Dynamic Bandwidth Allocation in GMPLS Optical Networks using Minimum Execution Time Technique

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***Abstract*—A new dynamic bandwidth allocation technique named as Minimum Execution Time (MET) is developed for reducing the blocking probability to improve quality of service of the Generalized Multi Protocol Label Switched (GMPLS) optical network. A statistical model of an optical network is developed for blocking probability of held calls and cleared calls. The bandwidth is allocated to users on the basis of predictable completion intervals at the servers in the proposed technique for bandwidth allocation, i.e. it calculates the minimum time required to execute the request so that bandwidth can be allocated to another user. Thus, the bandwidth can be allocated in an efficient manner in this process. The blocking probability variation is studied based on the traffic load and wavelengths available at the time of user request in the GMPLS network. The results revealed that the blocking probability drops off with increasing number of available wavelengths. The value of blocking probability remains below 1% by using the proposed bandwidth allocation technique.**

Keywords—blocking probability, minimum execution time, generalized multi protocol switching

I. INTRODUCTION

The main confront in today's world is to achieve the demand of required bandwidth which is growing very fast and various Quality of Service (QoS) requirements [1]. These demands are to be obtained along with the data security and that can be achieved by using optical fibers for communication purpose [2]. Optical networks use signals encoded in the form of light to transmit the required information among the nodes of communication networks. To enhance the data security and speed, Multi Protocol Label Switching (MPLS) was engaged in the optical networks. The technology was found suitable to solve QoS problem in a better than others was MPLS, largely due to its capabilities in traffic engineering. GMPLS has been adopted by optical networks as it decreases the signaling and switching costs than packet switched networks [3].

Now days, the main interest in optical networks is the blocking probability in GMPLS optical networks. Bouzid*et al*. studied the hybrid technology that fuses performances from both MPLS-TE and QoS known as the Diff Serv-aware MPLS-TE (DS-TE) [4]. The major parts of DS-TE, MPLS-TE and QoS-DS were studied in comparison with one another to analyze the differences and similarities by authors. The comparison told that DS-TE worked as MPLS-TE only with knowledge of QoS-DS that improved the delay in traffic transmission. Dallaglio *et al*. surveyed the multiflow bandwidth variable transponders supporting slice ability [5]. The observations revealed that node and spectrum resources were efficiently utilized by multi flow bandwidth variable transponders in elastic optical networks and were capable of creating subcarriers which could be aggregated or routed independently as per the traffic requirements. Sobieraj *et al*. proposed a new calculation method in switching networks with multiservice traffic sources carrying multicast traffic for determination of traffic characteristics [6]. The proposed calculation method was compared with the results of experiments after simulation as it was approximate. The correctness of the proposed analytical method was assured by the simulation results. Ge*et al*. proposed a blocking probability estimate method for path requests in flexi-grid networks [7]. The bundled neighboring carrier allocation was modeled with a group of birth–death processes and a hypothetical analysis to the blocking probability was provided under inconsistent bandwidth traffic. The first fit algorithm was used in network nodes to allocate neighboring carriers to path requests in simulations and verify approximation results. Vanitha*et al*. proposed two protocols for analyzing the utilization and blocking probability of each station to the access point [8]. The first protocol was based on Markovian Queuing based Single channel Single Access Point protocol with Blocking Probability (MQSSABP) and the second protocol proposed was Markovian Queuing based Single channel Multi Access Point protocol with Blocking Probability (MQSMABP). The performance of the protocols was measured both numerically and through simulations. Wason*et al*. proposed a statistical model to diminish the blocking probability in wavelength-convertible networks with WDM [9]. The simulation results show that the blocking probability can be condensed to small value using the proposed model.

Till now, the work has been done in the area of blocking probability for MPLS networks and WDM optical networks. In this paper, the work is based on analysis of blocking probability in GMPLS optical networks which is the novelty of our presented work. The significance of the work is that the proposed model is linked with GMPLS optical networks for

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the dynamic bandwidth allocation which has not been done in literature. The major advantage of the proposed model is that modifications are not required in the configuration of existing optical network as they can be put into operation without alteration. We have contributed in the existing technology in the way that the capacity of the network in accommodating number of users increases by using proposed minimum execution technique.

The paper is divided into four sections. This first section includes the introduction of GMPLS optical networks and motivation behind the proposed work. The second section discusses about the proposed work. Then the results are discussed in third section and finally the paper is concluded in the fourth section.

