Optimization of Passive Optical Burst Switching Networks

[1]Shiwani Gupta, [2]Mandeep Kaur
[1,2]Rayat Bahra University, Mohali, India

Abstract
It is assumed that optical burst switched networks employ shortest path routing along with next hop burst forwarding. In this paper, we have reviewed tha literature for optical burst switching network and some of the parameters are studied for the performance optimisation of OBS. This paper gives the detail study of the parameters for the performance optimisation of OBS network.

Keywords
Optical Networks, Passive Optical Network, Optimisation, Routing

I. Introduction

In recent years, explosive demand for network bandwidth has become a major challenge for network engineers due to increasing global popularity of the Internet and the increased applications it affords. A continuous demand for high capacity networks exists at low cost. Optical data communication has been recognized as the best solution for meeting the present bandwidth requirements of the users and for supporting future network services because in theory each optical fiber has the ability to support bandwidth demand of upto 50 THz. Apart from this, Optical fibers are inexpensive and provide extremely low bit-error rates. The Optical fiber is less immense than other cables and optical signals travel distinctly for longer distances and are also immune to electrical interferences.

A. Passive Optical Network

Passive optical network (PON) is a point-to-multipoint, the fiber to the premises network architecture in which unpowered optical splitters are used to enable a single optical fiber to serve multiple premises [7]. PON uses a dedicated optical fiber, to provide virtually unlimited bandwidth, without using any active component within the network. It offers a true triple play service of voice, video and data on a network. It is called passive because within the central office and the subscribers, there is no power element present; hence the cost of the network and its installation is reduced [3].

A passive optical network (PON) extends from an operators central facility into individual homes, apartment buildings and business. Depending on local demands, PONs can be deployed in a fiber-to-the home (FTTH), fiber-to-the-curb (FTTC) or fiber-to-the-cabinet (FTTCab) architecture.

ITU-T technology watch in order to reduce the need for separate fibers for the two directions of transmission, PON system can take advantage of the WDM signal multiplexing technique, where upstreamand downstream channels are transmitted at different wavelengths. A PON configuration reduces the required amount of fiber and equipment at the central facility compared to point-to-point architectures. The traffic is encrypted to prevent eaves dropping. One common application of PON has been in providing broadband Internet access to homes for applications such as IP television (IPTV), where it is a serious competitor with digital subscriber line (DSL) technology. FTTH allows for much greater bandwidth, which is necessary for broadband triple-play services. However, it also requires the installation of new wiring, transmission and receiving infrastructure.

PONs use passive optical components such as optical fibers, directional couplers, star couplers, splitters, passive routers and filters. Since Passive Optical Networks are used for communication our short distances, usually less than 60km, optical signals do not require amplification [7].

II. Related Work

Extensive research work in the area of achieving optimization in Passive Optical Burst Switching Network has been reported over the past few years which focused on reducing Blocking Probability, Delay and various approaches to achieve better optimized network performance.

Patel Bhumika G. [1] mathematically analyzed the Engset Model for the burst blocking probability and burst length for different Round Trip Delay, Average Packet Arrival Time and also analyzed the average Delay for fiber capacity and Burst Size which was made using a delay model and demonstrated that burst length and burst aggregation time should be chosen according to traffic so that blocking probability was reduced and minimum of resources was used in the network.

Meiqian Wang etal. [2] considered a circuit-switched multiservice network with non-hierarchical alternative routing and trunk reservation. Based on the fundamental concept of OPCA (Overflow priority classification approximation), two approximations for the estimation of the blocking probability were developed that was OPCA and service based OPCA and also applied the classical Erlang fixed-point approximation (EFPA) for the estimation of the blocking probability in the network and proposed the more conservative max (EFPA, service-based OPCA) as a reasonably accurate evaluation and discussed the robustness of the approximations to the shape of the holding time distribution and their performances under asymmetrical cases and illustrated that when the approximations were used for network dimensioning, their error was acceptable. Under a wide range of scenarios and parameter values had demonstrated that in most cases studied, service-based OPCA estimated the network blocking probabilities reasonably well and was generally more accurate and more conservative than EFPA and showed that max (EFPA, service-based OPCA) was applicable to the network blocking probabilities estimation in large networks such as the CORONET.

