Applied Mathematics & Information Sciences
An International Journal

http://dx.doi.org/10.18576/amis/110612

Performance Evaluation of Priority Based OBS Networks with Negative Bursts

D. Veera Vanitha[1,*], *M. Sabrigiriraj*[2] *and D. Sumitha*[3]

[1] ECE Department, Faculty of Engineering, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, India.
[2] ECE Department, SVS College of engineering, Arasampalayam, Coimbatore, India.
[3] Science and Humanities Department, Faculty of Engineering, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, India.

Received: 5 Sep. 2017, Revised: 2 Oct. 2017, Accepted: 9 Oct. 2017
Published online: 1 Nov. 2017

Abstract: In Optical Burst Switching networks there is a need for the promising solution to minimize the burst loss. When a burst enters into the ingress node of the network and finds the server free, burst transmission takes place normally. If the server is busy, the burst would enter into the buffer at the ingress node and the burst retransmission takes place after sometime or the burst leaves the network as impatient burst. This reduces number of bursts being processed in the network. To avoid burst loss, buffering and retransmission techniques are combined. The effect due to the presence of positive bursts and negative bursts and the effect of pre emptive priority on the number of bursts being processed in the network are analyzed.

Keywords: Optical Burst Switching; positive bursts; negative bursts; pre emptive priority.

1 Introduction

For the past several years, a significant amount of research has been conducted in the area of Optical Burst Switching (OBS) networks due to the heavy demand in huge bandwidth and efficient network resource allocation [1]. Three Optical switching techniques are available to handle the problem of effectively allocating the resources for the incoming traffic. They are Optical Circuit Switching (OCS), Optical Packet Switching (OPS) and Optical Burst Switching (OBS). Among these, OBS combines the merits of OCS and OPS. One of the major problems in OBS networks is burst contention. This research has been motivated by the need for the promising solution to minimize the burst loss in OBS networks [2]. Burst contention occurs when one or more number of arriving bursts are directed simultaneously to reserve a single server. So an efficient contention resolution technique is required. In order to resolve contention in OBS, various proactive and reactive approaches like buffering, wavelength conversion, deflection routing, retransmission and segmentation were discussed by various authors. Reactive approaches are invoked after contention occurs, but proactive approaches are used to reduce network contention by proactively attempting to avoid network overload. But each one has its own limitations [3,4].

In [5], the authors analysed mathematical models with various aspects of contention resolution techniques. In [6, 7,8,9,10], the authors proposed the concept of pre emptive priority. The aim of the priority is to serve higher priority burst first by pre-empting lower priority burst. In a pre emptive priority queue, the service of a lower priority burst will be interrupted at once if a high priority burst arrives and will not be resumed until the network is again void of higher priority bursts. The pre emptive method is favourable to higher priority bursts. In [11,12, 13,14], the authors studied the queueing model with arrival of customers (positive) and negative customers (bursts) 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. In [15], the authors proposed the concept of

* Corresponding author e-mail: vanithasvc@gmail.com

G-queue with pre emptive resume priority, delayed repair and buffer search. The authors analysed $M/M/1$ model with working vacations (maintenance activities), negative bursts and buffer search with retransmission queue and the steady state equations are solved using matrix method [16]. In [17], the authors explained about the effect of arrival of negative customers when the system is not empty. In this work, buffering with retransmission is considered to increase the number of bursts being processed in the network for a single server queueing system $(M^x/G/1/\infty)$ with infinite capacity buffer, positive bursts, negative bursts, pre emptive priority and with general service distribution.

2 Analysis Model

Figure 1 shows the analysis model of the OBS network. This OBS network has 2 nodes called edge nodes and core nodes. 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 a burst at ingress nodes, then routed through the core node if necessary and disassembled back into packets at the egress nodes. A core node is responsible to forward the data burst. In this model, the concept of buffering and retransmission for a single server queueing system $(M^x/G/1/\infty)$ with positive bursts, negative bursts and pre emptive priority with general distribution is considered. When a positive burst enter into the ingress node of the network and finds the server free, burst transmission takes place normally. If the server is busy, the burst would enter into the infinite capacity buffer at the ingress node and the burst retransmission takes place after sometime. Arrival of high priority positive burst moves the low priority positive burst being in the service to the buffer. Thus, the bursts with highest priority are served first. Arriving of negative burst discards positive burst in the service from the network and make the server inclined to breakdown. The repair of the failed server starts immediately. If the server is under repair the arriving burst enters the buffer with certain probability or leaves the network with complementary probability as impatient bursts. The repair work of the server starts instantaneously. After completion of the repair, the server accepts the new burst.

