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Performance Evaluation of Buffer under Load Balancing and Prioritized Conditions in High Speed Networks

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ABSTRACT

OPS is considered as next generation data transfer technology. In the past a few years, tremendous growth has been seen and it is expected that very soon optical technology will take over its electrical counterpart. In OPS contention among the packets is a major problem, to counteract the problem deflection and buffering of contending packets is proposed. The results are obtained through simulations, in terms of packet loss probability. This has been found that in general buffering of contending packets reduces packet loss rates. The packet loss rate can be further reduced using load balancing conditions where some of the contending packets sent to some other nodes, and they reach their destination using some alternative paths. Priority of packets is one of the very important aspects. In this work two classes of packets are considered i.e., Low Priority and High Priority. Low priority packets are not so important and they can be delayed or dropped over high priority packets. For example, downloading a song is low priority packets, while information send by defense applications are high priority packets. Currently most of the email providers like gmail, yahoo, rediffmail etc.. provide option to set priority. In this paper, effect of packets priorities and load balancing scheme on packet loss rate is evaluated,

Keywords: *OPS, Packet Priority, Load and Packet Loss Probability*

1. INTRODUCTION

The optical fiber technology is based on the propagation of the optical pulses in optical fiber. Hence, the system offers advantages like large optical bandwidth (theoretically infinite), shock-proof immune to interference etc. The information generated from any source (may or may not be electrical) is fed to a transmitter comprising electrical and electronic circuitry, which converts the electrical signal into an appropriate optical signal and transmitted [1-3]. The optical carrier is generally modulated with electrical and optical modulator. At the receiver end, the optical signal is again converted back into the electrical signals through O to E conversion and directed towards destination.

The generic layout of the network is shown in Figure 1. The network structure is composed of core and client networks. The edge routers sitting at the edge of network cloud serve as an interface between the core and the client network.

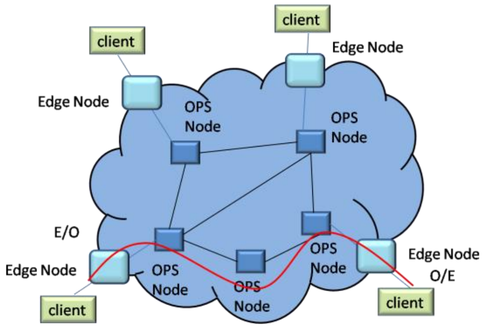

Figure 1: Generic layout of the OPS system

Currently, both the routers (core as well as the edge routers) are electronic in nature. The electronic switches/routers have very limited speed. Therefore, electronic routers cannot handle high data rate. The inefficiency of the electronic routers gives rise to the birth of optical networks. The major issue involved in the optical network is the design of the switch/routers which can perform switching operations efficiently at the high data rates. These can be classified as 'all'-optical or photonic switches. In all-optical mode, the propagation and the processing of data is assumed to be in optical domain [4-6]. Currently, due to the unavailability of the optical RAMs, all-optical switches are not technologically feasible. In the second mode (photonic), data remains in the optical form without any O/E and E/O conversion at the intermediate nodes in the network, but control operation is performed in electronic domain. The photonic packet switching offers very high speed, transparency to format, efficiency and flexibility in the configuration due to the switching operation in physical layer [6].

In communication, the data is generated by the electronic sources, and hence optical packet switch is only advantageous when edge router aggregate the large number of packets to form a big size packet and then converting it to an optical packet. This optical data payload is concatenated with a low bit rate header and sends into core network. The optical switches in the core network will only convert the header of the packet in electronic domain payload and remains in optical form. The header information is used to route the packet form source to destination. After traversing through the network packet reaches the egress node, where the aggregated packet can be de-assembled optically and after o/E conversion passed onto the client network. This type of networking structure is

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referred as aggregate core transport networks. In the next technological advancement, it is believed that edge router will remain in the electronic domain, because of the advent of the CMOS technology (which allows data rate of 40 Gbps) and core routers will be implemented optically [6]. The other advantage of CMOS technology is very low power dissipation, which is much less than their optical counterparts [7]. This hybrid approach allows the efficient utilization of the mature electronic technology and huge bandwidth of the fiber in optical domain. In this approach, it is assumed that edge routers are capable of packet aggregation. They can handle variable length packets arriving from the various client networks. Finally, edge routers push the fixed length packets in the core routers networks [7-12].

