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IMPACT OF BURST PRIORITY, COLLISIONS, FEEDBACK AND BUFFER SEARCH IN OBS NETWORKS

D. Veera Vanitha

Associate Professor, School of Engineering, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, Tamilnadu, India

D. Sumitha

Associate Professor, School of Engineering, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, Tamilnadu, India

M.Nila

Research Scholar, School of Engineering, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, Tamillnadu, India

Abstract— Optical Burst Switching (OBS) is a competitive and promising switching technology for the realization of high speed optical networks. In this OBS, Burst delivery ratio is the important factor which decides the performance of the network. Burst loss occurs due to heavy load and burst contention. The performance of the network can be improved by applying proper contention resolution schemes. This paper deals about hybrid buffering and retransmission technique with the impact of collisions, feedback and burst priority to increase the burst delivery ratio on the network. A mathematical model of the proposed model is framed and analyzed to derive the performance measures like steady state probabilities, average network size and average buffer size by Supplementary variable Method. The obtained results shows that the proposed model gives better results when compared with conventional OBS method.

Keywords— Optical Burst Switching; Burst Priority; Retransmission; Collision; Feedback.

I. INTRODUCTION

The OBS combines the best features of both optical circuit switching and optical packet switching techniques. For the past several years a significant amount of research has been conducted in the area of Optical Burst Switching (OBS) networks. The basic entity in OBS network is called burst and it is collection of packets with same source and destination. Burst contention is a major problem in OBS networks. Contention occurs when more than one data burst try to reserve the same wavelength channel on an outgoing link and it is solved by various reactive and proactive approaches. Reactive approaches are invoked after contention occurs but proactive approaches are used to reduce network contention by proactively attempting to avoid network overload. Due to lack of proper contention resolution techniques, bursts are lost when multiple bursts arrive simultaneously to reserve a single server. In order to resolve contention, various contention resolution techniques are available. Optical buffering, retransmission, wavelength conversion and deflection routing are few technologies that are mostly used as contention resolution approaches in OBS. Each one has their own limitations. [1-3].

Several authors have studied the queueing model with arrival of customers (positive customers or bursts) and negative customers with infinite capacity buffer. In an individual scheme, the negative customer removes a positive customer in service if any and make server breakdown. So, a negative customer can be considered as some kind of work cancelling signal. The arrival of negative customer has no effect on the system if it finds the system empty. Also they explained the concept of multi server queueing system with negative bursts and finite buffer capacity [4-7].The concepts of G-queue with pre emptive resume priority, delayed repair and buffer search, M/M/1 model with working vacations (maintenance activities), negative bursts, buffer search with retransmission queue and the steady state equations are solved using various methods and the effect of arrival of negative customers when the system is not empty also explained by various authors [8-10]. Table 1.1 gives the comparison of three switching architectures.

Table 1.1 Comparison of switching architectures

Switching Architectures	Advantages	Disadvantages	Bandwidth Utilization	Buffering
OCS	Reliability of components and subsystems commercially available	Low flexibility, low network utilization	Low	Not needed
OPS	Very high flexibility and very efficient network utilization	Only preliminary components & subsystems available	High	Needed
OBS	High flexibility, efficient network utilization.	Components & subsystems partly available. Effort for traffic aggregation Resilience more complex	High	Needed

The objective of this proposed model is to analyze a combined buffering and retransmission-based scheme with various parameters related with the network to increase the number of bursts being processed and reaching the destination of the OBS network.

In this proposed model, a network with retransmission, Burst Priority, Collision, feedback, buffer search with infinite capacity buffer at the source node is considered. The main objective of this model is to derive the performance measures like steady state probabilities, average network size and average buffer size by Supplementary Variable Method. The remaining part of the article is organized as follows. In section II, the proposed model is explained. In section III, the mathematical analysis, steady state distributions and performance measures are discussed. In section IV, the numerical results for the proposed model are given and compared with conventional OBS results. In section V, the summary of the proposed model is given.

II. PROPOSED MODEL

Figure 1 shows the OBS network architecture. This network has two nodes called edge node and core node. Edge node is the interface between electronic domain and optical domain. It can be either ingress or egress node. Packets are assembled based on assembly schemes into burst. That is, burst aggregation and segregation is being done at ingress nodes, then routed through the core nodes and disassembled back into packets at the egress nodes. A core node is responsible to forward the data burst. A burst has two parts called control packet (header) and data packet (payload). The control and data packets of a burst are sent separately with a time gap called offset time. The offset time is based on the number of hops that the burst has to travel to reach the destination and it allows the control packet to reserve the resource for data transmission.

