Design and Implementation of Closed Loop Efficient Routing with Distance Optimization in Optical Networks

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Abstract –This paper proposes an efficient closed loop routing in optical networks. It also proposes distance optimization by genetic approach subject to requirements of fairness, efficiency, and cost. It proposes a network design problem for the traffic grooming and routing in WDM networks. Moreover, effective ways to improve its performance and reduce its complexity are provided. In this work, it is concentrated on the effects of bandwidth, delay and bit error rate. This work deliberates the development in blocking probably for incoming requests while performing routing by proposed algorithm and shortest path algorithm. Used prior to network operation, the algorithm determines which route should be used for each potential connection. Moreover, since the routes provided by the genetic algorithm are stored in routing tables, it also ensures extremely fast on-line network operation. Shortest path can be calculated for any number of nodes. A number of important parameters like transmission distance, noise power, optical signal to noise ratio, channel load, bit error rate and packet delay have been calculated. The proposed algorithm is a dynamic algorithm and in it is easy to exploit present and alternate solution, each time a fittest path is calculated.

Index Terms – closed loop Routing, distance optimization, shortest path, Blocking Probability.

1. INTRODUCTION

An optical network connects computers (or any other device which can generate or store data in electronic form) using optical fibers. According to the physical technology employed, one can identify three generations of networks, Networks built before the emergence of optical fiber technology are the first generation networks (i.e. networks based on copper wire or radio). The second generation networks employ fibers in traditional architectures. The choice of fiber is due to its large bandwidth, low error rate, reliability, availability, and maintainability. Although some performance improvements can be achieved by employing fibers, the performance for this generation is limited by the maximum speed of electronics (a few gigabits per second) employed in switches and end-nodes. This phenomenon is called an electronics bottleneck [1].

The most advanced network concepts explore the use of optics beyond transmission, to implement switching and simple resource allocation functions. It analyses the current status and trends in both components and networks. A PON reduces the amount of fiber and central office equipment required compared with point-to-point architectures. A passive optical network is a form of fiber-optic access network. In its most general form, an optical network will contain both active and passive optical elements. Active components can be located at the central office, within termination points at the customer's premises, and in the repeaters, switches, and other equipment located in the transmission path between the central office and the customer [2].

The users of an optical network demand that data be sent from a source point to a destination point. These demands must be routed in most efficient way over the network. First of all, the router needs to find uncongested paths between the source and destination. Furthermore, in all networks the router must assign a wavelength for the data while it is travelling in a link. This all-optical path, consisting of both the routing and the wavelength assignments on the route, is generally known as alight-path. The light-path is reserved for a point to point demand until it is terminated. At the termination, all the corresponding wavelengths become available on the light-path [3].

Many of these devices are capable of being reconfigured by either a local or a remote control mechanism. They are used for functions such as coupling light from one fiber to another, redirecting the light signal to another transmission path, splitting the signal into two or more branches, amplifying the optical signal power, and processing information contained in the signal. Many new applications and services have emerged amidst the rapid growth of the internet and telecommunications industry resulting in a surge of data on voice networks. This surge of data rendered the voice telecommunications infrastructure insufficient in the metropolitan area resulting in a metro gap. This dilemma provided us with a dire need to replace or upgrade the existing telecommunications infrastructure. So to cope with the changed realities and enable new applications and services to utilize huge bandwidths available in the long haul backbone networks, optical network based on AWG multiplexers and AWG de-multiplexer can supplement the existing metro networks and increase their capacity to overcome the metro gap [4].

Learning in neural networks is an optimization process by which the error function of a network is minimized. Any appropriate numerical method can be used for the optimization. So it is value having a closer look at the efficiency and reliability of different strategies. In last few years genetic algorithms have involved considerable attention because they represent a new method of stochastic optimization with some interesting properties. With this class of algorithms an evolution process is simulated in the computer, in course of which parameters that produce a minimum or maximum of a function are determined [4].