Nitant Sabharwal et al. [3] reviewed the PON technology to know about the technology, its architecture, mechanism and its scope in the current and future market and concluded that the PON was a very good method for utilizing the fiber optics technology. And also concluded that PON was most economical way of achieving great capacity, high speed and large number of subscribers and also networks operators could better utilized their investment in true triple service of voice, video and data to the home with the use of PON.

Satish Sharma [4] discussed about the evolution and basic structure of Passive Optical Networks and also discussed about the access networks, their classification and its types. How copper networks was differ from optical network and difference between active and passive optical networks and showed from analysis that PON was very cheap and provide better services as compared to copper access networks and also better option for access networks.

Shuo Li et al. [5] demonstrated that the overflow priority classification approximation (OPCA) was an accurate method for blocking probability evaluation for various networks and systems, including OBS (Optical burst switched networks) with deflection routing. OPCA was a hierarchical algorithm that requires fixed-point iterations in each layer of its hierarchy. This was implied along running time and also proved that the OPCA iterations alternately produced upper and lower bounds that consistently become closer to each other as more fixed-point iterations in each layer are used. It had been observed that the speed of the bounds moving closer decreases when the proportion of the overflowed traffic increase due to the growth of the offered load or the maximum allowable number of deflections, as well as the reduction of the number of channel per trunk and also demonstrated in the case of NSFNET with 50 channels per trunk that the OPCA is faster and at least as accurate as the EFPA.

Meiqian Wang et al. [6] classified trunk utilization into effective and ineffective utilizations used for bursts that reach and do not reach their destinations respectively. As a benchmark for OBS, an idealized version of OCS was considered, designated I-OCS that does not incur ineffective utilization. The efficiency of OBS versus I-OCS network for selected scenarios was studied to facilitate the understanding of performance implications of effective and ineffective utilizations. By considering a 4-node ring topology, it had been demonstrated that very high network utilization was achievable by OBS if traffic was balanced, blocking probability was kept low and the number of channels per trunk was large.

III. Mathematical Model for Burst Length and Static Traffic

The Engset traffic model explores the relationship between offered traffic usually during the busy hour and the blocking which occur in that traffic and the number of circuits provided where there number of sources from which the traffic is generated is known. The Engset formula is used to determine the blocking probability or probability of congestion occurring within a Circuit group and assumes that blocked calls are cleared or overflowed to another circuit group. It is also similar to the Erlang B formula but specify a finite number of sources.

Each input wavelength channel transmits bursts as an on/off process. On-time refers to burst transmission time and off-time refers to idle time between bursts. Burst Length is the amounts of data send/receive in a single instance and Static Traffic is the fixed traffic send on the channel.

We have presented on-off modeling in the Engset model to calculate Burst Length and effectively allot a static traffic on the channel.

Various symbols used in this model are explained as:

T_{RTP} = Round Trip Delay or Round Trip Time in ms i.e. the length of time taken for a signal to be sent plus receiving of the acknowledgement.

T^d = Waiting Time in ms i.e. the time period between when an action is requested and when it occurs.

$1/\lambda$= Mean OFF Time/ Mean Packet inter-arrival Time for each buffer in µs

$1/\mu$= Mean ON Time/ Mean Packet Length for each buffer in B

T_b= Busy Period of buffer

R_{out}= Output Transmission Rate of channel in Gb/s

L_b= Burst Length

S_T= Static Traffic

From [1] it is found that T_d is directly proportional to T_{RTP}, so for

$$T_d = \beta T_{RTP} \text{ for } 0 \leq \beta \leq 10 \quad (1)$$

Where β is a constant

T_b from [1] can be expressed as given in equation (2)

$$T_b = \frac{1}{\mu} + \left(\frac{\lambda}{\mu}\right)(T_d + T_{RTP}) \quad (2)$$

Further solving the equations (1) and (2) we get equation (3)

$$T_b = \frac{1}{\mu} + \left(\frac{\lambda}{\mu}\right)(\beta T_{RTP} + T_{RTP}) \quad (3)$$

$$T_b = \frac{1}{\mu} + \left(\frac{\lambda}{\mu}\right)T_{RTP}(\beta + 1)$$

$$T_b = \frac{1}{\mu}(1 + \lambda T_{RTP}(\gamma)) \quad (4)$$

Where γ is a constant

$$\gamma = \beta + 1 \quad (5)$$

L_b from [1] can be expressed as given in equation (6)

$$L_b = R_{out}\, T_b \quad (6)$$

Further solving the equations (4) and (6) we get equation (7)

$$L_b = \frac{R_{out}}{\mu}\left(1 + \lambda T_{RTP}(\gamma)\right) \quad (7)$$

S_T from [8] can be expressed as given in equation (8)

$$S_T = \frac{T_{RTP} + T_b}{1/(\lambda + T_d)} \quad (8)$$

Further solving the equations (1), (4) and (8) we get the equation (9)

$$S_T = \frac{T_{RTP} + \frac{1}{\mu}(1 + \lambda T_{RTP}(\gamma))}{1/(\lambda + \beta T_{RTP})} \quad (9)$$