2. QUALITY OF SERVICE (QoS)

In optical networks, packet loss is a common phenomenon. As the network, or its links or any node (i.e. photonic packet switches), becomes congested, the switch buffer becomes full and start to drop packets. For non-real time applications, such as file transfer, e-mail, packet loss is not critical. But in real-time applications (i.e. voice, video), packet loss means unintelligible information. Also in real time applications, packet should reach their destination with least amount of delay. Although transmission in optical packet networks is very fast and in general packets delay could be lower than electronic packet networks, some applications (services) demands better packet delivery guarantees. The solution of QoS is service differentiation (prioritization of data or packet) in packet networks with big traffic load.

In this work two classes of packets are considered i.e.,

Low Priority

High Priority

Low priority packets are not so important and they can be delayed or dropped over high priority packets.

3. FRAMEWORK FOR THE SIMULATION

In figure 2, schematic of OPS network with shared buffer at each node is shown. Here, at each node with '*N*' input and output links can store a maximum of '*B*' contending packets can be stored in shared manner [11].

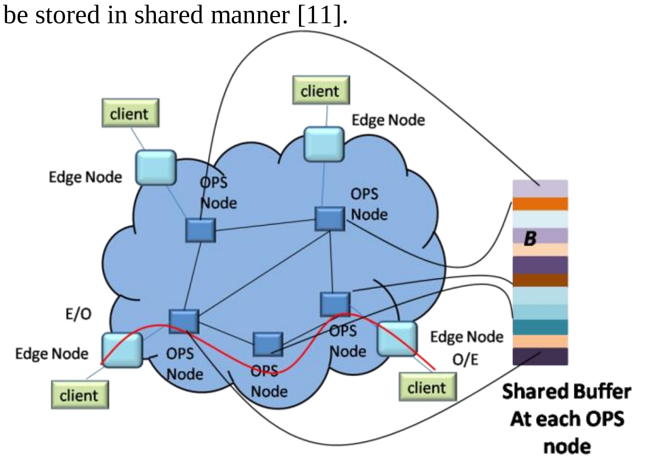

Figure 2: Schematic of OPS Network with Shared Buffer at Each Node

Packets arriving from any inputs will share the buffer in case of contention. Each input is considered to be equivalent. Each input has equal opportunity to occupy the buffer.

We divide the traffic or packets into two different priorities namely, high and low. Working of the switch with traffic of priority is described through algorithms followed by simulation results. The simulation work is done in MATLAB-10.

The Traffic Model

In this work random traffic model is considered. This model is simple; still it provides good insight into the performance of the architecture. This model assumes that the packet can arrive at any of the inputs with probability *P* and each packet is equally likely to be destined to any of the *N* outputs with probability $1/N$. Thus the probability that *K* packets arrive for a particular output in any time slot is given by

$$\Pr(K)=\frac{N!}{K!(N-K)!}\left(\frac{P}{N}\right)^{K}\left(1-\frac{P}{N}\right)^{N-K},0\le K\le N \qquad (1)$$

In case of traffic with different class or priority, if Q_1, Q_2, ……….., Q_P denote the ratio class-1,class-2,……, class-*P* packets to the total number of packets; $\sum_{i=1}^{P} Q_i = 1$.where *P* is the number of priority classes(1 is the highest, *P* is the lowest).

Probability that n_1 class-1, n_2 class-2, ……, n_P class-*P* packets arrive at the switch in a same time slot, is given by:

$$b_{n_1,n_2,n_3,\ldots,n_P} = \Pr\left(\sum_K (Q_1)^{n_1}(Q_2)^{n_2}\ldots\ldots(Q_P)^{n_P}\ X\ \frac{(\sum_K n_K)!}{\prod_K (n_K!)}\right) \qquad (2)$$

Where Q_1, Q_2, ……, Q_P mean the ratio of class-1, class-2,….,class-*P* packets to the total number of packets.