Here the packets are assumed to arrive in batches called bursts according to Poisson process with arrival rate λ^+. The burst size Y is a random variable with $P(Y=k)=C_k$, where k is a positive integer. The generating function of the burst size distribution with first two moments m_1 and m_2 is given by $C(z)$. If the arriving positive bursts find the server free, then one of the burst reserves the server and begins the transmission immediately and others join the buffer. If the server is busy, then the arriving bursts proceeds to the server with probability Φ and one of the bursts interrupts the burst in transmission to commence its own transmission and the interrupted burst along with the other bursts join the buffer. Otherwise all the bursts enter the buffer with probability $\overline{\Phi}(=1-\Phi)$.

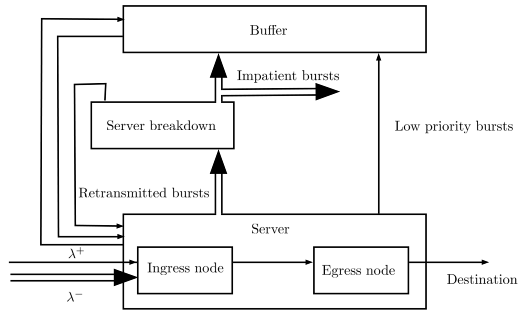

Fig. 1: Analysis model of the network

The retransmission time is assumed to follow general distribution with distribution function $R(x)$, density function $r(x)$, Laplace stieltjes transform $R^*(s)$. Negative bursts arrive independently according to Poisson process with rate λ^-. The negative burst removes the positive burst in transmission from the network and causes server breakdown. The repair of the failed server starts immediately. If the server is under repair the arriving burst enters the buffer with probability q or leaves the network with complementary probability as impatient burst. The repair times are assumed to follow general distribution with distribution function $B(x)$, density function $b(x)$, Laplace stieltjes transform $B^*(s)$ with first two moments b_1 and b_2. As soon as the transmission of the positive bursts is completed, the server searches for the bursts in the buffer with probability θ or remains idle with probability $\overline{\theta}=(1-\theta)$. The service times are assumed to be generally distributed with distribution function $S(x)$, density function $s(x)$, Laplace stieltjes transform $S^*(s)$ with first two moments μ_1 and μ_2.

The state of the network at time t can be described by the Markov process $\{X(t),t\geq 0\}=\{C(t),N(t),\xi(t),t\geq 0\}$ where $C(t)$ denotes the server state 0, 1 or 2 according as the server being idle, busy or under breakdown. $N(t)$ denotes the number of bursts in the buffer at time t.

Also,

$$\xi(t)=\begin{cases}\text{elapsed retransmission time, if } C(t)=0\\ \text{elapsed service time, if } C(t)=1\\ \text{elapsed breakdown time, if } C(t)=2.\end{cases}$$

The functions $\gamma(x)$, $\mu(x)$ and $\Delta(x)$ denote the respective conditional completion rates (at time x) for retransmission, service and breakdown respectively. Then $\gamma(x)=\frac{r(x)}{1-R(x)}, \mu(x)=\frac{s(x)}{1-S(x)}$ and $\Delta(x)=\frac{b(x)}{1-B(x)}$. The steady state equations are solved using supplementary variable technique [15].

2.1 Steady State Distribution

For the process $\{X(t), t \geq 0\}$, define the probability densities

$$E_0(t) = P\{C(t) = 0, N(t) = 0\}$$
$$E_n(x,t)dx = P\{C(t) = 0, N(t) = n, x \leq \xi(t) < x + dx\} \quad \text{for } x \geq 0, n \geq 1$$
$$W_n(x,t)dx = P\{C(t) = 1, N(t) = n, x \leq \xi(t) < x + dx\} \quad \text{for } x \geq 0, n \geq 0$$
$$R_n(x,t)dx = P\{C(t) = 2, N(t) = n\}, x \leq \xi(t) < x + dx\} \quad \text{for } x \geq 0, n \geq 0$$