Equation (7) and (9) can be taken as the proposed mathematical model. From this equation we can observe that Burst length and static traffic is directly proportional to Gamma γ and increased when γ is increased and also observed that Burst length and static traffic is directly proportional to Round Trip Delay T_{RTP} and increased when Round Trip Delay T_{RTP} is increased. From equation (7) we can observe that Burst Length is directly proportional to Mean Packet Length (1/µ) and if Mean Packet Length (1/µ) is increased the Burst Length is also increased and from equation (9) we can observe that static Traffic is directly proportional to Mean Packet Length (1/µ) if Mean Packet Length (1/µ) is increased the Static Traffic is also increased.

V. Results and Discussion

In this Model we have discussed the Burst Length and Static Traffic on the Channel in the Engset Model. Burst Length and Static Traffic varies according to various parameters. Variation of some of these presented as below.

Fig. 4.1 Shows Variation of Burst Length with Gamma (γ) for T_{RTP}=0.005s, the parameters used are given in Table 4.1.

Table 4.1: Parameters Used for Variation of Burst Length and Static Traffic

Parameters	Values
β	10
λ	0.5μs, 0.25μs, 0.1666μs
μ	0.0025 B
R_{out}	1Gb/s
T_{rtp}	0.005s, 0.010s, 0.015s, 0.020s

It is evident from the response of Burst Length that with the increase of Gamma the Burst Length also increases. And also if the value of Round trip Delay increases the Burst Length increases with Gamma and with the increase in Mean Packet inter-arrival time the Burst Length increases.

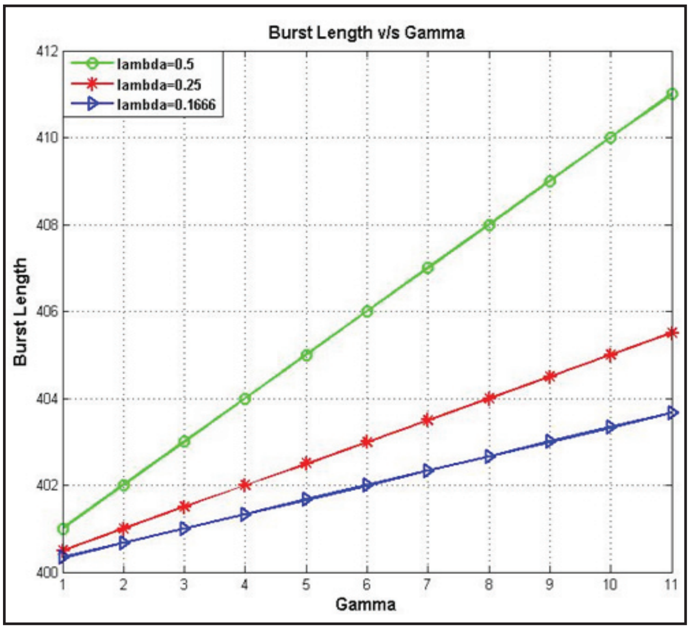

Fig. 4.1 Burst Length v/s Gamma for T_{RTP} = 0.005s

Fig. 4.1 shows the variation of Burst Length with Gamma (γ) for T_{RTP}= 0.005s. The values of the parameters are: β=10; λ= 0.5μs, 0.25μs, o.1666μs; μ=0.0025B; R_{out}=1 Gb/s; B=10Hz; K=20; N_c=15. From the graph we can conclude that as the Gamma increases the Burst Length increases and with the increase of Mean packet inter-arrival time the Burst Length increases.

Fig. 4.2 Shows Variation of Burst Length with Gamma(γ) for T_{RTP}=0.010s, the parameters used are given in Table 4.1. From the graph we can conclude that as the Gamma increases the Burst Length increases and with the increase of Mean packet inter-arrival time, the Burst Length increases. Also depicted from Fig. 4.1 and Fig. 4.2 that as the Round Trip Delay increases, the Burst Length also increases.