The paper is organized as follows. In section II, we deliberate related work with the network routing and genetic algorithm scheme. In Section III, it describes the system architecture and components of system. Section IV explains the design and implementation techniques of system. In section V, it contains the all results of the system. At last, conclusion is given in Section VI.

2. RELATED WORK

Some authors adopted a new framework to handle the problem in which we fix the sequence of the customer demands while trying to find the path for each demand in order to obtain more reasonable solution for the whole. Besides, a genetic algorithm using priority-based encoding combined with an efficient local search process is proposed to cover the shortage of the K-shortest path strategy which is the most widely used routing strategy in RSA but with limited search space [4].

Some proposed novel distance-adaptive optical transmission technologies to boost transceiver data rates and to enable more flexibility in the allocation of traffic flows. Traffic grooming and spectrum assignment using transceivers with fixed baud rate of 28 and 14 GB and distance-adaptive modulation formats in optical metro networks is performed [5].

Some analysed the performance of Traffic Groomed optical networks and found that the number of wavelength channels required decreases as wavelength grooming factor increases. The grooming factor is defined as the ratio of wavelength channel capacity to the basic wavelength channel capacity. Blocking probability is plotted against the number of channels per link and it is found that as the load increases the blocking probability increases for the same number of channels per link [6].

Some authors propose a novel colourless optical transmitter based on all-optical wavelength conversion using a reflective semiconductor optical amplifier for upstream transmission in wavelength-division-multiplexed passive optical systems. The proposed optical transmitter for optical network unit is composed of an electro-absorption modulated laser, a photo-sensitive coupler and amplifier. The proposed optical transmitter is based on fast gain recovery of amplifier governed by carrier-carrier scattering and carrier-phonon relations [7].

This paper investigated problem of dynamic wavelength allocation and fairness control in WDM optical networks. A network topology, with a two-hop path network, is considered for mainly three classes of traffic. Each class corresponds to a source &destination pair. For each class call inter-arrival&holding times remain studied. The objective is to find a wavelength allocation policy to take full advantage of weighted sum of users of all the three programs. In a conventional WR network, an entire wavelength is assigned to a given connection. This can lead to inferior channel utilization when individual sessions do not need entire channel bandwidth [8].

3. PORPOSED MODELLING

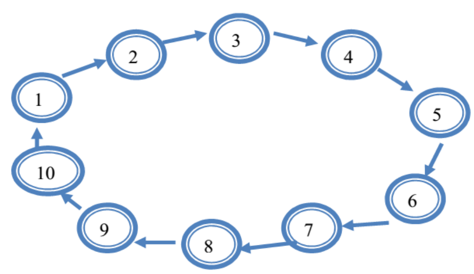

Figure 1: Network of 10 Nodes

A logical way to deploy optical fiber in the local access network is to use a point-to-point topology, with dedicated fiber runs from the CO to each end-user subscriber. While this is a simple architecture, in most cases it is cost prohibitive due to the fact that it requires significant outside plant fiber deployment as well as connector termination space in the Local Exchange. In optical networks, the wavelength division multiplexing technology which multiples a number of optical carrier signals into a single optical fiber using different wavelengths (colours) of a signal. Using this technique, we can join signals at the transmitter side referred as multiplexer and it splits signals at receiver side referred as de-multiplexer as shown in fig 2.

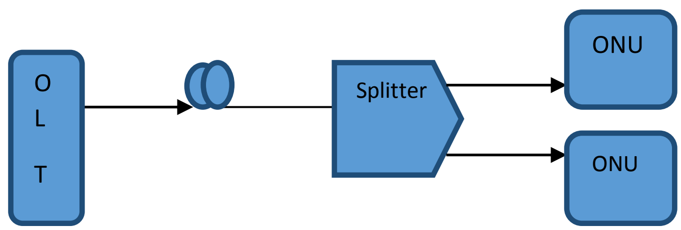

Figure 2: System Architecture of a System

The active modules in the network consist of an optical line terminal (OLT) situated at the central office, either an optical network terminal (ONT) or an optical network unit (ONU) at the far end of the network and optical amplifiers for amplification purposes [11].