4. RESULTS

Figure 3, shows the packet loss probability vs. Load. The loss of the low priority packets is shown as diamond marker, loss for high priority packet is shown by square marker while total packet loss which include the loss of both high and low priority packets is shown with circle marker. Out of the total generated packets 20% are of low priority while rest 80% are high priority packets.

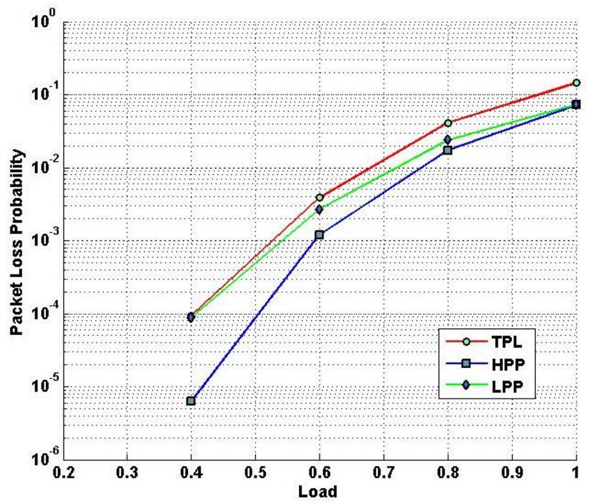

Figure 3: N =4, B = 4 Low priority 0.2

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Comparing the results at the load of 0.4, the packet loss probability for high priority packets is 6×10^{-6}, for low priority packets it is 9×10^{-5} which is nearly equal to the total loss. It is also evident from the figure that as the load increases, the packet loss rate also increases. Still the packet loss rate of high priority packets is much less than that of low priority packets.

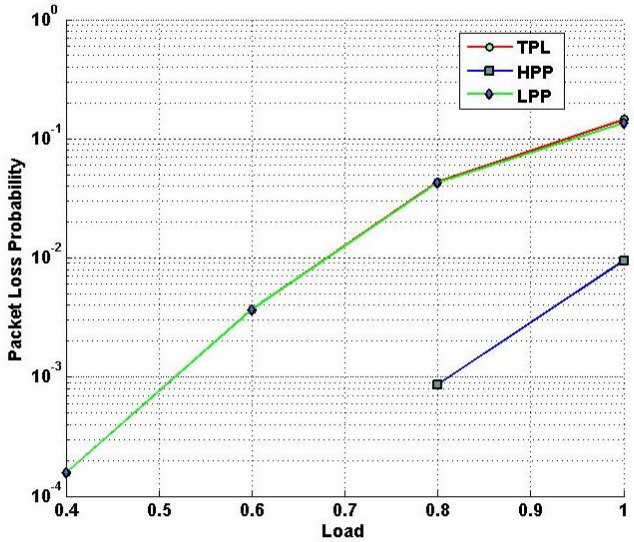

Figure 4: N = 4, B = 4 Low priority 0.6

Figure 4 shows the packet loss probability vs. Load. In this curve the low priority packets are 60% while remaining 40% packets are high priority packets. Comparing the results at the load of 0.8, the packet loss probability for high priority packets is 9×10^{-4}, for low priority packets it is 4×10^{-2} which is nearly equal to the total loss. Here, the packet loss rate of high priority packets is much less than that of low priority packets. As in the buffering high priority packets are preferred over the lower priority packets. Thus more number of lower priority packets are lost over the higher priority packets.