A. Generalized Multi-Protocol Label Switching

The apparent command of MPLS networks directed the industry to identify its expansion in the generalized form known as Generalized Multi Protocol Label Switching [10]. GMPLS enriches MPLS to maintain network switching along with packet switching for wavelength, time and fiber switching. The policy adapting GMPLS minimizes the costs which involve bandwidth, switching and signaling [11, 12]. The major problem in optical networks is Routing and Wavelength Assignment (RWA). Many studies have been carried out which investigated RWA problem [13, 14]. The GMPLS framework offers an advancement to employ IP over DWDM with diverse route assignments depending on the restrictions taking place due to remaining dispersion accumulated on the light wave path [15]. The selection of light path connections can be efficiently done with the help of GMPLS [16, 17]. In GMPLS, the label includes the implicit values defined by the medium used as indicated in Fig. 1. The switch fabric contains the label as its inherent part and wavelength and timeslot etc decides the switching operations. The physical possessions of the received data stream is used to identify LSP in GMPLS.

GMPLS increases the network capacity by allowing large number of parallel links between nodes in a network which is the basic requirement in optical communication where hundreds of parallel links may exist between a pair of nodes.

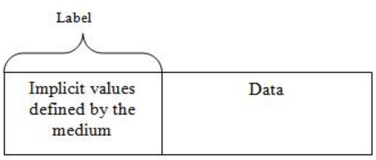

Fig. 1.Packet format for GMPLS

GMPLS also facilitates switchovers to alternate channels, rapid fault detection, fault isolation and reducing network downtime. GMPLS based Multi Region Networks (MRN) allows domains hosting numerous technologies to operate as a single network [18]. The GMPLS control plane may not operate by itself; therefore, a holistic service production platform is required by the network providers when intensified traffic engineering capabilities are taken into account [19]. Its adoption faces major challenges in regard to feasibility, gain and performance while moving from inheritance packet over optical multi-layer networks determined by overlaid control planes [20].

B. Blocking Probability

Probability is calculated by taking the proportion of the constructive cases to the total number of achievable cases. It is analyzed as a number between 0 and 1, where, freely speaking, 0 signifies impracticality and 1 signifies assurance. It can be represented either in the form of number (0 to 1) or percentage [21].

Blocking probabilities are amongst the major performance procedures in communication networks. For their analysis, networks can be modeled as networks of Erlang loss queues with ordinary capacity limitations dictated by the distribution of frequencies to the network cells [20]. The tradeoff between transmission radius and blocking probability for multi-hop calls is required [21]. In queuing theory, the Eng set formula is used to analyze the blocking probability of M/M/c/c/N queue (in Kendall's notation) [20]. Let the call holding times be exponentially distributed with mean 1/μ and the time until an idle source attempts to make a call is also exponentially distributed but with mean 1/γ. Assume that there is no dependence between the holding times and the idle periods of the sources. Let the number of customers (sources of traffic) be c, the number of circuits be k, the number of busy circuits as j and the blocking probabilityP_{be}.

Eq. (1) represents the Eng set loss formula [22] which gives the blocking probability for the case c > k as follows:

$$P_{be} = \frac{\binom{c-1}{k}\gamma^k}{\sum_{j=0}^{k}\binom{c-1}{j}\gamma^j} \tag{1}$$

II. PROPOSED MODEL

The analysis of blocking probability is performed for enhancing the QoS of GMPLS optical network. On arrival of a call, all channels are checked for their availability and the free channel is allocated to that call and thus the call gets finished. But when all the M servers are engaged on arrival of any call then the incoming call does not get completed and is tackled in any of the following ways:

I. Cleared calls: call gets cleared from list if the server forgets it.

II. Held calls: call is put in a queue of certain size, q on hold, while waiting to be serviced.

Take r as the average rate of generating calls, μ as mean call rate, λ as the number of wavelengths, m as number of calls that can be completed in time T, N is the number of users that can be handled with M servers in time T as shown in Fig. 2. M as the number of servers, q as the queue size, Poisson's equation and Engset Formula are used to calculate the blocking probability for cleared calls and calls to be held.

The number of users considered to be modeled is n. The Poisson distribution for generated calls [22] in given time interval, T is given by:

$$P_r\,(m\ calls\ generated\ in\ T) = \frac{(rT)^m}{m!}e^{-rT} \quad ;m \geq 0 \tag{2}$$

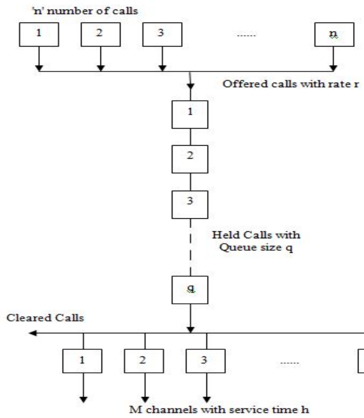

Fig. 2.Model for blocking probability analysis.