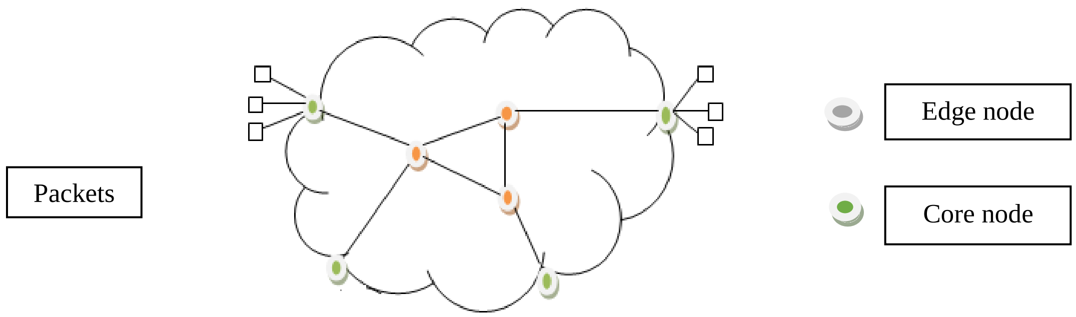


Figure 1. OBS Network Architecture

The detailed explanation of the concept of the proposed model is given shown in Figure 2. Assume that bursts arrive the network according to Poisson process. If the arriving bursts find the server (data channel) free, one of the bursts reserves it. If the server is busy the incoming burst either enters into the retransmission queue or one of the bursts disrupts the burst already in service to get his service (preemptive priority) [11] and the disrupted burst with remaining bursts join the retransmission queue or creates a collision with existing burst and all being shifted to the retransmission queue. When the server is free, the burst in the incoming batch begins the service immediately and rest move to the buffer. The burst is allowed to make feedback. In an OBS network, a method with the inclusion of preemptive priority on the server, collisions, feedback and buffer search is studied to measure the performance of the network. The major advantages of OBS networks are High flexibility, efficient network utilization.

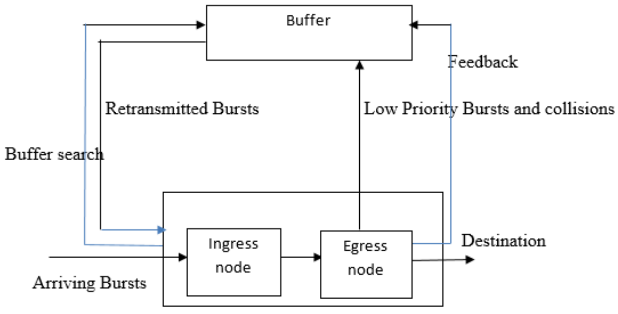


Figure 2. Network model

2.1 Mathematical Analysis

In this section, consider a single server retransmission queueing system with preemptive priority, collision, feedback and buffer search. The bursts arrive at the system according to Poisson stream with arrival rate λ (bursts/ sec). The batch size Y is a random variable with probability distribution P{Y=k} = Ck, k =1, 2, 3...., $\sum_{k=1}^{\infty}$ Ck= 1, the probability generating function (pgf) C(z) having two moments m1 and m2. If an arriving batch finds the server idle, one of the bursts from the batch gets the service immediately and the rest enter into the retransmission queue and try again after some random amount of time. The cumulative distribution function (cdf), probability density function (pdf), Laplace Stieltjes Transform (LST) of retrial time are represented by A(x), a(x), A*(s) respectively.

On the other hand, if the server is busy, then the arriving batch proceeds to the server with probability ρ. When the incoming batch proceeds to the server, one of the burst in the batch either disrupts with the bursts in service to get his own service with probability α and the disrupted burst along with others arrive into the retransmission queue or collide with the burst in service resulting in both being transferred to the retransmission queue along with arriving batch with complementary probability. The cdf, pdf and LST of service time are represented by B(x), b(x), B*(s) respectively with first two moments μ1 and μ2. After executing service, the burst may go back to the retransmission queue as a feedback burst for getting another service with probability β or departs the network. On each service completion the server takes bursts from the retransmission queue for service with probability γ or remains idle. Stochastic behavior of the retrial queueing system can be described by the Markov process {N(t); t ≥ 0}={X(t), C(t), ε(t), t ≥ 0}where C(t) denotes the server state 0,1 according as server being idle, providing service respectively . X(t) represents to the number of bursts in the buffer. If C(t)=0 , then ε0(t) represents elapsed retrial time. If C(t)=1 , then ε1(t) represents the elapsed service time. Define the respective hazard rate function for repeated attempts and service as η(x) = a(x) /1- A(x) and μ(x) = b(x) /1- B(x) [12-18].

