IJCSI International Journal of Computer Science Issues, Vol. 7, Issue 5, September 2010
ISSN (Online): 1694-0814
www.IJCSI.org

Performance Analysis of the Signaling Channels of OBS Switches

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Abstract

Nowadays, fiber optic networks that make transmission possible in high capacities become widespread. There is a partial decrease in network problems with the capabilities provided by these networks such as telephone, wide area network, Internet, video conference on a single fiber line. Also in optical networks, optical burst switching that is a new technology stands out by its some partial benefits. Optical burst switching (OBS) is a promising solution for all optical networks. In this paper, a program is developed which simulates signaling channel of an OBS switch, for signaling messages that uses signaling protocols while going from source node to destination node through intermediate OBS switches. In this study, some models for inter-arrival time of the signaling messages and processing time in the service are used and a comparison of these models with the other well known models is done (M/M/1/K queuing model and a model using self-similar traffic as arrival process).

Keywords: Optical Networks, Optical Burst Switching, Queuing Models, OBS Switches.

1. Introduction

Optical Burst Switches (OBSs) are designed to meet the increasing bandwidth demands [1,2]. This increase in bandwidth demands has led to the development of optical fibers which gives the opportunity to carry high bit-rates. Even the high bit-rates obtained with optical fibers are not capable to provide enough bandwidth for future network requirements; dense wavelength division multiplexing (dWDM) became the solution for providing higher bandwidth.

OBS seems to be the answer to the increasing bandwidth demand problem. OBS is designed as an intermediate solution between optical circuit switching and packet switching and looks like the best candidate to carry IP traffic over dWDM networks.

In this study, we concentrate on the signaling and control plane of the OBS switch. The data plane is out of scope of this study. Xu et al. has already proposed a queuing network model to analyze the data plane of an OBS switch in [3]. However, the signaling and control plane is different than the data plane where there is no optic-electronic-optic (OEO) conversion and the bursts are handled in all optical planes. Interested readers could refer to [4,5] for further information related with signaling protocol. On the other hand, for the signaling and control plane, OEO conversion is necessary. Once OEO is required, switches need a buffer mechanism. The switch is considered to be an NxN optical burst switch. The switch architecture is explained in detail in [4]. There are both input and output buffers for signaling channels. The switch fabric is non-blocking. The output contention is resolved by input and output buffers. The rate of the signaling channel will be estimated with different stochastic processes.

This paper is organized as follows. Section 2 gives the system description. In section 3, we give different approximation methods used for analysis purposes. In section 4 we compared our results. Section 5 concluded our study.

2. Problem Definition

In this paper, we analyze an OBS switch that contains input and output buffers. The messages traversing on that OBS switch are signaling and control messages. Therefore, they are apt to OEO conversions at each switch along their path. The rate of data channel is assumed to be 2.4 Gbps. The rate of signaling channel is on the other hand 155 Mbps. Signaling message size is 1 Kbps and burst size is variable taking values among 32 Kbps, 64 Kbps and 128 Kbps. The aim of this study is to calculate the dropping probabilities at input and output buffers with fixed buffer sizes. Once we model the system with this approach, we can also analyze input and output buffer sizes with fixed dropping probabilities.

In literature, we can see some proposals related with the buffer dimensioning for packet switches. Jung et al. proposed an analytical solution for back-pressure type packet switches with input and output buffers in [5]. They analyzed the switch as a Geom/PH/1/K queue. Another model is proposed by Iliadis et al. again for packet switches in [6] where they modeled the system with two tandem queues. The input queue is analyzed as an M/G/1 queue and the output queue is modeled as an M/D/1 queue. Chen et al. in [7] analyzed the same problem with M/G/1 and M/M/1 tandem queues. However, all of them worked on packet switches. On the other hand, OBS is designed as an intermediate solution between optical circuit switching and packet switching. Therefore, another modeling approach is needed to analyze these systems.

3. Our Modeling Approach

Our analysis is organized is three steps. We defined a simple approximation based on M/M/1/K model as the first step. In the second step, we changed the arrival process, and used self-similar traffic as the input process. In the third step, we defined a new model with MMPP/C2/1/K queue.