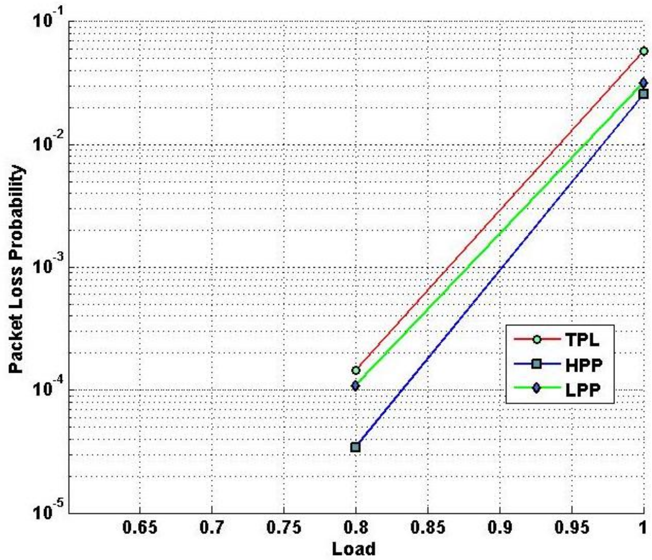

Figure 5: N = 4, B = 16 Low priority 0.2

Figure 5 shows the packet loss probability vs. Load. In this curve the low priority packets are 20% while remaining 80% packets are high priority packets. Comparing the results at the load of 0.8, the packet loss probability for high priority packets is 3.2×10^{-5}, for low priority packets it is 1.1×10^{-4} while the total loss is 1.5×10^{-4}. As in this curve 80% packets are high priority packets, therefore total packet loss is slightly differ from the loss of low priority packets. As buffer is increased from 4 to 16, the packet loss decreases at all the loads.

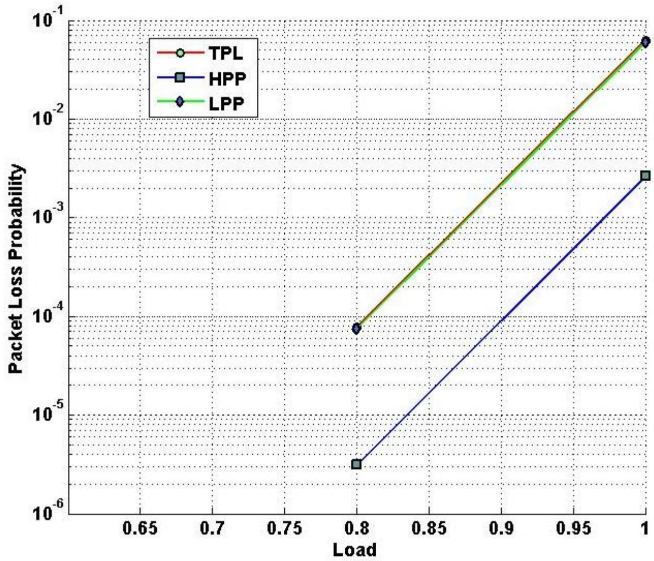

Figure 6: N = 4, B = 16 Low priority 0.6

Figure 6 shows the packet loss probability vs. Load. In this curve the low priority packets are 60% while remaining 40% packets are high priority packets. Comparing the results at the load of 0.8, the packet loss probability for high priority packets is 3×10^{-6}, for low priority packets it is 7×10^{-5} while the total loss is 7.01×10^{-5}. As in this curve 60% packets are low priority packets, therefore total packet loss is same as the loss of low priority packets. Comparing figures 3.3 and 3.4, total loss is nearly same, however loss probability for high priority packets reduces as their percentage decrease.