The system of steady state equations are

$$\lambda^+ E_0 = \int_0^\infty W_0(x)\mu(x)dx + \int_0^\infty R_0(x)\Delta(x)dx \quad (1)$$
$$\frac{d}{dx}E_n(x) = -(\lambda^+ + \gamma(x))E_n(x), \, n \geq 1 \quad (2)$$
$$\frac{d}{dx}W_n(x) = -(\lambda^+ + \lambda^- + \mu(x))W_n(x) + \lambda^+ \Phi \sum_{k=1}^{n} C_k W_(n-k)(x), \, n \geq 0 \quad (3)$$
$$\frac{d}{dx}R_n(x) = -(q\lambda^+ + \Delta(x))R_n(x) + \lambda^+ q \sum_{k=1}^{n} C_k R_{n-k}(x), \, n \geq 0 \quad (4)$$

with boundary conditions

$$E_1(0) = \overline{\theta} \int_0^\infty W_1(x)\mu(x)dx + \int_0^\infty R_1(x)\Delta(x)dx \quad (5)$$
$$E_n(0) = \overline{\theta} \int_0^\infty W_n(x)\mu(x)dx + \int_0^\infty R_n(x)\Delta(x)dx \quad (6)$$
$$W_0(0) = \lambda^+ C_1 E_0 + \int_0^\infty E_1(x)\gamma(x)dx + \theta \int_0^\infty W_1(x)\mu(x)dx \quad (7)$$
$$W_n(0) = \lambda^+ C_{n+1} E_0 + \int_0^\infty E_{n+1}(x)\gamma(x)dx + \lambda^+ \Phi \sum_{k=1}^{n} C_k \int_0^\infty W_{n-k}(x)dx + \lambda^+ \sum_{k=1}^{n} C_k \int_0^\infty E_{n-k+1}(x)dx + \theta \int_0^\infty W_{n+1}(x)\mu(x)dx, \, n \geq 1 \quad (8)$$
$$R_n(0) = \lambda^- \int_0^\infty W_n(x)dx, \, n \geq 0 \quad (9)$$

The normalising equation is

$$E_0 + \sum_{n=1}^{\infty} \int_0^\infty E_n(x)dx + \sum_{n=0}^{\infty} \int_0^\infty W_n(x)dx + \sum_{n=0}^{\infty} \int_0^\infty R_n(x)dx = 1 \quad (10)$$

After solving the above equations using supplementary variable technique we get the following performance measures.

2.2 Performance Measures

- The probability that the server is idle during retransmission time is given by

$$E(1) = E = E_0(1 - R^*(\lambda^+))[(1 - S^*(\lambda^+\Phi + \lambda^-)) (\lambda^- m_1(1 + (\lambda^+ q b_1) + \lambda^+(m_1 + \Phi) + (\lambda^+\Phi + \lambda^-)(\overline{\theta} m_1 S^*(\lambda^+\Phi + \lambda^-) - 1)]/J \quad (11)$$

where

$$J = (S^*(\lambda^+\Phi + \lambda^-) - 1)[\lambda^+\Phi + \lambda^+ m_1 + \lambda^- \lambda^+ m_1 q b_1 + m_1(1 - R^*(\lambda^+))\lambda^-] + (\lambda^+\Phi + \lambda^-)(1 - m_1(1 - R^*(\lambda^+))\overline{\theta} S^*(\lambda^+\Phi + \lambda^-)). \quad (12)$$

- The probability that the server is busy is given by

$$W(1) = W = \frac{E_0 R^*(\lambda^+)\lambda^+ m_1 (1 - S^*(\lambda^+\varphi + \lambda^-))}{J} \quad (13)$$

- The probability that the server is in break down mode is given by

$$B(1) = B = \frac{E_0 R^*(\lambda^+)\lambda^- \lambda^+ m_1 b_1 (1 - S^*(\lambda^+\varphi + \lambda^-))}{J} \quad (14)$$

- The number of bursts in the buffer L_q is given by

$$L_q = \lim_{z \to 1} \frac{d}{dz} p_q(z) = \frac{J N_2 N_1 J_1}{2J^2} \quad (15)$$