3.1 An Approximate Solution

The arrival process to the switch input buffers are assumed to be homogeneous. That means the total traffic is distributed uniformly to each output port. Burst arrivals to each input come from independent and identical Poisson processes with an arrival rate λ burst/unit time and bursts have exponentially distributed service time with mean $\frac{1}{\mu}$ unit time.

The switch is modeled as two M/M/1/K queues in tandem. The first queue represents the input buffers and the second one represents the output buffers. Arrival rate to the first queue is Poisson with rate λ, and P_{in} is the blocking probability of traffic for the first queue, while the arrival rate for the second queue is the rate of the traffic that has not been blocked in the first queue and is described as $\lambda(1-P_{in})$.

3.1.1. Calculation of Load

The amount of load that is used through this work calculated as follows:

$$\rho = \frac{\frac{R_D}{S_B} S_S}{R_S} \qquad (1)$$

where R_D is the rate of data channel, R_S is the rate of signaling channel, S_B is the burst size and S_S is the signaling message size. In our switch, R_D is 2.4 Gbps, R_S is 155 Mbps, S_S is 1 Kbps and S_B can be 32, 64, 128, 256, or 512 Kbps. In our comparisons we used S_B as 32, 64 and 128 Kbps and represented the required buffer sizes.

3.2 Self-Similar Traffic as the Input Process

To obtain more realistic results in terms of similarity, a real system's behavior must be examined (e.g. The Internet). Existing researches on this field show that Internet traffic behavior is self-similar. For this reason, self-similar traffic is used in arrival process. Figure 3.1 shows a measured Internet traffic which is also self-similar. The Internet traffic is compared with Poisson distribution in this figure.

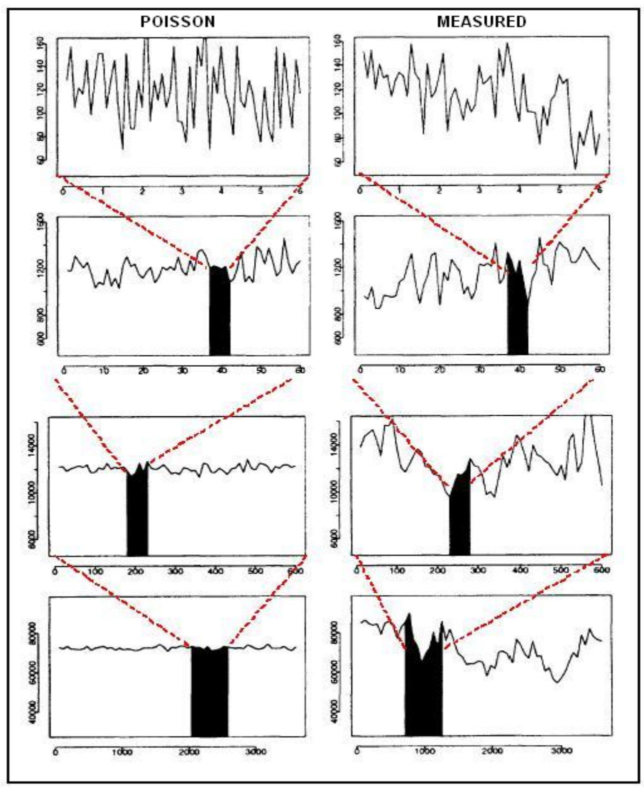

Fig. 3.1 Comparison of the self-similar Internet traffic (measured) with Poisson [8]

As shown in the Figure 3.1, the traffic that uses Poisson distribution is far from real traffic. For this reason, we modified the arrival process, and used self-similar traffic as the input process. In the self-similar traffic model, arrival process is produced as self-similar and the incoming packets are gathered in input queue. For the incoming packets, the service duration is produced by exponential distribution as in the M/M/1/K model.

3.3. A New Model MMPP/C2/1/K queue

In our model, arrival processes are designed as Three-State-Markov Model shown in Figure 3.2. Arrival process can be one of these 3 states: short signaling, long signaling and idle. If it is short signaling state, a short signaling packet is coming to the OBS switch. Also, in long signaling state, a long signaling packet is coming to the OBS switch. In idle state, there is no packet arrival to the OBS switch. Passing through short signaling, long signaling and idle state is calculated by exponential distribution.