2.2 Steady state distribution

The Steady state equations governing the model are given below

$$\lambda R_0 = \bar{\beta} \int_0^{\infty} S_0(x)\, \mu(x) dx \qquad (1)$$

$$\frac{d}{dx} R_n(x) = -\,[\lambda + \eta(x)] R_n(x),\ n \geq 1 \qquad (2)$$

With boundary conditions

$$\frac{d}{dx} S_n(x) = -[\lambda + \mu(x)] S_n(x) \ +(1-\rho)\, \lambda \sum_{k=1}^{n} C_k S_{n-k}(x),\ n \geq 0 \qquad (3)$$

$$R_1(0)=\bar{\gamma}\bar{\beta} \int_0^{\infty} S_1(x)\mu(x)\, dx+\bar{\gamma}\beta \int_0^{\infty} S_0(x)\mu(x)\, dx \qquad (4)$$

$$R_n(0)=\bar{\gamma}\bar{\beta} \int_0^{\infty} S_n(x)\mu(x)\, dx +\bar{\gamma}\beta \int_0^{\infty} S_{n-1}(x)\mu(x)\, dx + \bar{\alpha}\, \rho\lambda \int_0^{\infty} \sum_{k=1}^{n} C_K S_{n-(k+1)}(x) dx, n \geq 2 \qquad (5)$$

$$S_0(0)=\lambda c_1 R_0 + \int_0^{\infty} R_1(x)\eta(x) dx + \gamma\bar{\beta} \int_0^{\infty} S_1(x)\mu(x)\, dx + \gamma\beta \int_0^{\infty} S_0(x)\mu(x)\, dx \qquad (6)$$

$$S_n(0)= \lambda c_{n+1} R_0 + \int_0^{\infty} R_{n+1}(x)\eta(x) dx + \lambda \int_0^{\infty} \sum_{k=1}^{n} C_K R_{n-k+1}(x) dx + \gamma\bar{\beta} \int_0^{\infty} S_{n+1}(x)\mu(x)\, dx +$$

$$\beta \int_0^{\infty} S_n(x)\mu(x)\, dx + \rho\lambda\alpha \int_0^{\infty} \sum_{k=1}^{n} C_K S_{n-k}(x) dx,\ n \geq 1 \qquad (7)$$

The normalizing condition is

$$R_0 + \sum_{n=1}^{\infty} \int_0^{\infty} R_n\,(x) dx + \sum_{n=0}^{\infty} \int_0^{\infty} S_n\,(x) dx = 1 \qquad (8)$$

To solve these equations define the probability generating functions as

$$R(x, z) = \sum_{n=1}^{\infty} R_n(x)z^n, \; S(x, z) = \sum_{n=0}^{\infty} S_n(x)z^n$$

2.3 Performance Measures

The probability of the idle server during retransmission time is,

$$R = (1 - A^*(\lambda))R_0\{ (1 - B^*(\rho\lambda))[\rho + m_1 + \rho m_1\bar{\alpha}] - \rho[1 - \beta B^*(\rho\lambda) - \bar{\gamma}m_1B^*(\rho\lambda)]\} / T_1$$

The probability of the busy server is given by,

$$S = R_0 m_1 A^*(\lambda)[1 - B^*(\rho\lambda)] \; / \; T_1$$

where

$$T_1 = \{\rho B^*(\rho\lambda)\bar{\delta}\beta(1 - B^*(\rho\lambda)) - m_1(1 - A^*(\lambda)) [\rho B^*(\rho\lambda)\bar{\gamma} + \rho\bar{\alpha}(1 - B^*(\rho\lambda))]\}/\alpha$$

Normalising condition (8) is equivalent to $R_0 + R + S = 1$, substituting the expressions of R, S

we get,

$$R_0 = T_1 / \rho\, \beta\, A^*(\lambda)B^*(\rho\lambda)$$

The pgf of network size is,

$$P_s(z) = R_0 + R(z) + zS(z)$$

$$= R_0A^*(\lambda)(1 - \bar{\rho}C(z))B^*(\lambda - \bar{\rho}\lambda c(z))(1 - z)\bar{\beta} / D(z)$$