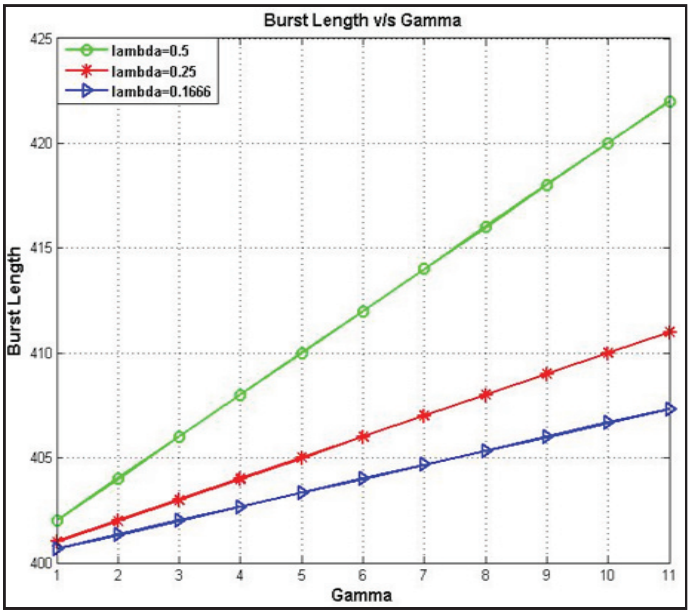

Fig. 4.2: Burst Length v/s Gamma for T_{RTP}=0.010s

Fig. 4.3 Shows Variation of Burst Length with Gamma (γ) for T_{RTP}= 0.015s, the parameters used are given in Table 4.1. From the graph we can conclude that as the Gamma increases the Burst Length increases and with the increase of Mean packet inter-arrival time the Burst Length increases. Also depicted from Fig. 4.2 and Fig. 4.3 that as the Round Trip Delay increases, the Burst Length also increases.

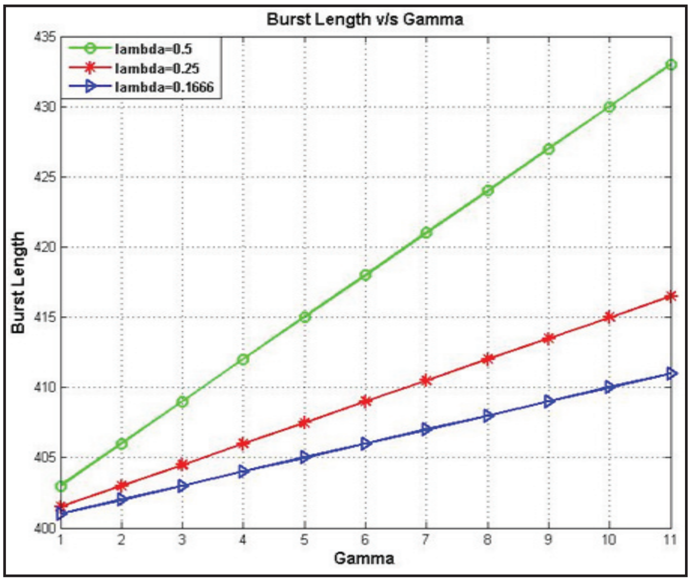

Fig. 4.3: Burst Length v/s Gamma for T_{RTP}=0.015s

Fig. 4.4 Shows Variation of Burst Length with Gamma (γ) for T_{RTP}= 0.020s, the parameters used are given in Table 4.1. From the graph we can conclude that as the Gamma increases the Burst Length increases and with the increase of Mean packet inter-arrival time the Burst Length increases. Also depicted from Fig. 4.3 and Fig. 4.4 that as the Round Trip Delay increases, the Burst Length also increases.