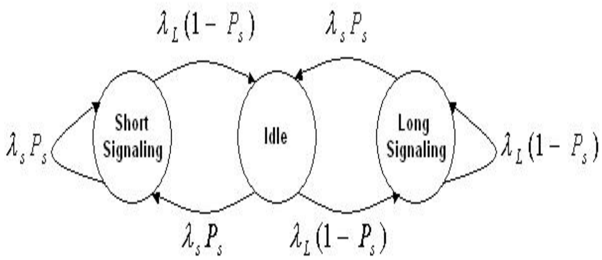

Fig. 3.2 Three-State Signaling Arrival Process

Starting state is idle state. It is possible to pass short signaling state by P_s possibility and the short signaling state can be kept or can be changed to idle state according to the next arriving value. It is not possible to change between long and short signaling states directly. So, before changing state to short or long signaling, must be passed to idle state. All these events are same, when the state changes to long signaling state with the possibility of $(1-P_s)$.

Control packets that come out from input queue are passed to the two-state Coaxian Server as shown in Figure 3.3. μ_1 and μ_2 show rate of the Coaxian Server in the first and second states. α is the possibility value which shows if it is possible or not passing to second state. A control packet that arrived to server and was processed with μ_1 server rate is processed again by the α possibility with μ_2 server rate. After that, it can be passed to output queue. In the second case, when the possibility is $(1-\alpha)$, it can be passed to output queue without being processed with μ_2 server rate.

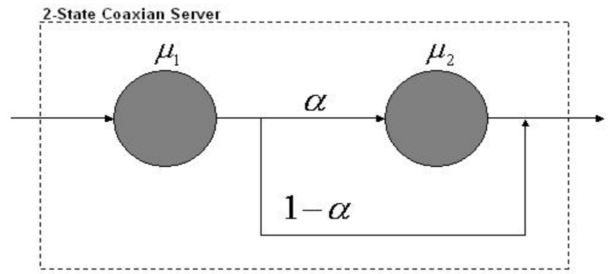

Fig. 3.3 Two-State Coaxian Server

The control packets that leaves from the server, is sent to output queue. If the output queue is not empty, the newly arriving control packet is also added to the end of the output queue. Otherwise, it is sent to next OBS switch.

4. Comparing Results

In this section, we give three different graphics for each model. These three different graphics are for each burst size. At each graph, output buffer sizes vary from 10 to 700 and input buffer sizes are fixed.

Figure 4.1, 4.2 and 4.3 show packet dropping probability of the M/M/1/K model for the load of 0.4, 0.24 and 0.12, respectively. Figure 4.1 and 4.2 are plotted until dropping probability value reaches 0.3. However in Figure 4.3, under 0.12 load, it is seen that initial dropping probability is already about 0.3.

In Figure 4.1, dropping probability starts at 0.8 and ends at 0.3 with 380 buffer size. Different from Figure 4.1, in Figure 4.2, dropping probability starts at 0.6 and almost decreasing linearly, ends at 0.3 with 230 buffer size.

In Figure 4.3, because of low load value, the initial value of dropping probability is already 0.3 with less than 2 buffer size. It can be seen that with increasing buffer size the dropping probability converges to zero as expected.

Figure 4.4, 4.5 and 4.6 show packet dropping probability of the self-similar model for the load of 0.4, 0.24 and 0.12, respectively. Figure 4.4, 4.5 and 4.6 are plotted until dropping probability value reaches 0.3. In Figure 4.4, dropping probability starts at 0.99 and ends at 0.3 with 700 buffer size. Like Figure 4.4, in Figure 4.5 under 0.24 load, dropping probability starts at 0.99 and ends at 0.3 with 700 buffer size. In Figure 4.6, under 0.12 load, the OBS switch behaves the same as in Figure 4.4 and 4.5.