where

$$N_1 = E_0 R^*(\lambda^+)[\lambda^+ \Phi S^*(\lambda^+\Phi + \lambda^-) + \lambda^-(1 + (1 - S^*(\lambda^+\Phi + \lambda^-))\lambda^+ m_1 \overline{q} b_1)]$$
$$N_2 = E_0 R^*(\lambda^+)[2\lambda^+(\Phi k_2 + m_1 \Phi S^*(\lambda^+\Phi + \lambda^-) - m_1) - \lambda^-(2S^*(\lambda^+\Phi + \lambda^-))\lambda^+ m_1 \overline{q} b_1) + \lambda^+(\overline{q} k_1 (1 - S^*(\lambda^+\Phi + \lambda^-))]$$
$$J_1 = S^*(\lambda^+\Phi + \lambda^-) - 1)[\lambda^+(2m_1 + m_2) + \lambda^- q \lambda^+ k_1 + 2m_1 \lambda^- \lambda^+ q b_1 (1 - R^*(\lambda^+)) + m_2 \lambda^-((1 - R^*(\lambda^+)) + 2\lambda^+ \overline{\Phi\theta} m_1^2 (1 - R^*(\lambda^+))S^*(\lambda^+\Phi + \lambda^-) - (\lambda^+\Phi + \lambda^-)\overline{\theta} k_2 (2m_1(1 - R^*(\lambda^+)) + m_2 \overline{\theta}(1 - R^*(\lambda^+))S^*(\lambda^+\Phi + \lambda^-) + 2k_2(\lambda^- \lambda^+ m_1 q b_1 + \lambda^+ \Phi(1 + m_1) + m_1(1 - R^*(\lambda^+))\lambda^-]$$
$$k_1 = m_2 b_1 + q \lambda^+ m_1^2 b_2 \text{ and}$$
$$k_2 = \lambda^+ \overline{\Phi} m_1 \int_0^\infty e^{-(\lambda^+\Phi + \lambda^-)x} x s(x) dx$$

- Number of bursts being processed in the network L_s under steady state is

$$L_s = L_q + W \tag{16}$$

3 Application

Negative bursts are used to model server failure in computing and Communication system. Also, they have been used to model random neural networks, task termination in speculative parallelism, faulty components in manufacturing systems and server breakdown [18]. A breakdown at a server is represented by the arrival of a negative customer which causes some customers to be lost. The failure due to negative customers is interested as loss of call in telecommunication networks and loss of messages in OBS networks [19]. In a manufacturing system, a negative customer represents a cancellation of a job. These lead to many applications in the modelling of manufacturing systems and communication systems[20].

4 Simulation Results and Discussion

Simulation results are carried out by assuming that the retransmission time, service time and repair time follows exponential distribution with respective ratesγ, μ and Δ. The equations have been validated using MATLAB simulation for the parameters [21] as $\lambda^+ = 10$, $\lambda^- = 0.3$, $\Phi = 0.6$, $q = 0.5$, $\theta = 0.5$, $\mu = 4$, $\Delta = 1$, $\gamma = 30$. The number of bursts being processed in the network is calculated by varying the rates λ^+, λ^-, q and Φ for single server scenario and presented in Figure 2 to Figure 6.

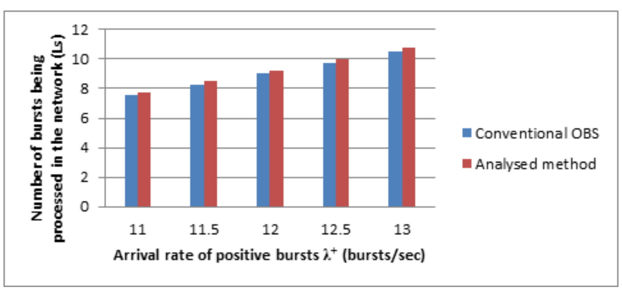

Fig. 2: Arrival rate of positive bursts vs. number of bursts being processed in the network

Figure 2 describes the effect of arrival rate of positive bursts on the number of bursts being processed in the network in both conventional and analysed methods. It is observed that the arrival rate of bursts has a significant impact on performance of the network. Simulation result shows for increase in arrival rate, more numbers of bursts are being processed in the network in the analysed method is more when compared to the conventional OBS method.

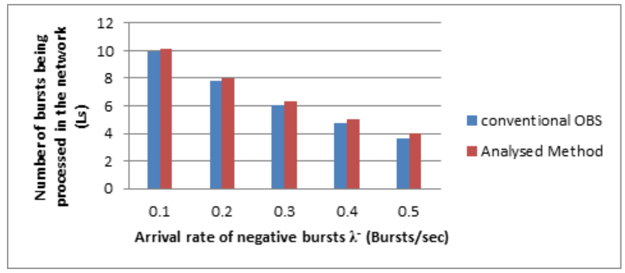

Fig. 3: Arrival rate of negative bursts vs. number of bursts being processed in the network

Figure 3 shows the impact of arrival rate of negative bursts on the number of bursts being processed in the network. It is noted that the arrival rate of negative bursts has a significant impact on performance of the network. Simulation result shows that the number of bursts being processed in the network decreases on increase in arrival rate of negative bursts. The analysed method gives better results than the conventional OBS method.

