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Abstract. In an optical burst switching core node, each output port is equipped with a different network interface unit that can provide a specific data rate. Bursts will use different probabilities of select output ports, which is in accordance to the path-length metric-based routing optimal algorithm and wavelength resource situation. Previous studies ignore this issue. We establish a burst-outputted model considering the different service rate of output ports and different port-selected probabilities. We calculate burst-blocking probability and analyze the relationship between service rate and output-port-selected probability in detail. [DOI: 10.1117/1.OE.52.4.040502]

Subject terms: optical burst switching; burst blocking probability; service rate.

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1 Introduction

With the explosive growth of data traffic in the Internet, optical burst switching (OBS) has been regarded as an ideal switching technique to realize terabit-level data transmission in next-generation optical networks.[1] In an OBS core node, bursts have been processed and outputted through a reserved output port and wavelength. In reference to the outputted process of a burst, according to the studies cited in this paper, the same probability to select the output ports, which lead to the same edge node (or destination), was used. Such an assumption makes it easy to establish the burst-outputted model in an OBS core node, but it ignores the difference of the service rates of network interface units (NIUs)[2,3] and the difference of output ports-selected rules based on optimal routing algorithms.[4] In fact, according to the general rule of an optimal routing, if there is enough remaining wavelength in a network, it should select a shortest path; it should also increase the probability of selecting a low-load or short-delay path. The wavelength indicates that a burst will use different probabilities to select output ports that lead to the same destination in an OBS core node. In addition, different NIUs equipped at the output interface of a core node have a different data processing rate, thus directly affecting the service rate. Therefore, under such conditions, the outputting performance of bursts will show a variety of scenarios. References 5 and 6 have proposed two-output ports with two different probability output port-selected burst output models in an OBS core node. However, they only consider two output ports and different service rate situation, thus limiting the results.

In this paper, we develop an analytical model for the burst output issue. In this model, we not only give a more generalized three-output port system in an OBS core node, but also consider both different service rates and different output port-selected probabilities according to different network-related conditions.

2 Analytical Model

In this section, we develop an analytical model based on a Markov chain to evaluate the burst output issue in an OBS core node. Without loss of generality, we assume that there are three output ports, Port_A, Port_B, and Port_C that can lead to the same destination. Each output port of the core node is equipped with a NIU, and the data output performances among them are different; thus, the service rate of each port is μ_1, μ_2, and μ_3, respectively. We assume that the service rates of the three output ports are the negative exponent distributed with the relationship of $\mu_1 > \mu_2 > \mu_3$, and the wavelength conversion is unavailable in our analysis. We also assume that the burst-arriving process is Poisson with rate of λ. Thus, burst output process in the OBS core node can be described as follows:

$$\pi_{000}\lambda = \pi_{001}\mu_3 + \pi_{010}\mu_2 + \pi_{100}\mu_1, \tag{1}$$

$$\pi_{001}(\lambda + \mu_3) = \pi_{011}\mu_2 + \pi_{000}\lambda\phi_3 + \pi_{101}\mu_1, \tag{2}$$

$$\pi_{010}(\lambda + \mu_2) = \pi_{011}\mu_3 + \pi_{000}\lambda\phi_2 + \pi_{110}\mu_1, \tag{3}$$

$$\pi_{011}(\lambda + \mu_2 + \mu_3) = \pi_{010}\lambda(1 - \phi_5) + \pi_{001}\lambda(1 - \phi_6) + \pi_{111}\mu_1, \tag{4}$$

$$\pi_{100}(\lambda + \mu_1) = \pi_{101}\mu_3 + \pi_{000}\lambda\phi_1 + \pi_{110}\mu_2, \tag{5}$$

$$\pi_{101}(\lambda + \mu_1 + \mu_3) = \pi_{111}\mu_2 + \pi_{001}\lambda\phi_6 + \pi_{100}\lambda(1 - \phi_4), \tag{6}$$

$$\pi_{110}(\lambda + \mu_1 + \mu_2) = \pi_{111}\mu_3 + \pi_{100}\lambda\phi_4 + \pi_{010}\lambda\phi_5, \tag{7}$$

where $\pi_{i,j,k}(i, j, k = 0, 1)$ are steady states probabilities in the blocking OBS system, ϕ_1, ϕ_2, and ϕ_3 denote Port_A, Port_B, and Port_C selected probability by an arriving burst at a specific moment, respectively, under the condition where all the three ports are idle at that moment. The ϕ_4, ϕ_5, and ϕ_6 denotes the selective probability for Port_B, Port_A, and Port_C under the condition that Port_A, Port_B, and Port_A have been occupied at that moment, respectively.

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3 Results and Discussion

In this section, we evaluate the burst output process under three network scenarios. We assume Port_A, Port_B, and Port_C of the OBS core node is attached with a NIU with the data rate of 100, 10, and 1 G/s, respectively. The average length of bursts is 12.5 M octets in the OBS network.

3.1 *Different Ports-Selected Probabilities*

Different from the previous work on burst output process models in the literature, which only considers the same probability to select all the output ports, here we use Fig. 1 to describe the limitation of the conventional model and explain the improvement of the proposed model. In our analysis, we assume that all the output ports can lead to the same destination through different paths. We can observe that, under the different service rate conditions, burst-blocking probability varies with the different output port-selected probabilities. It also can be seen that the burst-blocking probability with different port-selected probabilities may be either greater or less, with the same port-selected probabilities applied in the conventional work.