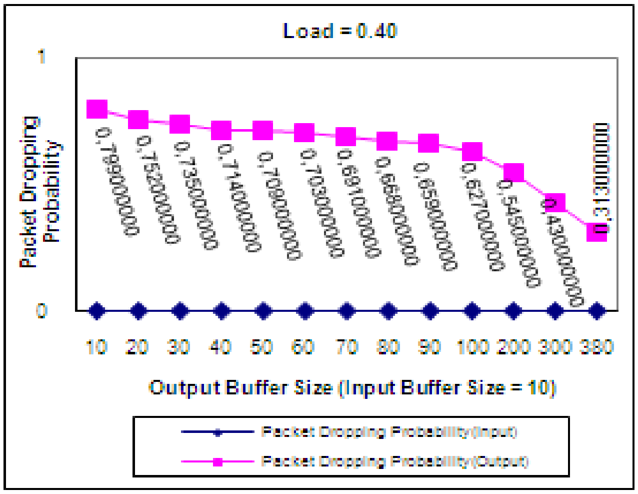

Fig. 4.1 Packet dropping probability in input and output buffers for load=0.4 (M/M/1/K)

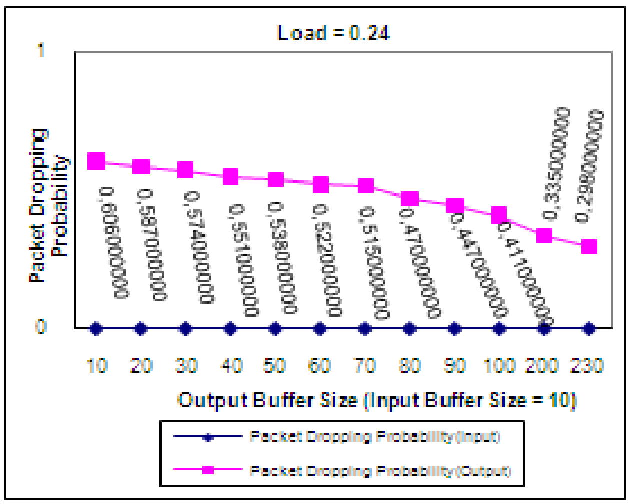

Fig. 4.2 Packet dropping probability in input and output buffers for load=0.24 (M/M/1/K)

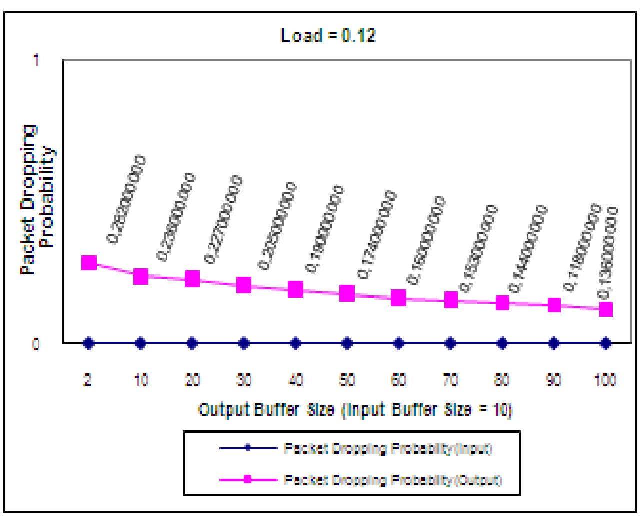

Fig. 4.3 Packet dropping probability in input and output buffers for load=0.12 (M/M/1/K)

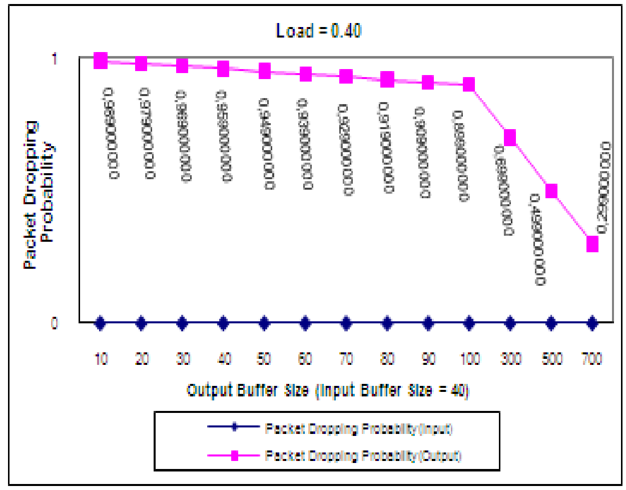

Fig. 4.4 Packet dropping probability in input and output buffers for load=0.4 (Self-Similar)