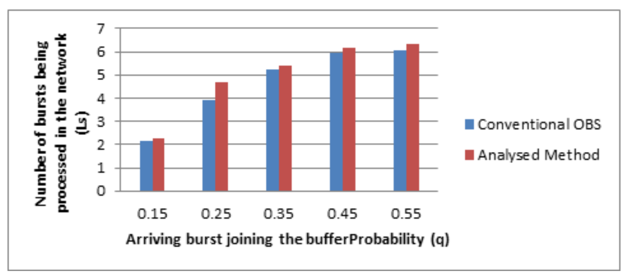

Fig. 4: Probability of bursts joining the buffer for retransmission vs. number of bursts being processed in the network

Figure 4 shows the effect of probability of bursts joining the buffer for retransmission on the number of bursts being processed in the network. This shows that in the analysed method more number of bursts are waiting in the buffer for retransmission and to be processed in the network.

Figure 5 shows the comparison of number of bursts being processed in the network with analysed method to the conventional OBS method. The graph is plotted for number of bursts being processed in the network with varying the pre emptive priority probability. Figure shows the number of bursts being processed in the network is

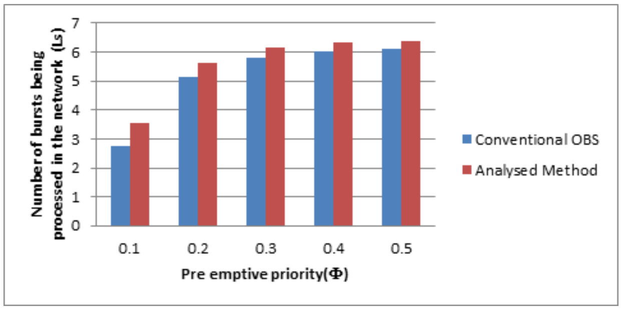

Fig. 5: Pre-emptive priority vs. number of bursts being processed in the network

more in the analysed method than in conventional OBS method since higher priority bursts are served first.

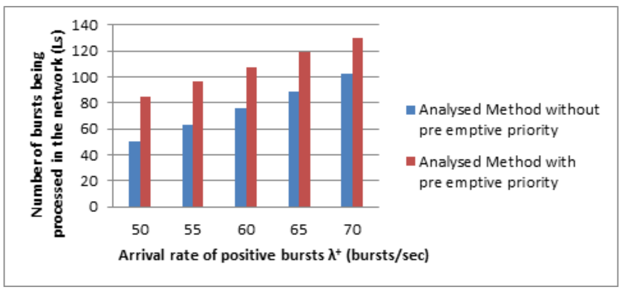

Fig. 6: Arrival rate of positive bursts vs. number of bursts being processed in the network with and without priority

Figure 6 shows the comparison of number of bursts being processed in the network for the analysed method with and without pre emptive priority. When arrival rate of positive bursts increases, more number of bursts are processed in the network with pre emptive priority when compared to network with non pre emptive priority.

5 Conclusion

To avoid burst loss, buffering and retransmission techniques are combined. The effect due to the presence of positive bursts and negative bursts on the number of bursts being processed in the network is studied in this paper. Also the effect of pre emptive priority on the number of bursts being processed in the network is analysed. The number of bursts being processed in the conventional OBS network is compared with the analysed method by varying arrival rate of positive bursts and negative bursts, burst joining the buffer and pre emptive priority.

References

[1] P. Kesar and K. S. Mandeep, Security issues in the optical burst Switched network: a review, International Journal of Computer Science and Mobile Computing, **6(3)**, 255-260, (2017).

[2] R. Lamba and A. K. Garg, Survey on Contention Resolution Techniques For Optical Burst Switching Networks, International Journal of Engineering Research and Applications, **2(1)**, 956-961, (2012).

[3] A. K. Garg, Congestion prevention for reliable OBS, optik-International Journal for Light and Electron Optics, **124(21)**, 5025-5029, (2013).

[4] A. M. Balamurugan and A. Sivasubramanian, Optical burst switching issues and its features, International journal of Emerging Trends & Technology in computer science, **2(3)**, 306-315, (2013).

[5] M. K. Dutta and V. K. Chaubey, Comparative analysis of wavelength conversion and segmentation based dropping method as a contention resolution scheme in optical burst switching (OBS) network, Procedia Engineering, **30**, 1089-1096, (2012).

[6] A. K. Garg, Contention reduction and service differentiation in OBS networks, Optik-International Journal for Light and Electron Optics, **123(12)**, 1108-1111, (2012).

