

# Analysis of Burst Loss Probability in Optical Burst Switching Networks

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## ABSTRACT

Optical burst switching (OBS) is one of the most important switching technologies in the future optical WDM networks and Internet. In OBS, IP packets with a common destination arriving at the same ingress node are aggregated into large bursts, each being switched and routed as one unit. The header (also called *control packet*) precedes the burst payload and attempts to reserve the required switching and transmission resources at each switch and output link port along the route. The payload follows the header without waiting for acknowledgment. At every switch, if the requested resources (wavelengths) are available, the burst is transparently switched to its next hop; otherwise, the burst is blocked and a fraction or all of it is lost. The *burst blocking probability* (also called *burst loss probability* if the entire burst is lost after being blocked) has been the topic of intensive research in OBS. For a typical OBS switch, assuming that the incoming traffic is uniformly distributed, one only needs to investigate the performance of a typical output port. Consider a given output port having  $k$  wavelengths. Assume that the burst arrival process is Poisson with rate  $\lambda$  and the burst lengths are exponentially distributed with mean  $1/\mu$ . Then the burst loss probability is given by the well-known Erlang-B formula  $P_u = B(\rho, k)$ , where  $\rho = \lambda/\mu$  is the offered load. To reduce the blocking probability, a fiber delay line (FDL) of virtual size  $D$  can be used to queue a burst in case all the  $k$  wavelengths are busy. In this case, blocking occurs when a burst upon arrival finds the FDL full. Hence the blocking probability,  $P_l$ , is given by the blocking probability of the delay-loss queue  $M/M/k/N$ ,  $P_l = H(\rho, k, N)$ , where  $N = D + k$  is the capacity of the system. Noting that  $B(\rho, k) \geq H(\rho, k, N)$ , we call  $P_u = B(\rho, k)$  and  $P_l = H(\rho, k, N)$  the upper and lower blocking probability, respectively. In literature of OBS and even in queueing theory, computational aspects of these two blocking probabilities are ignored. Rather, they are computed directly. However, their calculation may easily cause numerical overflow and underflow due to large factorials and large powers for large  $k$ . In this paper, for the first time we study the computational aspects of these two blocking probabilities in OBS. Specifically, we propose a recursive formula for  $H(\rho, k, N)$  in terms of  $N$ . Based on three monotonic properties of  $H(\rho, k, N)$  in terms of  $\rho, k$  and  $N$ , we develop four computer algorithms in order to find the other parameter given any three out of the four parameters  $\rho, k, N$ , and  $H(\rho, k, N)$ . We reduce to the two simultaneous nonlinear equations:

$$\begin{aligned} P_u &= B(\rho, k) \\ P_l &= H(\rho, k, N), \end{aligned} \tag{1}$$

which have five variables  $\rho, k, N, P_u$  and  $P_l$ . Based on the published results about  $B(\rho, k)$  by the authors of the paper, we further develop computer algorithms to find any two variables given other three variables. For instance, given  $k$  and the upper and lower probabilities  $P_u$  and  $P_l$ , we can find the offered load  $\rho$  and the total capacity  $N$  and hence the buffer size  $D$ . Given  $k$ , the buffer size  $D$ , and the lower bound of the blocking probability  $P_l$ , we can find the offered load  $\rho$  and the upper bound of the blocking probability  $P_u$ . Our algorithms are easy to implement and significantly reduce the time complexity. In this paper, we also present numerical examples to illustrate our computer algorithms.

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