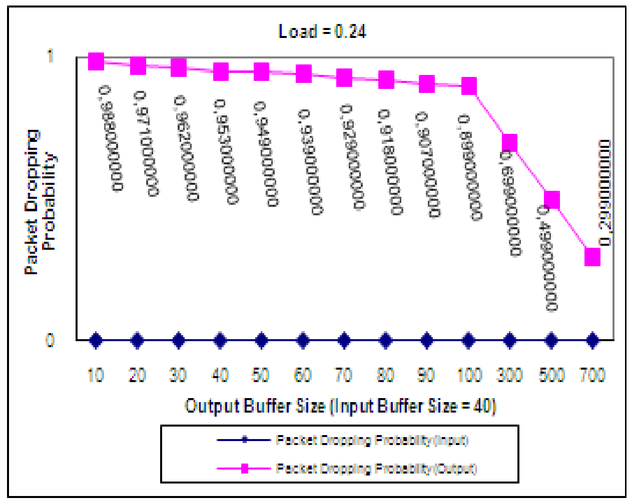

Fig. 4.5 Packet dropping probability in input and output buffers for load=0.24 (Self-Similar)

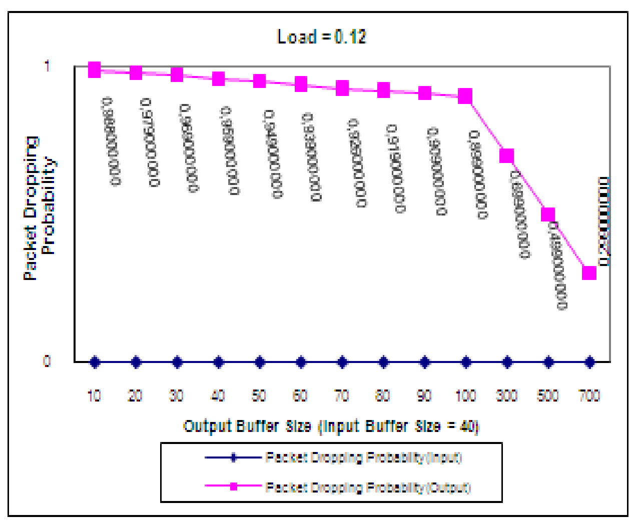

Fig. 4.6 Packet dropping probability in input and output buffers for load=0.12 (Self-Similar)

Figure 4.7, 4.8 and 4.9 show packet dropping probability of the MMPP/C2/1/K model for the load of 0.4, 0.24 and 0.12, respectively. Note that all three of dropping probabilities are decreasing almost linearly. Figure 4.7, 4.8 and 4.9 are plotted until dropping probability value reaches 0.3. In Figure 4.7, dropping probability starts at 0.75 and ends at 0.3 with 500 buffer size.

Different from Figure 4.7, in Figure 4.8, dropping probability starts at 0.6 and almost decreasing linearly, ends at 0.3 with 350 buffer size.

In Figure 4.9, because of low load value, the initial value of dropping probability is already 0.3 with 10 buffer size.