3.2 *Effect of the Shortest Path Routing*

In this case, there is enough available wavelength for assignment. Thus, the shortest path first-routing algorithm has been applied for the entire OBS network. It means that an arriving burst will use larger probability to select the output port that leads to the shortest path in the OBS core node. We assume that Port_A leads to the shortest path, whereas Port_C leads to the longest path for a given destination. Figure 2 plots the burst-blocking probability considering the effect of the shortest path-routing algorithm. From the graph, we can observe that the burst-blocking probability increases with the increment of selective probability for Port_A under the same load condition. We also see that burst-blocking probability reduces with the increasing values of ϕ_4, ϕ_5, and ϕ_6 under the same values of ϕ_1, ϕ_2, and ϕ_3. In this case, the arriving bursts use the same probability to select the three ports when they are all idle at a given moment, thus getting the lowest burst blocking probability.

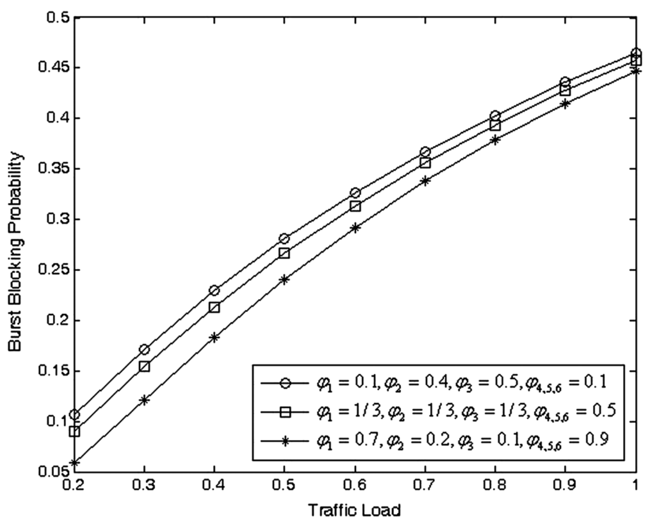

Fig. 1 Burst output process with different service rates and different port-selected probabilities.

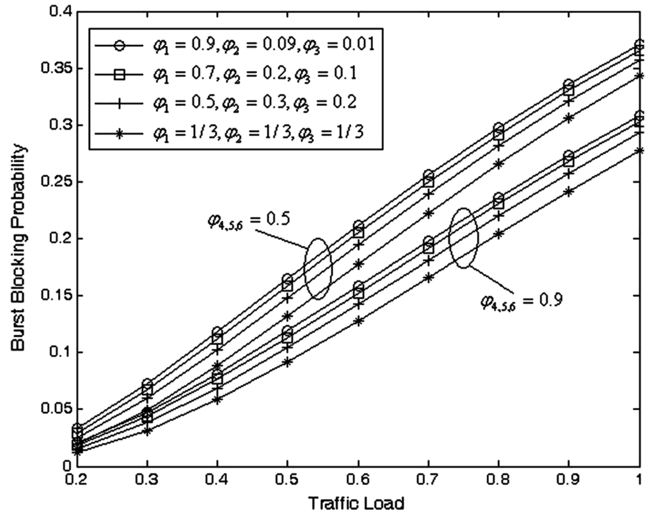

Fig. 2 Burst output process affected by shortest path routing algorithm.

3.3 *Effect of Different Service Rates*

In the OBS network, traffic is heavy, and there is not enough of a remaining wavelength resource for each bandwidth reservation requirement. In this case, the shortest path-routing algorithm may be inefficient or even of no use; thus, an arriving burst will select an output port with high service rate. To illustrate the effect of service rates on burst output process, we consider a reverse condition comparing with the above case that of Port_A that leads to the longest path, whereas Port_C leads to the shortest path regarding a given destination. From Fig. 3, we could observe that burst-blocking probability reduces with the increased selective probability for Port_A under the same load condition. It indicates that although bursts select an output port that leads to a long path, they get a low-blocking probability, thus improving the network-losing performance effectively in a bufferless OBS network. We also see that, similar to Fig. 2, the burst-blocking probability with large value of ϕ_4, ϕ_5, and ϕ_6 is lower than that with a small value. However, different from Fig. 3 under the same load condition, the adjacent difference

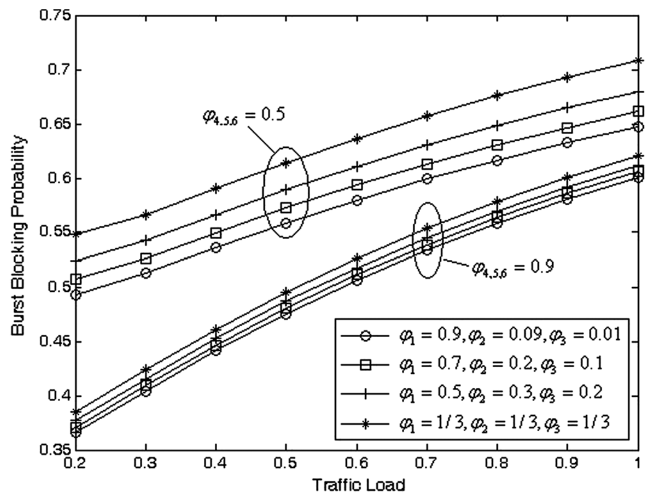

Fig. 3 Burst output process affected by different service rates.

of burst- blocking probabilities among $\phi_1 = 0.9, 0.7, 0.5$ and $1/3$ with $\phi_{4,5,6} = 0.5$ is larger than that of $\phi_1 = 0.9, 0.7, 0.5,$ and $1/3$ with $\phi_{4,5,6} = 0.9$.

4 Conclusion

In this paper, we proposed an enhanced burst-outputted model in an OBS core node and evaluated burst-blocking performance considering the different service rates and output port-selected probabilities under different load conditions. The consideration of a different service rate for NIUs and different output port-selected probabilities for bursts makes the result closer to the real networks-running scenario and, thus has practical significance for the construction of OBS test beds.

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