An ONU is a device that terminates the PON and presents customer service interfaces to the user. Some ONUs implements a separate subscriber unit to provide services such as telephony, Ethernet data, or video. The multiple wavelengths of a WDM-PON can be used to separate Optical Network Units (ONUs) into several virtual PONs co-existing on the same physical infrastructure. An optical fibre access network primarily employing passive optical components and configured around a passive splitter/combiner is called a passive optical network(PON).It was initially referred to as a passive since no components electrical power, except at the fiber end points which may incorporate optoelectronic devices.

PON allows removing all active components between the server and client introducing in place optical passive components to guide the traffic throughout the network. Its principal element is the optical splitter. The usage of passive architecture can reduce costs and are mainly used in FTTH networks. By contrast, the bandwidth is not dedicated, but rather multiplexed in a single fiber in the network access points. In short, this is a point-to-multipoint configuration network.

To achieve objectives, following assumptions are made:

1) Network is static and circuit switched.

2) The wavelength continuity constraint is satisfied.

3) Both fiber links and light-paths are bi-directional.

4) There is no limit on the number of available wavelengths a fiber can carry.

Optimization is concerned with finding an answer x from a set of alternatives X that is best with respect to some criterion f . The variables may be integer, real, or a mixture. The feasible search space X is the set of solutions over which the search is performed. In a standard constrained optimization problem, the set X is defined by a set of equality and non-equality constraints. In many standard optimization problems, the function f is available in algebraic form allowing an optimizer to evaluate solutions by simply computing f. However, for some problems the mapping between the decision variables and their effects on the fitness of a solution is cost prohibitive to define or simply unknown; in this case we also say that the function f is black box.

In the 60s and 70s, closed-loop optimization problems were mainly concerned with shape design problems for fluid dynamics. Due to the increasing computational power and the constant development of innovative simulation software, problems related to fluid dynamics can nowadays often be optimized in silicon. This technological progress affected the prominence of closed-loop optimization.

Routing is act of moving information across an internetwork from a source to a destination. Along the way, at least one midway node typically is encountered. Routing is frequently contrasted with bridging, which might seem to achieve precisely same thing to the casual observer. Routing involves two basic activities: determining optimal routing paths and transporting information groups (typically called packets) through an internetwork. In context of routing procedure, the latter of these is referred to as packet switching. Although packet transferring is relatively straightforward, path determination can be very composite. Routing protocols use metrics to evaluate what path will be best for a packet to travel [8].

A metric is a standard of measurement, such as bandwidth, that is used by routing algorithms to determine the optimal path to a destination. To aid process of path determination, routing algorithms modify and maintain routing tables, which comprise route information. Route information differs depending on the routing algorithm used. A light-path request between s and d is realized by finding a physical path p € P(s,d) and wavelength w € W that is assigned to every link on p; which ensures wavelength continuity constraint. The pair (p, w) is called a light path. To avoid wavelength clash, two light paths with the same wavelength cannot share a common fiber. The goal is to minimize the number of wavelengths and maximize the number of light path requests realized.

Efficient routing algorithm must take into account that the data traffic is not of the same type since they do not belong to a single class of applications. These different traffic types have different quality requirements and need to be dealt with differently. Some of the traffic requires more bandwidth than others, whereas some other applications need less end-to-end delay. Genetic algorithm is an optimization technique based on natural evolution. In proposed genetic algorithm, the use of digits in place of binary modelling is used. Also it computes shortest distance to its neighbours to provide a closed loop. As process continues, it optimizes the distance and provides minimum distance so that data may transfer and reaches its destination. It include the survival of the fittest idea into a search algorithm which provides a method of searching which does not need to explore every possible solution in the feasible region to obtain a good result.