The pgf of buffer size is,

$$P_q(z) = R_0 + R(z) + S(z)$$

$$= R_0A^*(\lambda)\{(1 - \bar{\rho}C(z))[B^*(\lambda - \bar{\rho}\lambda c(z))(\beta z + \bar{\beta}) - z] + (1 - B^*(\lambda - \bar{\rho}\lambda C(z)))[zc(z)\rho + 1 - C(z)]\} / D(z)$$

$$D(z) = (1 - \bar{\rho}C(z))\{[C(z) + (1 - C(z))A^*(\lambda)]\bar{\gamma}(\bar{\beta} + \beta z)\, B^*(\lambda - \bar{\rho}\lambda C(z)) + \gamma(\bar{\beta} + \beta z)B^*(\lambda - \bar{\rho}\lambda C(z))\, z\} + \rho z C(z)\bar{\alpha}(1 - B^*(\lambda - \bar{\rho}\lambda C(z)))[C(z) + (1 - C(z))\, A^*(\lambda)] + \rho z C(z)\alpha(1 - B^*(\lambda - \bar{\rho}\lambda C(z)))$$

The average buffer size is given by,

$$L_q = \lim_{z\to 1} \frac{d}{dz} P_q(z) = \frac{N_2D_1 - D_2N_1}{2(D_1)^2}$$

Where,

$$N_1 = -R_0A^*(\lambda)\rho\bar{\beta}B^*(\rho\lambda)$$

$$N_2 = -2R_0A^*(\lambda)[\rho\,\bar{\beta}k_1 + m_1(\rho + \beta\bar{\rho})B^*(\rho\lambda) + m_1]$$

$$D_1 = m_1(1 - B^*(\rho\lambda)) - \rho B^*(\rho\lambda)\bar{\beta} + m_1(1 - A^*(\lambda))\,[\,\rho B^*(\rho\lambda)\bar{\gamma} + \rho\bar{\alpha}(1 - B^*(\rho\lambda))]$$

$$D_2 = (1 - B^*(\rho\lambda))\{m_2 + \rho\bar{\alpha}\,(1 - A^*(\lambda))[m_2 + 2m_1 + 2m_1^2]\} + \rho m_2\bar{\theta}B^*(\rho\lambda)\,(1 - A^*(\lambda)) + 2m_1(1 - A^*(\lambda))\{\bar{\gamma}B^*(\rho\lambda)[\rho\beta - \bar{\rho}m_1] + \rho k_1(\bar{\gamma} - \bar{\alpha})\} + 2m_1(1 - k_1) - 2m_1B^*(\rho\lambda)[\bar{\rho}\,\beta + \rho] - 2\rho k_1\bar{\beta}$$

$$k_1 = \lim_{z\to 1} \frac{d}{dz} B^*(\lambda - \bar{\rho}\lambda C(z))$$

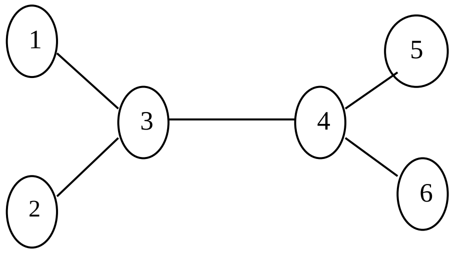
The average network size is given by

$$L_s = \lim_{z\to 1} \frac{d}{dz} P_s(z)$$

$$= L_q + S$$

III. NUMERICAL RESULTS AND DISCUSSION

Consider the simple network topology shown in Figure 3. Based on this proposed model, any node in the network can be chosen as source and destination nodes. Consider maximum number of hops between any random source and destination pair along the selected path in the network is one. So the destination node can be reached by maximum of one hop from the source node. In Figure 3, assume the source destination pair for the bursts are (1,3). When contention occurs, the bursts are stored in buffer at the source node and retransmission from the buffer takes place. Otherwise, the normal transmission process continues.



[Source: 19]

Figure 3. Network model with 5 links topology

Simulation results are presented by assuming arrival rate, retransmission, and service rate to follow exponential distribution with respective rates λ, η, μ. The equations have been validated using MATLAB simulation. The effect of the arrival rate λ and service rate μon number of bursts being processed in the network is studied for the default parameters [20] and presented in Figure 4 and Figure 5.

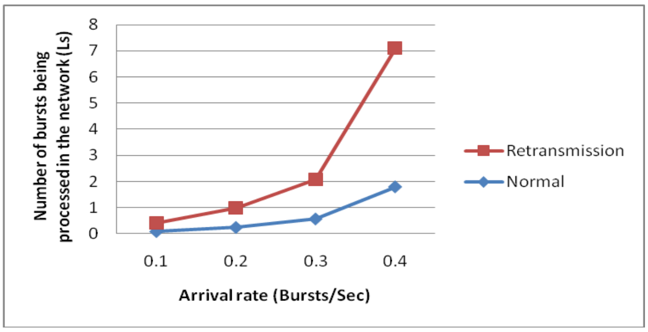


Figure 4. Impact of arrival rate on number of bursts processed in the network

Figure 4 gives the relationship between the arrival rate of the bursts with number of bursts waiting for being processed in the network. It can be observed that, for increase in arrival rate, the number of bursts waiting for being processed and reaching the destination is more in the analysed method than the conventional OBS method.