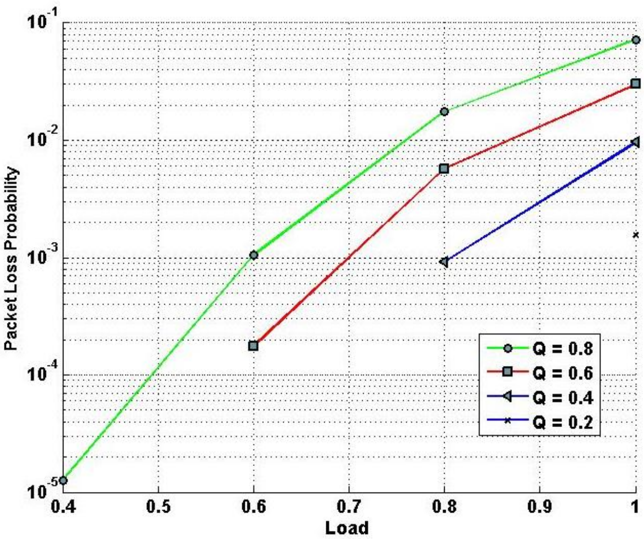

Figure 7: N = 4, B = 4 varying high priority

Figure 7 shows the packet loss probability vs. Load. In this curve the high priority packets are varied from 20% to 80% while in each case remaining packets are low priority packets. It is clear from the figure that as the percentage of high priority packets increases, packet loss also increases, this happens as in total number of packets, fraction of low priority packets decreases and thus some of the high priority packet will be lost.

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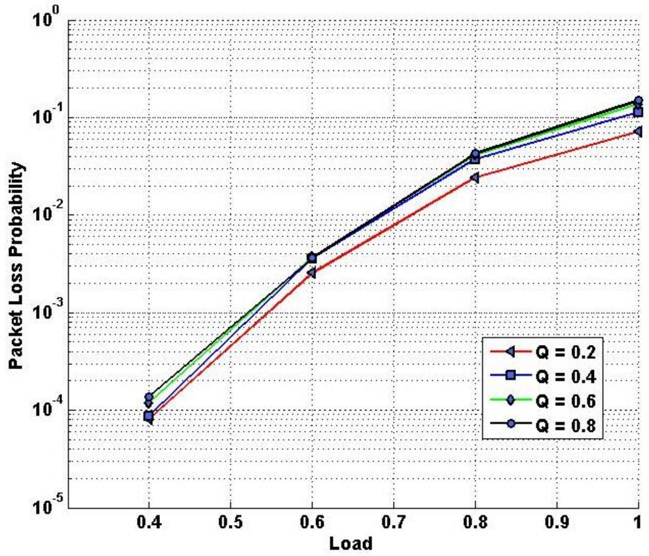

Figure 8: N = 4, B = 4 varying Low priority

Figure 8 shows the packet loss probability vs. Load. In this curve the low priority packets are varied from 20% to 80% while in each case remaining packets are high priority packets. It is clear from the figure that as the percentage of low priority packets increases, packet loss also increases, but rise is minimal, this happens as in total number of packets, fraction of low priority packets increases and these low priority packets lost first then high priority packet will be lost.

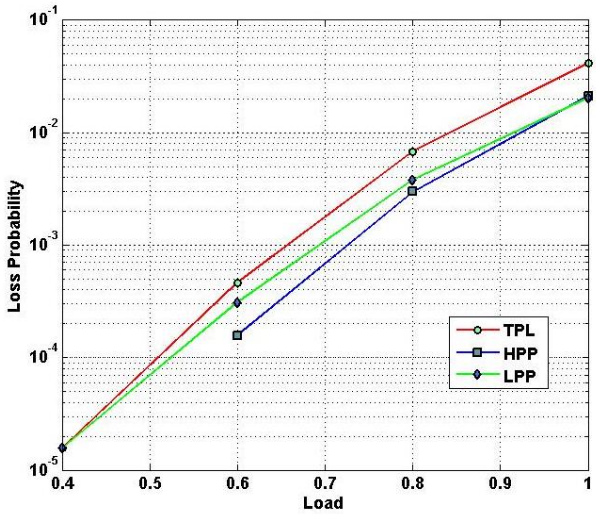

Figure 9: N = 4, B = 4, Low priority 0.2, load balancing factor 0.2

Figure 9 shows the packet loss probability vs. Load. Out of the total generated packets 20% are of low priority while rest 80% are high priority packets and out of generated packets 20% packets are directed towards the output through some alternative path.. Comparing the results at the load of 0.6, the packet loss probability for high priority packets is 1.71×10^{-4}, for low priority packets it is 3.1×10^{-4} which is slightly lesser than to the total loss. It is also evident from the figure that as the load increases, the packet loss rate also increases. Still the packet loss rate of high priority packets is much less than that of low priority packets.