Genetic algorithms are based on the natural process of evolution. In nature, the fittest individuals are most likely to survive and mate; therefore the next generation should be fitter and healthier because they were bred from healthy parents. This same idea is applied to a problem by first 'guessing' solutions and then combining the fittest solutions to create a new generation of solutions which should be better than the previous generation. Although there are many possible variants of a simple GA, the fundamental underlying mechanism operates on a population of chromosomes and consists of three operations:

- evaluation of individual fitness,
- formation of a gene pool (intermediate population) and
- Recombination and mutation.

A fitness function must be devised for each problem to be solved. Given a particular chromosome, a solution, the fitness function returns a single numerical fitness, which is supposed to be proportional to the utility or adaptation of the individual which that chromosome represents.

Proposed Algorithm

- Set maximum number of nodes in network.
- Obtain the costs of links in network G.
- Generate the first generation (initial) population.
- For every, employ Dijkstra's algorithm to find the minimum-cost path for routing.
- For each fiber link in every p, cut only one link at a time (disturbance), and find the minimum cost paths to form a new chromosome as in step 1 at each time. Stop when the pop is reached, i.e. where pop is the population strength.
- If pop is not reached after all the disturbances, copy the existing ones multiple times until enough chromosomes are generated.
- Evolve the fitness using fitness function
- Selection of the next generation population.
- Process is repeated until it reaches the starting node or initial population to form a closed loop.
- Compute distance matrix, total distance travelled and number of iterations evolved.
- Evaluate other performance parameters of optical networks & verify the result.

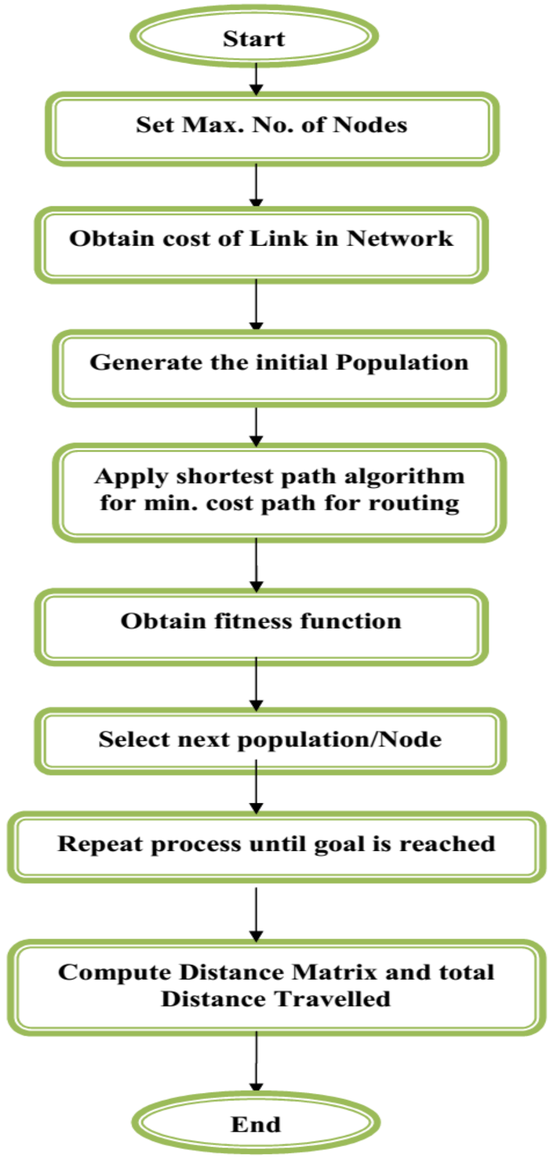

Figure 3: Proposed System Model

Firstly, the optimization problem is given a chromosome structure. After which, an initial population or initial number of nodes is generated randomly. Then, members of the population with higher fitness are selected. The fitness of members is evaluated by an evaluation function. A member with a higher fitness has a more chance to be selected; therefore, weaker members with lower fitness are gradually replaced by stronger members. Selected members mate two by two randomly and the next population is generated using three genetic operators namely mating, crossover and mutation. This procedure is repeated until iteration number is reached. Pairs of chromosomes in the new population are chosen randomly for exchange of genetic material, with their bits in a mating operation called crossover.