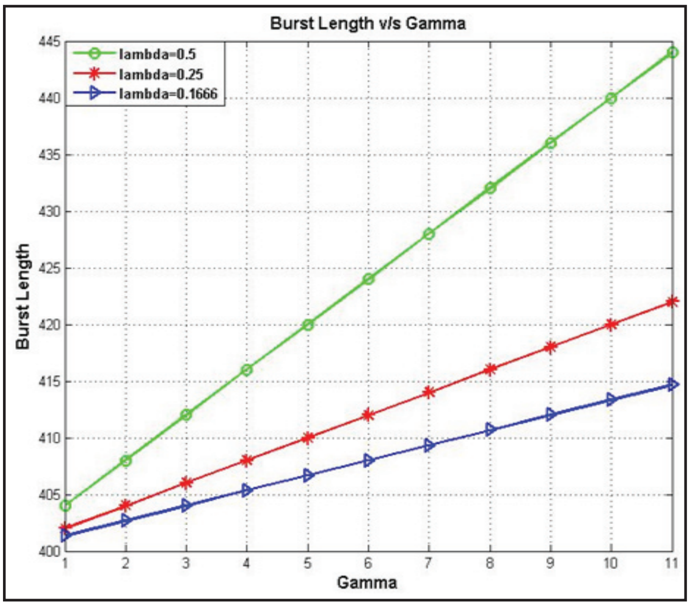

Fig. 4.4: Burst Length v/s Gamma for T_{RTP}= 0.020s

It is evident from the response of Static Traffic that with the large change in Gamma there was small change in Static Traffic and with the increase in Gamma, Static Traffic increases slowly. Also if the value of Round trip Delay increases the Static Traffic also increases slowly with Gamma and with the increase in Mean Packet inter-arrival time Static Traffic fast increase.

Fig. 4.5 Shows Variation of Static Traffic with γ for T_RTP=0.005s, the parameters used are given in Table 4.1. The values of the parameters are: β=10; λ= 0.5μs, 0.25μs, o.1666μs; μ=0.0025B; R_{out}=1 Gb/s; B = 10Hz; K= 20; N_c= 15. From the graph we can conclude that as the Gamma increases the Static Traffic increases slowly and with the increase of Mean packet inter-arrival time the Static Traffic increases.

Fig. 4.6 Shows Variation of Static Traffic with γ for T_{RTP}=0.010s, the parameters used are given in Table 4.1. From the graph we can conclude that as the Gamma increases the Static Traffic increases slowly and with the increase of Mean packet inter-arrival time the Static Traffic increases.