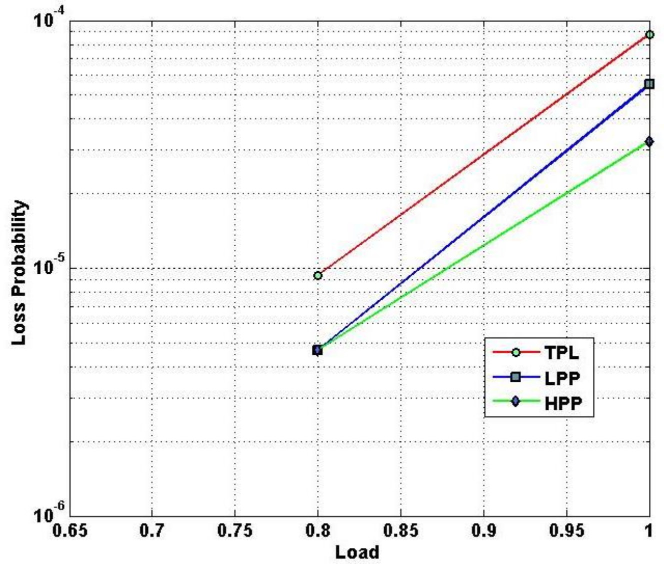

Figure 10: N = 4, B = 4, Low priority 0.2, load balancing factor 0.6

Figure10 shows the packet loss probability vs. Load. Out of the total generated packets 20% are of low priority while rest 80% are high priority packets and out of generated packets 60% packets are directed towards the output through some alternative path.. Comparing the results at the load of 0.8, the packet loss probability for high priority packets is 4.85×10^{-5}, for low priority packets it is 4.85×10^{-5}while the total loss is 9.7×10^{-5}. In the figure 3.7 at the load of 0.8, the packet loss probability for high priority packets is 3×10^{-3} for low priority packets it is 4×10^{-3}. Thus it is evident from the figures load balancing reduces the packet loss probability.

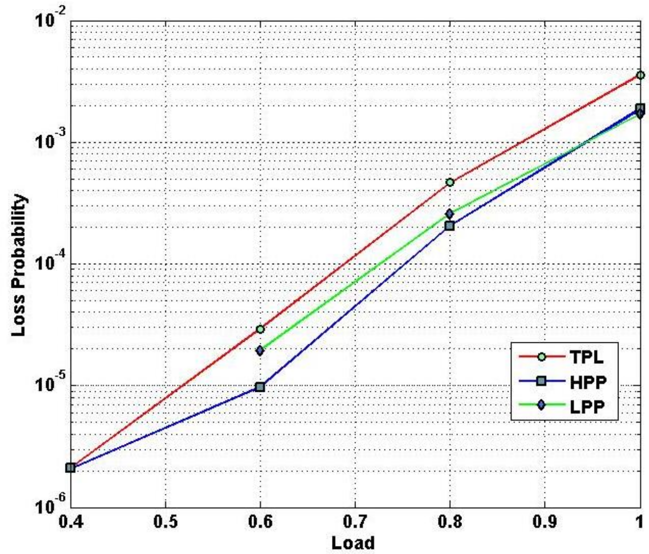

Figure 11: N = 4, B = 4, Low priority 0.2, load balancing factor 0.4

Figure 11, shows the packet loss probability vs. Load. Out of the total generated packets 20% are of low priority while rest 80% are high priority packets and out of generated packets 40% packets are directed towards the output through some alternative path.. Comparing the results at the load of 0.8, the packet loss probability for high priority packets is 2.2×10^{-4}, for low priority packets it is 2.81×10^{-4} while the total loss is 5×10^{-4}.