This produces two new chromosomes which replaces its parents. Randomly chosen bits in the offspring are flipped. This process is called mutation**.** Crossover continues until the new generation is full. It is possible to check each new chromosome to make sure it does not already exist in the new generation. This means that we will get a variety of possible solutions in each generation, but also that once we have found the optimal solution in one chromosome, the other chromosomes will probably not be optimal. The convergence criterion of a genetic algorithm is a user-specified condition e.g. the maximum number of generations or when string fitness value exceeds certain threshold.

4. RESULTS AND DISCUSSIONS

A GUI represents information and actions available to a user through graphical icons and visual indicators such as secondary notation, as opposite to text-based interfaces, typed command tags or text navigation. The actions are usually done through direct manipulation of the graphical elements.

Table 1: Input Parameters of System

Input Parameters	**Value**
Wavelength	(1500-1560 nm)
Frequency	193 THz
Bit Rate	10.3 Gbps
Length of Fiber	30 km
Nodes	10/50/100

4.1. Routing in Network

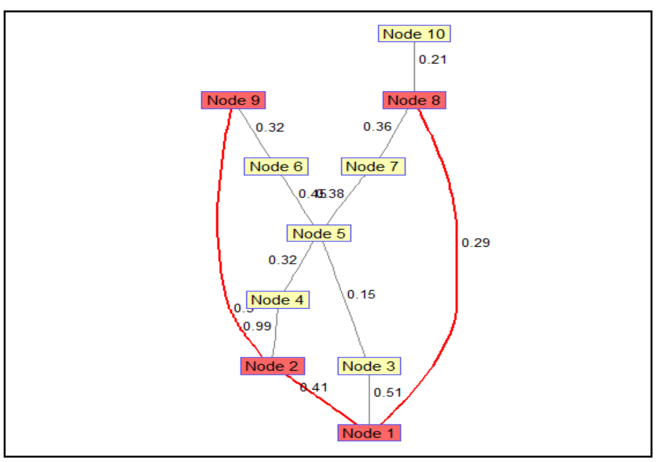

Figure 4: Routing in Networks by Shortest Path Approach

Dijkstra's algorithm is applied to automatically find directions between physical locations, such as driving instructions on websites like Map-quest or Google Maps. In a networking or communication applications, Dijkstra's algorithm has been used for resolving the min-delay path problem (which is the shortest path problem). For example in network routing, the goal is to find path for data packets to go through a switching network with minimal delay. It is also used for solving a variety of shortest path problems arising in plant and facility plan, robotics, transportation, and VLSI design. The shortest path is shown in fig 4.

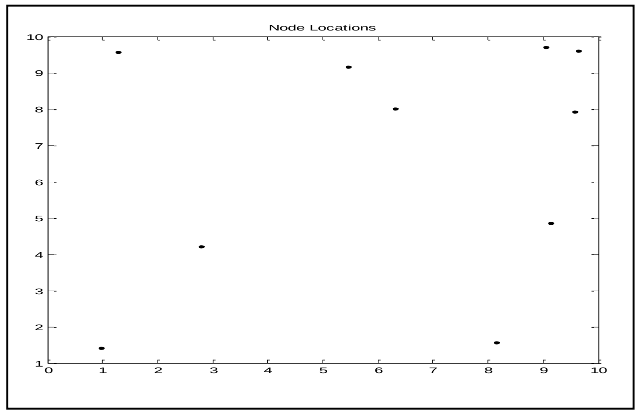

Figure 5: Node Locations in Genetic Approach

A genetic algorithm (or GA) is a search technique used in computing to find true or approximate solutions to optimization and search problems. The evolution usually starts from a population of randomly generated individuals and happens in generations. In each generation, fitness of every individual in the population is assessed, multiple individuals are selected from current population (based on their fitness), and adapted to form a new population. The advantage of the GA approach is the ease with which it can handle arbitrary kinds of constraints and objectives; all such things can be handled as weighted components of the fitness function, making it easy to adapt GA scheduler to the particular requirements of a very wide range of possible overall objectives. The results are shown.

