Congestion Control Using Modified Erlang's Loss Formulae

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Abstract

Internet demand is growing day by day. With this growing demand, congestion occurs. To reduce the congestion in the system various congestion control algorithms were developed. These algorithms were related with various parameters like link utilization, contention, blocking probability etc. For calculating the result for these parameters Erlang Loss Formulae was used. In this paper, we develop the Modified Erlang Loss Formulae to calculate congestion in Optical Burst Switching Network. We develop the relation between congestion and blocking probability. Simulation is done using MATLAB software. Results show that, with increase in the value of traffic intensity, blocking probability increases but negligibly small. This result is compared with previous algorithm and provides better results.

Keywords: *Blocking Probability, Congestion, Erlang Formula, Traffic Intensity*

1. Introduction

For increasing the demand of internet services different systems were developed like Wavelength Division Multiplexing, Optical Circuit Switching, Optical Packet Switching and Optical Burst Switching which are covered under optical networks [3]. Optical network is used to convey signals over distances by employing any sort of optical technology. Earlier as well as today, there are sets of optical fibers interconnecting electronic switches known as first-generation (1G) optical networks. In second-generation (2G) optical networks, routing and switching is performed in the optical domain, without signal conversion to the electrical form [1].

All these systems had some limitations which lead to the development of new system. For future network Optical Burst Switching Network will be used for which parameters include link utilization, traffic intensity, contention resolution, blocking probability, congestion, and number of servers, offset time, delay etc. In Optical Burst Switching Network instead of packet, burst was transmitted. Burst was defined as the collection of packets having similar properties. For the transmission of burst, burst header packet was used in which header was transmitted by source followed by a packet burst [2] [4]. The header was transmitted at low speed on a dedicated control channel. The packet was processed electronically at each node and activated the switch fabric to connect the associated burst to the appropriate output port. The main motive was to aggregate incoming packets from the access network into defined size bursts. Tell-And-Wait (TAW) and Tell-And-Go (TAG) [6] protocols were used to perform optimal scheduling schemes. With the deployment of technology several critical issues which affect the network performances were addressed.

2. Congestion

With the transmission of large amount of data in a node which is larger than the capacity of the system, causes congestion which decreases the quality of service of the system. Queueing delay and Packet loss were the main issues. Traffic congestion increases when its use increases means when demand increases and it is characterized by slower speeds, longer trip times and increased vehicular queueing. As demand approaches the capacity of the system it leads to congestion [7], [8]. The demand is directly proportional to traffic intensity.

The traffic intensity (T) is defined as the product of the calling rate (λ) and the average holding time (h) as:

$$T = \lambda / h$$

Hence demand,

$$D = cT = c\lambda / h$$

3. Blocking Probability

The probability determined when the telephone connection was not established due to insufficient transmission resources in the network. It is expressed as a percentage or decimal equivalent of calls blocked during the busy hour by network congestion [7], [9].

On the basis of the traffic intensity of the busy hour, the design equipment requirement in a telecommunication system is determined.

The Traffic Intensity is the product of the calling rate and the average holding time [11]. When the traffic intensity is highest, it is determined by Busy Hour which is continuous sixty-minute (60-min) period. Blocking Probability is also defined as the number of lost calls in the system.

4. Erlang Loss Formulae

Erlang's Loss Formulae was defined A.K. Erlang in 1908 [7], [8]. His main motive was to solve the problem in telephone system, that for the known traffic load, how many channels were required? Hence some key concepts were studied like Erlang which is the basic unit for traffic intensity. It is defined as traffic of 60 minutes and dimensionless.

There are two traffic formulas known as Erlang B and Erlang C formulas. Erlang B is used when traffic was blocked and Erlang C is used when traffic was delayed. Erlang B formula was easy as compared to Erlang C. The formulas for both are given in [7].

Erlang B Formulae is also known as Erlang Loss Formulae. There is relation between blocking probability and traffic intensity. This formulae suppose that for the traffic it had infinite number of sources, much greater than number of channels. Also it presumes that it had low call rate failure. In traffic theory the Erlang B formulae is written as:

$$B = \frac{\frac{A^n}{n!}}{\sum_{i=0}^{n} \frac{A^i}{i!}}$$

5. Modified Erlang Loss Formulae

To control congestion, we modified the Erlang's Loss Formula. The relation between congestion (C_g) and blocking probability (B) is developed. From earlier study, it came into light that demand is directly proportional to congestion. As demand of the signal increases, congestion increases and vice-versa. Also, demand (D) is directly proportional to traffic intensity (A).

$$D \alpha A$$
$$D = cA$$

Where, c is constant.