The number of completed calls for a given channel for extended time is basically a Poisson random variable specified by:

$$P_r\,(m\ calls\ completed\ in\ T) = \frac{(\mu T)^m}{m!} e^{-\mu T} \quad ; m \geq 0 \tag{3}$$

Now, using these Poisson equations and Engset formula, the blocking probability for cleared calls and held calls for infinite number of sources is calculated as:
For cleared calls, blocking probability for infinite sources,

$$B_p = \frac{(\lambda/\mu)^N}{N!} \left(\sum_{m=0}^{N} \frac{(\lambda/\mu)^m}{m!} \right)^{-1} \tag{4}$$

For infinite sources, blocking probability for held calls is:

$$B_{ph} = \frac{\left(\frac{(\lambda/\mu)^N}{N!}\right)\left(\frac{1-\left(\frac{(\lambda/\mu)}{N}\right)^{q+1}}{1-\left(\frac{(\lambda/\mu)}{N}\right)}\right)}{\sum_{m=0}^{N-1}\frac{(\lambda/\mu)^m}{m!} + \left(\frac{(\lambda/\mu)^N}{N!}\right)\left(\frac{1-\left(\frac{(\lambda/\mu)}{N}\right)^{q+1}}{1-\frac{(\lambda/\mu)}{N}}\right)} \tag{5}$$

Using the model proposed above, a new algorithm named as Minimum Execution Time (MET) is developed for allocating bandwidth dynamically in an efficient manner for proper utilization of available resources and also for reducing the blocking probability in the GMPLS optical network which in turn improves the quality of service.

M*Et al*gorithm finds the resource which has minimum execution time to complete the task. It allocates the work to the resource based on first comes first service i.e. the user sending request for the channel to transfer data first will be allotted least time consuming server at priority. The algorithm is least concerned with the amount of data to be transferred. The priority of server allotment does not waiting for the next request. The server will then provide the connection by assigning the wavelength and link rates, taking in account their routing table and link stability.

In this algorithm as shown in Fig 3, the position of users and servers is defined in the specified network area. It is done dynamically as the users are not static in nature. The range of wavelengths and link rates are specified, keeping in mind the routing table and link stability. Then the coverage area among the neighbor users is calculated and the routing table is maintained. The distance among all the users and server is investigated. If the distance is not greater than zero then it means the user is finding distance with itself so it needs to update the routing table. But if the distance is found to be greater than zero then the servers are analyzed for least time consumption to complete the task.

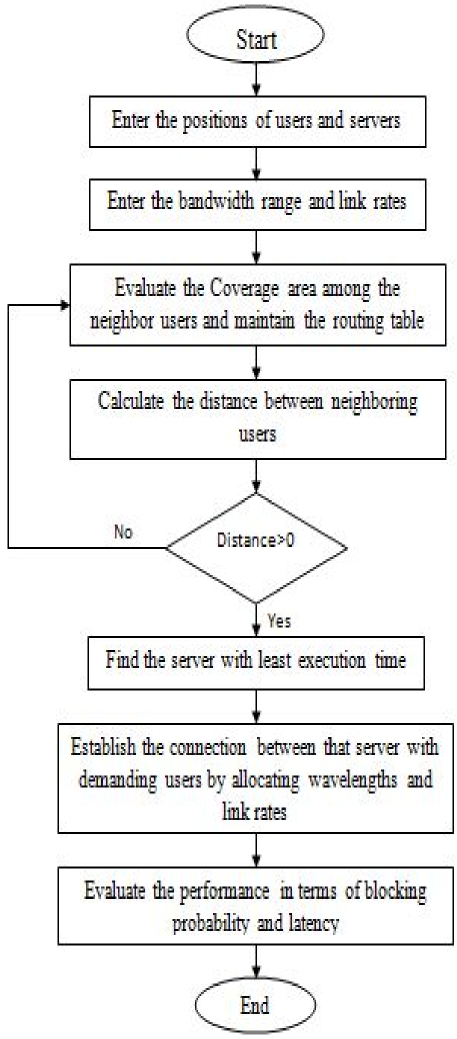

Fig. 3.Flowchart for the proposed algorithm.

Now, when the requests from different users occur, the time to complete the task by each server is estimated and the server having least predictable execution time period is allocated to the respective users. That is why the proposed algorithm is named as Minimum Execution Time algorithm. After the allocation of servers to the users, the available wavelengths are assigned to the demanding users. The link rates are evaluated to maintain the link stabilities and are provided to the users. Then the performance is evaluated in terms of blocking probability and latency in the GMPLS optical network.

III. Results and Discussions

In this section, a graph that contains the complete GMPLS optical network having different users placed at their positions is presented. It also shows the location of servers placed in the network. Further, the results are plotted for the blocking probability with respect to the number of wavelengths available at the time of user request. Different graphs are plotted for various parameters like latency and traffic load.