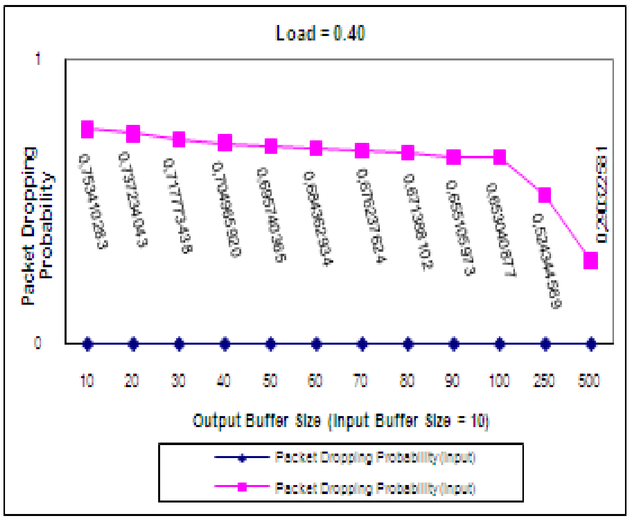

Fig. 4.7 Packet dropping probability in input and output buffers for load=0.4(MMPP/C2/1/K)

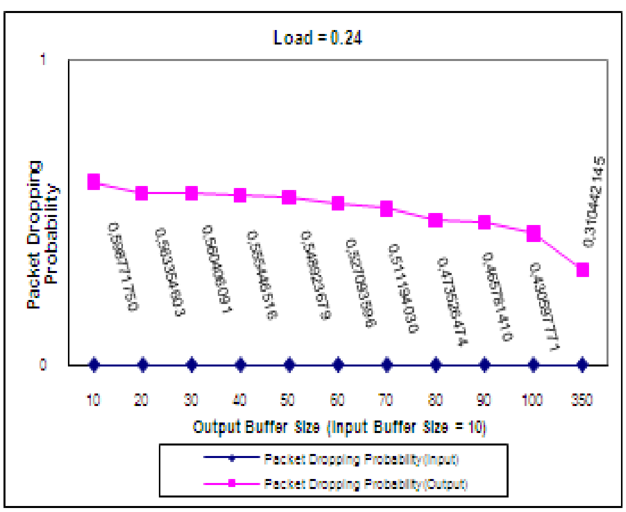

Fig. 4.8 Packet dropping probability in input and output buffers for load=0.24(MMPP/C2/1/K)

In Figures 4.1 to 4.9, the change on the output buffers for varying loading of the system can be seen. According to the Figures 4.1 to 4.3, for a 0.3 dropping probability and for 0.24 load, in M/M/1/K model (best case) we need 230 buffers/port in addition. For a message size of 1Kbps, the required buffer size is (1 Kbps * 230) 230 Kbps/port. For a four port switch, the total buffer requirement is (4*230) 920 Kbps (=0.92 Mbits).

According to the Figures 4.4 to 4.6 for a 0.3 dropping probability and for a 0.24 load, in self-similar model (worst case) we need 740 buffers/port in addition. For a message size of 1Kbps, the required buffer size is (1 Kbps * 740) 740 Kbps/port. For a four port switch, the total buffer requirement is (4*740) 2960 Kbps (=2.96 Mbits).

According to the Figures 4.7 to 4.9 for a 0.3 dropping probability and for a 0.24 load, in MMPP/C2/1/K model we need 360 buffers/port in addition. For a message size of 1Kbps, the required buffer size is (1 Kbps * 360) 360 Kbps/port. For a four port switch, the total buffer requirement is (4*360) 1440 Kbps (=1.44 Mbits).

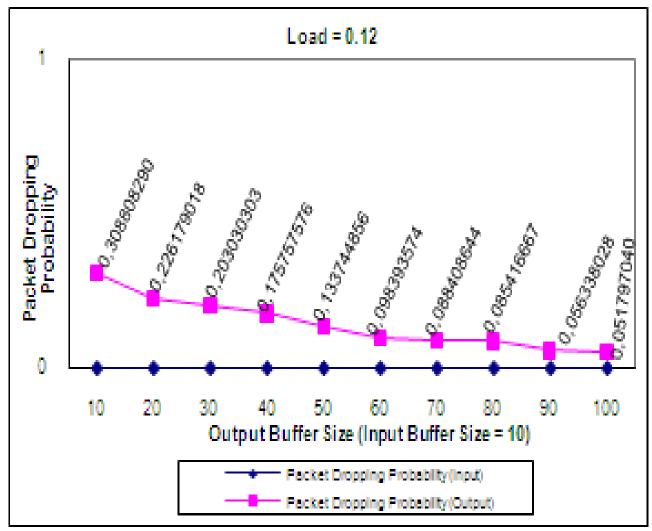

Fig. 4.9 Packet dropping probability in input and output buffers for load=0.12(MMPP/C2/1/K)