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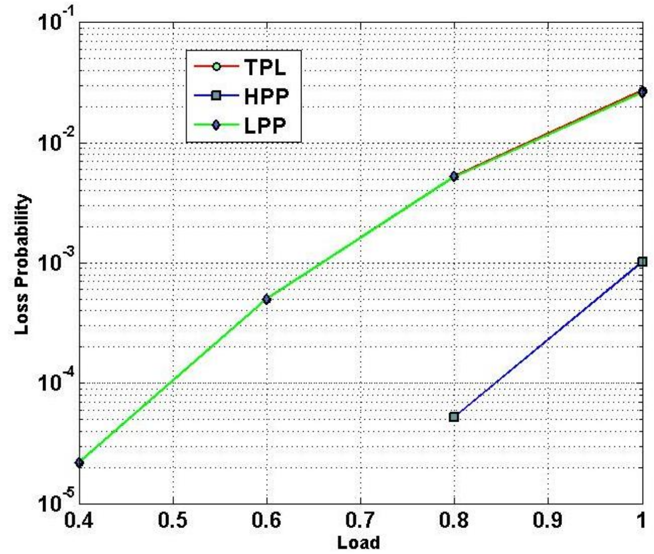

Figure 12: N = 4, B = 4, Low priority 0.2, load balancing factor 0.6

Figure 12, shows the packet loss probability vs. Load. Out of the total generated packets 20% are of low priority while rest 80% are high priority packets and out of generated packets 60% packets are directed towards the output through some alternative path. Comparing the results at the load of 0.8, the packet loss probability for high priority packets is 5×10^{-5}, for low priority packets it is 5×10^{-3} while the total loss is 5×10^{-3}.

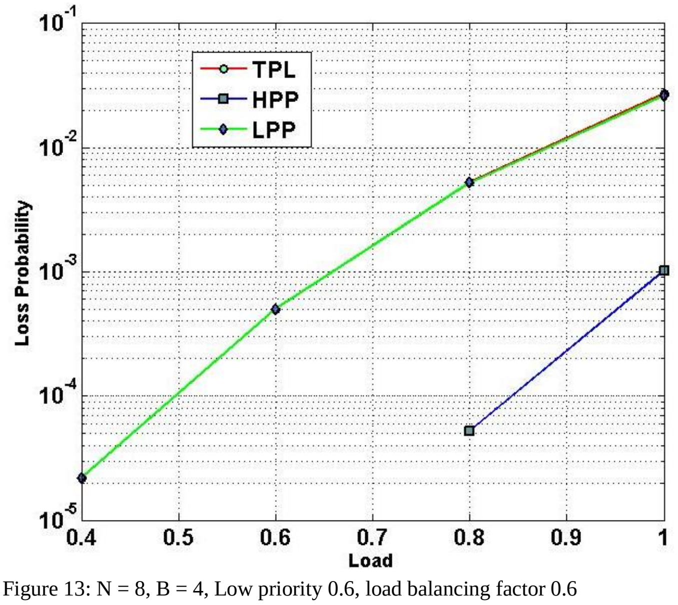

Figure 13: N = 8, B = 4, Low priority 0.6, load balancing factor 0.6

Figure 13, shows the packet loss probability vs. Load. Out of the total generated packets 60% are of low priority while rest 40% are high priority packets and out of generated packets 60% packets are directed towards the output through some alternative path. Here the numbers of inputs have increased from 4 to 8. Comparing the results at the load of 0.8, the packet loss probability for high priority packets is 5.5×10^{-5}, for low priority packets it is 5.2×10^{-3} while the total loss is 5.2×10^{-3}.

5. CONCLUSIONS

This work aim to view to performance of optical buffers under various conditions, and on the basis of obtained results following conclusions can be made:

- As the number of buffer modules increases keeping number of inputs fix, the packet loss probability also improves.
- Keeping buffer constant and increasing number of inputs increases the packet loss.
- .We also see that at a particular load as the buffer size increases the delay also increases.
- The packet loss rate for higher priority packets is lesser in comparison to lower priority packets.
- Lower priority packet loss rate is close to the total packet loss rates.
- Load balancing scheme reduces the loss rates.

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