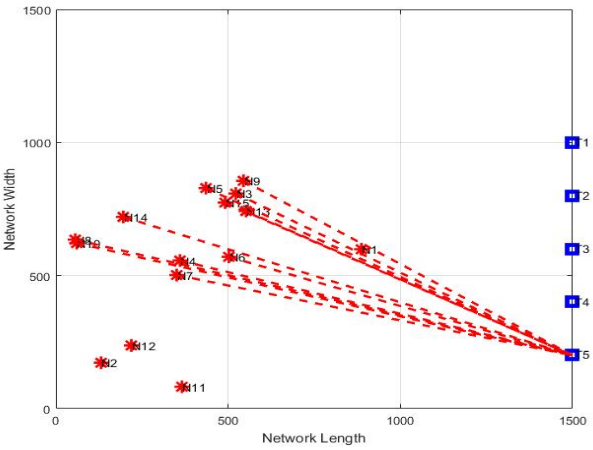

Fig. 4.Scenario of GMPLS optical network showing connection establishment.

The Fig. 4 represents the scenario of GMPLS optical network containing the users and servers at their specified positions which shows the assignment of server with least execution time to the demanding users in the GMPLS optical network. When the users send request to send their data, the network servers are analyzed in terms of least completion time i.e. the time to complete the request by each server is estimated and the server with minimum execution time gets selected.

Then the selected server allocates the wavelengths and link rates to the users and data transfer occurs. The red lines show the connection between the users and the server. In this particular result, fifth server is found to complete the task at the earliest and is selected for the connection establishment.

Fig. 5 depicts the relation between the blocking probability in GMPLS optical network and the number of wavelengths available at the time of request. The plot reveals that the blocking probability reduces with increasing accessible wavelengths at that time. The proposed technique uses the concept of minimum execution time due to which the wavelengths get available frequently. Thus, the number of available wavelengths increases and the call drops decreases which in turn decreases the blocking probability. Thus, the QoS for the complete network increases.

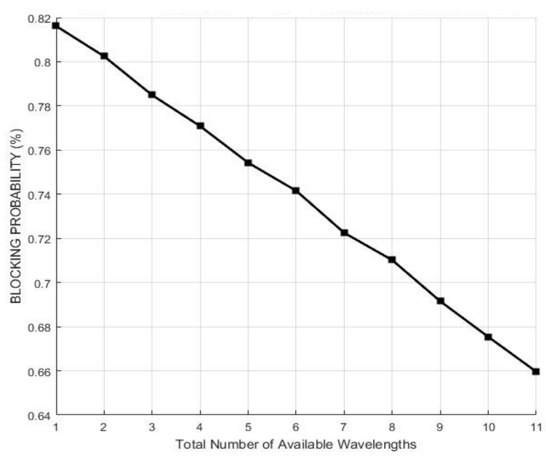

Fig. 5.Blocking probability as a function of number of available wavelengths.

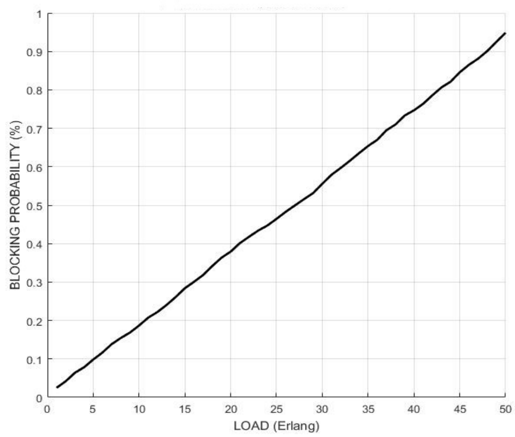

Fig. 6.Blocking probability as a function of load.

The deviation of blocking probability with regard to the increasing traffic load in the GMPLS optical network is represented in Fig. 6. As the traffic load increases, the channels or the wavelengths get occupied therefore, the user requests get blocked but by using the proposed technique, more traffic load can be handled without blocking as the channels get available recurrently due to the use of least completion time concept. The graph shows that the blocking probability increases with the increased traffic load but its value remains below 1% using the proposed technique.

IV. Conclusion

A new technique is proposed for dynamic bandwidth allocation in an efficient manner for proper utilization of available resources and also for reducing the blocking probability in the GMPLS optical network which in turn improves the quality of service. It involves scheduling in which the task (data transfer) completion time at each server is predicted and the server with least execution time is assigned to the respective user. The proposed technique controls the load imbalances on the destination users to transmit requests in the GMPLS optical network. Due to the availability of more wavelengths at the time of new requests, the rate of call drops decreases and more number of calls get handled in the network which in turn decreases the network blocking probability. The value of blocking probability remains below 1% which is acceptable in the GMPLS optical network by using the proposed bandwidth allocation technique.

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