Classi* and *Classj* bursts, if $i < j$, schedule *Classi* bursts to the output-port with D_{q1}, while schedule *Classj* burst to the output-port with D_{q2}, on the condition of $q_1 < q_2$.}
}
else if (all output-ports in the core node have been occupied ($M = 0$))
{the arriving bursts will be blocked, but the high class burst has the preemptive priority to get service for QoS support, even if a low class burst has been processed.}

From the procedure listed above, we could observe that, in MPOM applied OBS network, two key guiding lines should be abided for QoS support. One denotes that arriving bursts should be given large select probability to be assigned SPP, and another denotes that the high-class traffic should be given the output-ports absolute occupancy preemption over the low-class traffic if there exists contention.

3. Simulation and discussion

In this section, we will give an analytical model for MPOM in an OBS core node that is based on Markov chain. For simplicity but not loss generalization, we assume that the core node has two output-ports labeled, *NO.*1 and *NO.*2. *NO.*1 is the SPP while *NO.*2 is the LPP for our discussion. The data rate of the OBS network is 100 Gbps, and the average burst length is 100 Mb. There are three priority classes traffic in the OBS network which are: HDTV assigned as *Class*1, IP voice denoted as *Class*2 and text-data traffic denoted as *Class*3. *Class*1 traffic has the highest class, while *Class*3 traffic has the lowest class. Here, we set φ as the *NO.*1 port selected probability for bursts.

Fig. 2. Burst relative through capacity in the core node.

Fig. 1 plots the burst blocking probability for priority multi-classes traffic versus the normalized traffic load. The share ratio of total load for *Class*1, *Class*2 and *Class*3 traffic is 20%, 30% and 50%, respectively. From the graphs we could observe that, it is valuable to notice that the burst blocking probability for all class traffic will alternate with the changing of *NO.*1 port selected probability. To *Class*1 traffic as an example, the adjacent average decrement ratio of blocking probability between $\varphi = 0.5, 0.7$ and 0.9 is 21.3% and 33%, respectively. So, the same select probability scheme for all bursts only is a special case in MPOM applied OBS core nodes. Given a specific class traffic, the blocking probability is decreased with the increment of SPP selected probability. In addition, high-class traffic gets the lower blocking probability than low-class traffic gets under our proposed scheduling principle. The QoS in the OBS core node has been supported.

Figs. 2 and 3 give the burst relative through capacity and the burst absolute through capacity in the OBS core node system, respectively. From the two figures we could see that, with the increment of traffic load, burst relative through capacity shows the trend of decreasing but the burst absolute through capacity is on the reverse. As burst relative through as example, given $\varphi = 0.7$, the parameter decrement ratio between load 0.1 and 1.0 are 2.9%, 17% and 44.6% for *Class*1, *Class*2 and *Class*3 traffic respectively. It concludes that, the *Class*1 traffic has the smallest decrease range, and the *Class*3 traffic has the reverse condition.

Figs. 4 and 5 give the system occupied expectation value and the system efficiency in the OBS core node, respectively. From the two graphs we could observe that the two graphs have the similar curve

Fig. 1. Burst blocking probability for multi-classes traffic.

Fig. 3. Burst absolute through capacity in the core node.