[7] B. C. Chatterjee, N. Sarma and P. P. Sahu, A heuristic priority based wavelength assignment scheme for optical networks, Optik-International Journal for Light and Electron Optics, **123(17)**, 1505-1510, (2012).

[8] R. Hou, T. Mao and J. Yu, Performance analysis of multi-probability outputted model in a prioritized multi-classes traffic existed OBS network, Optik-International Journal for Light and Electron Optics, **124(8)**, 765-767, (2013).

[9] M. E. Daz and X. Hesselbach, Routing with prioritization based on statistics in OBS networks, Eleventh International Conference on Transparent Optical Networks, 1-4, (2009).

[10] I. Atencia, A discrete-time queueing system with changes in the vacation times, International Journal of Applied Mathematics and Computer Science, **26(2)**, 379-390, (2016).

[11] J. Wang, Y. Huang and T. Van Do, A single-server discrete-time queue with correlated positive and negative customer arrivals, Applied Mathematical Modelling, **37(9)**, 6212-6224, (2013).

[12] R. Chakka and T. Van Do, Some new Markovian models for traffic and performance evaluation of telecommunication networks, Network performance engineering (Book chapter), **5233**, 642-664, (2011).

[13] R. Chakka, T. Van Do and Z. Pndi, A Generalized Markovian Queue to Model an Optical Packet Switching Multiplexer, Tenth International Conference on Analytical and Stochastic Modelling Techniques and Applications, 290-295, (2003).

[14] T. Van Do and R. Chakka, A new performability model for queueing and FDL-related burst loss in optical switching nodes, Computer Communications, **33(1)**, S146-S151, (2010).

[15] D. Sumitha and K. Udaya Chandrika, Batch Arrival Retrial Queue with Positive and Negative Customers, Priority or Collisions, Delayed Repair and Orbital Search, International Journal of Applied Mathematics, **88**, 36182-36189, (2015).

[16] T. V. Do, D. Papp, R. Chakka, J. Sztrik and J. Wang, $M/M/1$ retrial queue with working vacations and negative customer arrivals, International Journal of Advanced Intelligence Paradigms, **6(1)**, 52-65, (2014).
[17] T. Li and L. Zhang, An $M/G/1$ Retrial G-Queue with General Retrial Times and Working Breakdowns, Mathematical and Computational Applications, **22(1)**, 1-17, (2017).
[18] R. Chakka, T. V. Do and Z. Pandi, A generalized Markovian queue and its applications to performance analysis in telecommunications networks, Performance Modelling and Analysis of Heterogeneous Networks, **2(387)**, 371, (2009).
[19] P. G. Harrison, N. M. Patel, and E. Pitel, Reliability modelling using G-queues, European Journal of Operational Research, **126(2)**, 273-287, (2000).
[20] W. K. Ching, Iterative methods for queuing systems with batch arrivals and negative customers, BIT Numerical Mathematics, **43(2)**, 285-296, (2003).
[21] T. Tachibana, B.O. Nassar and S. Kasahara, Hop-Based Burst-Cluster Transmission: Fairness Improvement in High-Performance OBS Networks, Journal of Optical Communications and Networking, **3(6)**, 542-552, (2011).

D. Veera Vanitha received the B.E. Degree in Electronics and Communication Engineering from Bharathiar University, M.E. Degree in VLSI Design, Anna University of Technology, Coimbatore and Pursuing the Ph.D. degree in Information and Communication Engineering in Anna University, Chennai. She is currently working as an Assistant Professor in the department of Electronics and Communication Engineering in Faculty of Engineering, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore. Her research area is Optical networks.

M. Sabrigiriraj received the B.E. degree in Electronics and Communication Engineering from Bharathiar University, M.E. degree in Optical Communication from Anna University, Chennai and Ph.D. degree in Information and Communication Engineering from Anna University, Chennai. He is currently working as a Professor and Head of the Department of Electronics and Communication Engineering at SVS College of Engineering, Coimbatore. His research interests include Optical Networks, VLSI design, Design and Analysis of Algorithms. He has to his credit a few publications in Elsevier, Springer, IET and IETE

D. Sumitha received her Ph.D. degree in Mathematics from Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, India. Currently, She is working as an Assistant Professor in Department of Science and Humanities, Faculty of Engineering, Avinashilingam Institute for Home Science and Higher Education for Women. Her research interests include Queueing theory, Probability theory and Optimization techniques.