5. Conclusions

If results of M/M/1/K model is considered as the best case, and the self-similar traffic, which is applied to our model as arrival process, is considered as the worst case, it is been observed that when Three-State Signaling Arrival Process (our arrival process) is applied to our model; we have minimum packet dropping probability against optimum buffer size (Figure 5.1). Therefore, in real life our model (MMPP/C2/1/K) is much more applicable than both M/M/1/K model and self-similar traffic which is applied to our model.

For future works, our model (MMPP/C2/1/K) can be analyzed analytically. Consequently, more suitable input and service rates can be obtained and it would be possible to purpose getting more certain values.

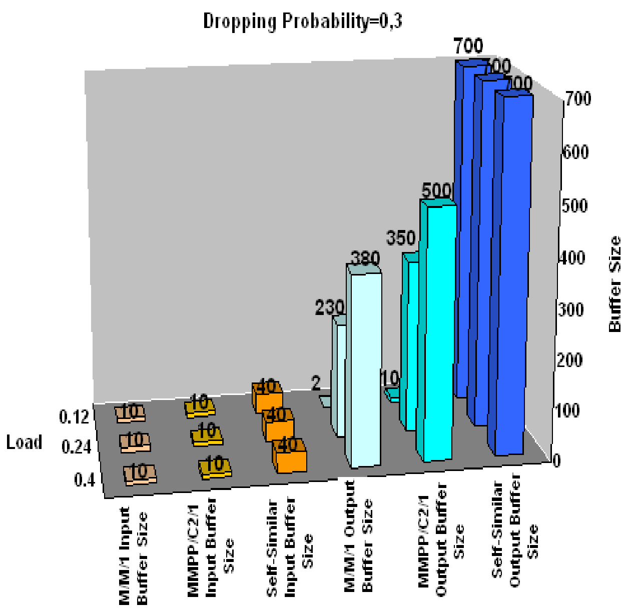

Fig.5.1 Comparing buffer sizes for each model under the 0.3 dropping probability

References

[1] I. Baldine, G.N. Rouskas, H.G. Perros, and D. Stevenson, “Jumpstart: a just-in-time signaling architecture for WDM burst-switched networks”, IEEE Communications Magazine, 2002, Volume:40 Issue: 2, pp.82-89.

[2] A.H. Zaim, I. Baldine, M. Cassada, G. Rouskas, H. Perros, and D. Stevenson, “JumpStart just-in-time signaling protocol: a formal description using extended finite state machines”, Optical Engineering, 2003, Volume:42 pp. 568-585.

[3] L. XU, H.G. Perros, and G. Rouskas, “Techniques for Optical Packet Switching and Optical Burst Switching”, IEEE Communications Magazine, 2001, pp.136-142.

[4] J. Wei, and R. Mcfarland, “Just-in-time Signalling for WDM Optical Burst Switching Networks”, Journal of Lightwave Tech., 2000, Vol. 18, No. 12, pp. 2019-2037.

[5] C. Qiao, and M. Yoo, “Optical Burst Switching (OBS) – A New Paradigm for an Optical Internet”, Journal of High Speed Nets., 1999, Vol. 8, No. 1, pp. 69-84.

[6] I. Iliadis, and W.E. Denzel, “Performance of Packet Switches With Input and Output Queueing”, in Proc. ICC '90, Atlanta, GA, Apr. 1990, pp. 747-753.

[7] J.S.-C. Chen and T.E. Stern, "Throughput analysis, optimal buffer allocation, and traffic imbalance study of a generic nonblocking packet switch," IEEE J. Select. Areas Commun., Apr. 1991, vol. 9, no. 3, p. 439-49.

[8] T.B. Fowler, “A Short Tutorial on Fractals and Internet Traffic”, The Telecommunications Review, 1999, Volume: 10, pp. 1-15.