The Traffic Intensity (A) is given in [11] as:

$$A = \lambda h = \lambda W = \frac{\lambda}{\mu}$$

Where, h or W= Call holding time
λ= Call arrival rate
μ= Average number of requests processed per time

Hence,

$$D = c\lambda h = c\lambda W = c\frac{\lambda}{\mu}$$

Congestion is directly proportional to traffic intensity.

So,

$$D = c\lambda h = c\lambda W = c\frac{\lambda}{\mu} = C_g$$

Now, the Modified Erlang's Formulae is given as:

$$B = \frac{\frac{\left(\frac{C_g}{C_1}\right)^n}{n!}}{\sum_{i=0}^{n} \frac{\left(\frac{C_g}{C_1}\right)^i}{i!}}$$

Where, B = Blocking Probability
C_g = Congestion
C_1 = Constant value
n = Number of channels

6. Simulation And Results

For the control of congestion, MATLAB simulator is used. The result from earlier algorithm and new proposed model is compared. In 2007, the authors proposed new algorithm to reduce the blocking in the system. They introduced FCRB techniques for the reduction in blocking probability. The result was given in [10] and shown as under.

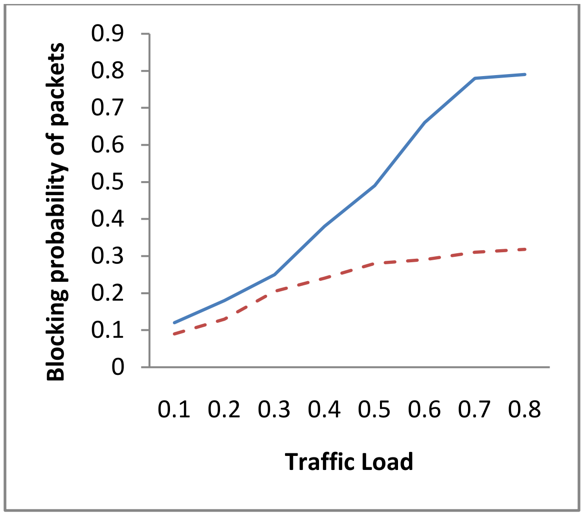

Figure1.1 Traffic Load v/s Blocking Probability of packets

——— represent Traditional OBS Curve

---------- represent FCRB Curve

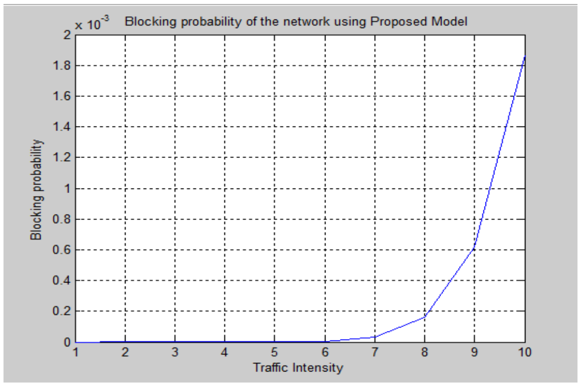

Figure 1.2 Traffic Intensity v/s Blocking Probability for $n=20$ and $\rho= 10$

The comparison of both the results showed that, the proposed model performs better than previous algorithm. In earlier algorithm, with increase in traffic load (upto 1 Erlang), the blocking probability reduces to 0.31 (31%) approximately in FCRB and 0.8 (80%) approx. for traditional Optical Burst Switching. But in new proposed model, upto 1 Erlang the blocking probability is zero, means call is established properly. And with further increase in traffic intensity upto 6 Erlang, blocking probability is still zero. But when the traffic intensity increases upto 10 Erlang the blocking probability increases but negligibly (i.e. upto $2x10^{-3}$ when the traffic intensity is 10 Erlang).

7. Conclusion

To reduce congestion in the system various congestion control algorithms were developed. These algorithms were related with other parameters also. For calculating the blocking probability, Erlang Loss Formulae was used in modified form known as Modified Erlang's Loss Formulae. The comparison between earlier algorithm and new proposed model is done, which showed that new proposed model performs better than earlier algorithm. The call is established properly upto 6 Erlangs in modified version and with further increase in traffic intensity to 10 Erlang the blocking probability is increases but negligibly small.

8. References

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