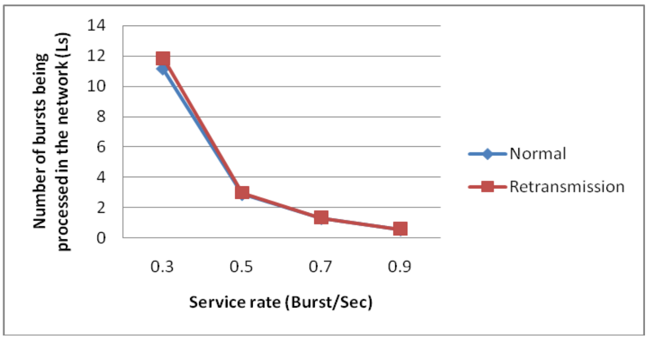


Figure 5. Impact of service rate on number of bursts processed in the network

Figure 5 shows the impact of service rate on the number of bursts waiting for being processed in the network. It can be observed that, as service rate increases, the number of bursts waiting for being processed in the network decreases in both the analysed method and the conventional OBS method. However, as service rate increases, the reduction in number of bursts waiting for being processed in the network is more in analysed method than the conventional OBS method.

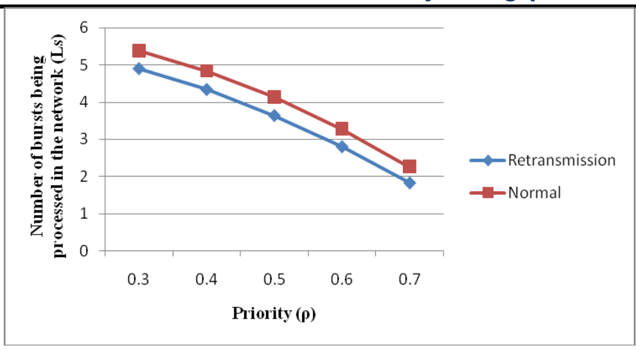


Figure 6. Impact of priority on number of bursts processed in the network

Figure 6 shows the impact of priority on the number of bursts waiting for being processed in the network. It can be observed that, as priority increases, the number of bursts waiting for being processed in the network decreases in both the analysed method and the conventional OBS method because the priority bursts are processed and reach the destination and does not go to buffer. However, as priority increases, the reduction in number of bursts waiting for being processed in the network is less in analysed method than the conventional OBS method.

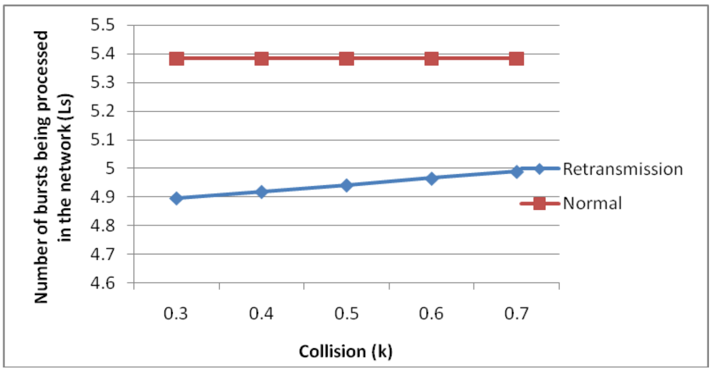


Figure 7. Impact of collision on number of bursts processed in the network

Figure 7 shows the impact of collision on the number of bursts waiting for being processed in the network. It can be observed that, as collision increases, the number of bursts waiting for being processed in the network increases in the analysed method and no change in the conventional OBS method. This indicates collision plays vital role in transmission of bursts.

IV. CONCLUSION

In conventional OBS method the bursts are dropped if the server is not free. To resolve the contention single server queueing system with buffering and retransmission with the impact of burst priority, collisions, feedback and buffer search is studied. Simulation results are carried out to validate the performance of the network in terms number of bursts waiting for being processed in the network. The simulation results show the effectiveness of the analysed method, which enhances the performance of the network when compared with conventional OBS method due to retransmission.

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