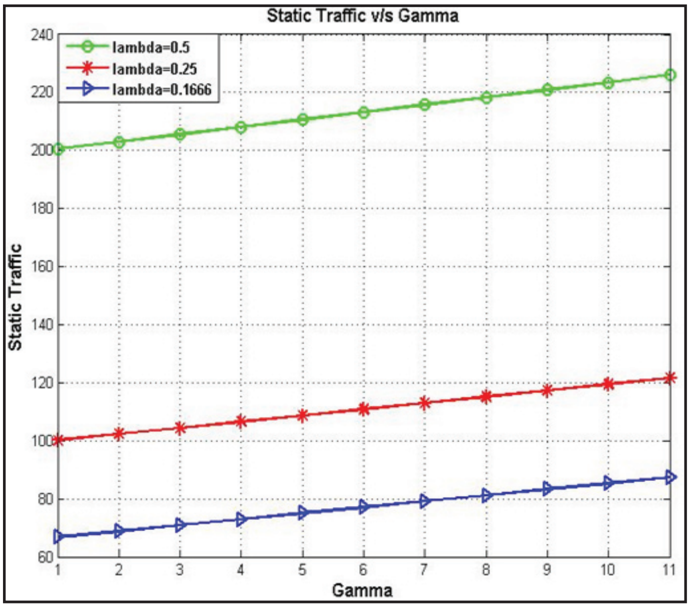

Fig. 4.5: Static Traffic v/s Gamma for T_{RTP}= 0.005s

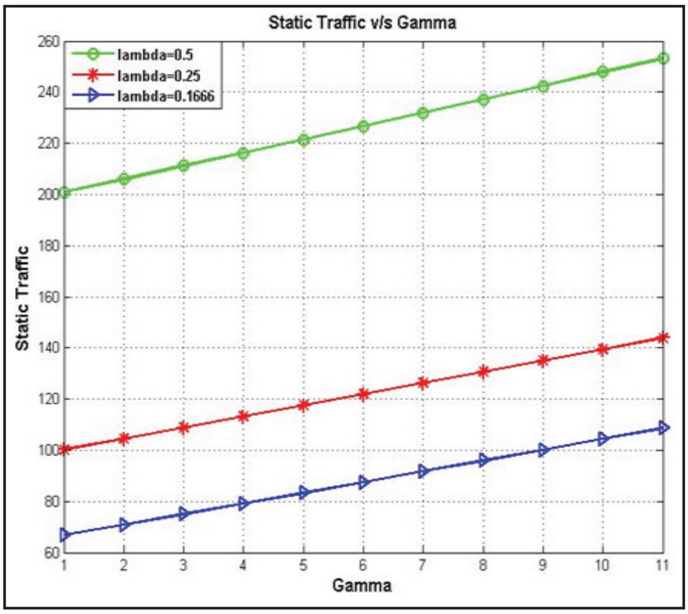

Fig. 4.6: Static Traffic v/s Gamma for T_{RTP}= 0.010s

Fig. 4.7 Shows Variation of Static Traffic with γ for T_{RTP}= 0.015s, the parameters used are given in Table 4.1. From the graph we can conclude that as the Gamma increases the Static Traffic increases slowly and with the increase of Mean packet inter-arrival time the Static Traffic increases.

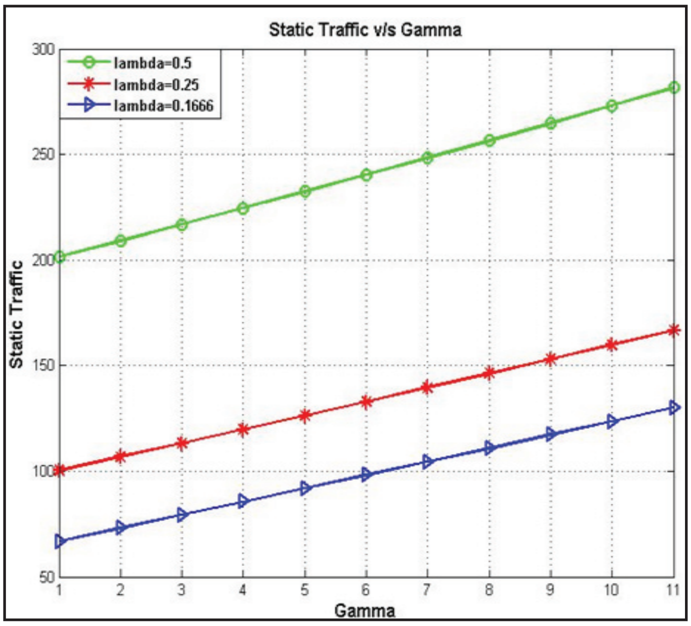

Fig. 4.7: Static Traffic v/s Gamma for T_{RTP}= 0.015s

Fig. 4.8 Shows Variation of Static Traffic with γ for T_{RTP}= 0.020s, the parameters used are given in Table 4.1. From the graph we can conclude that as the Gamma increases the Static Traffic increases slowly and with the increase of Mean packet inter-arrival time the Static Traffic increases.

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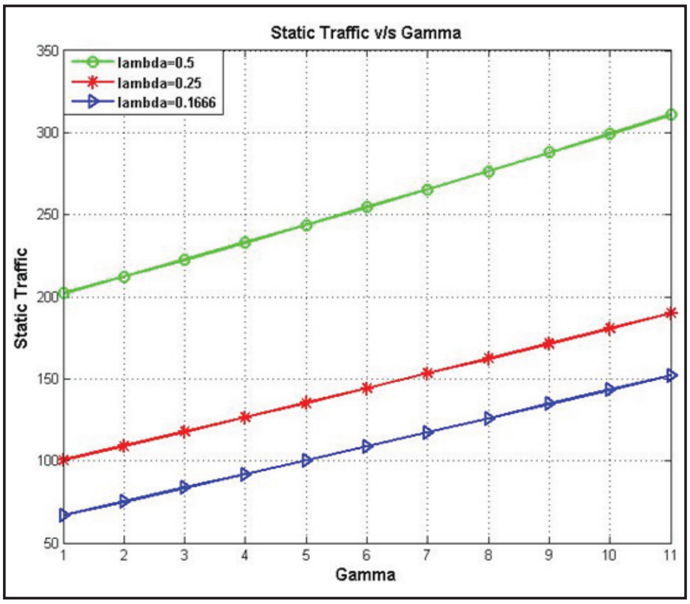

Fig. 4.8: Static Traffic v/s Gamma for T_{RTP} = 0.020s

VI. Conclusion

We have proposed a mathematical model in which we have discussed the dependence of Burst Length and Static Traffic on the Channel in the Engset Model. Burst Length and Static Traffic varies according to various parameters. The results show that as the Round Trip delay increases the Burst Length also increases and with this increase there is a small increase in Static Traffic.

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