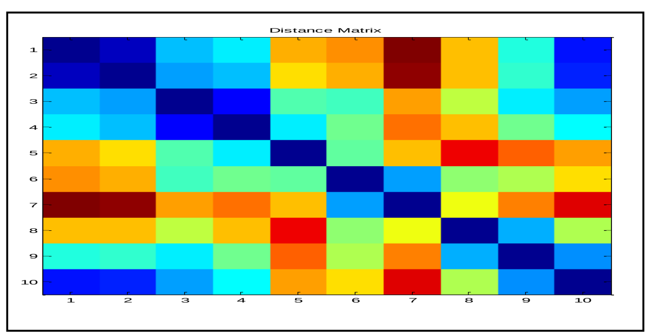

Figure 6: Distance Matrix of 10 Nodes

In each generation, the fitness of every individual in the population is evaluated, multiple individuals are selected from the current population (based on their fitness), and modified to form a new population. The new population is used in the next iteration of the algorithm. The algorithm terminates when either a maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population.

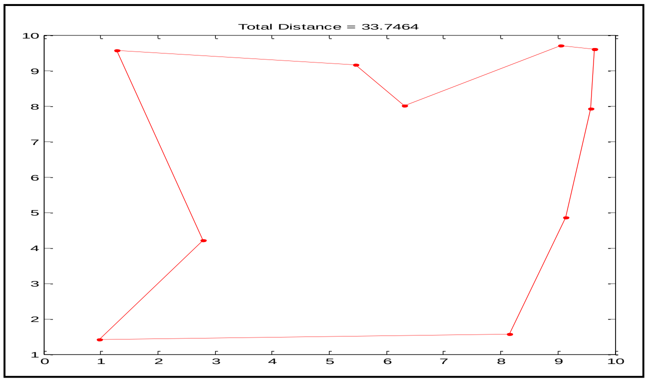

Figure 7: Closed Loop Routing by Genetic Approach

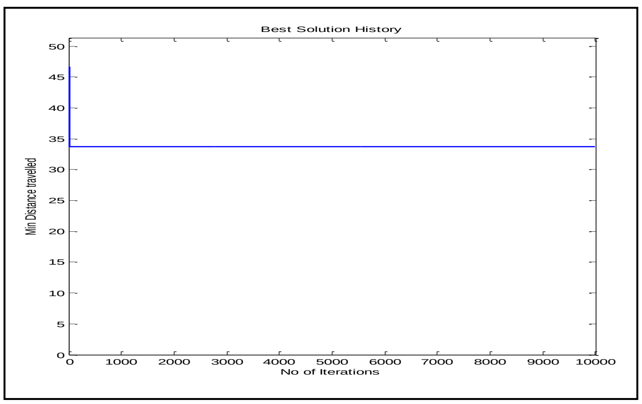

Figure 8: Distance Optimization Response of 10 Nodes

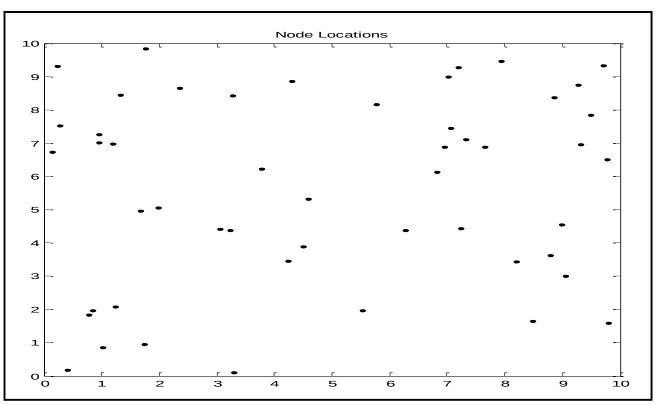

Figure 9: 50 Node Locations in Proposed System

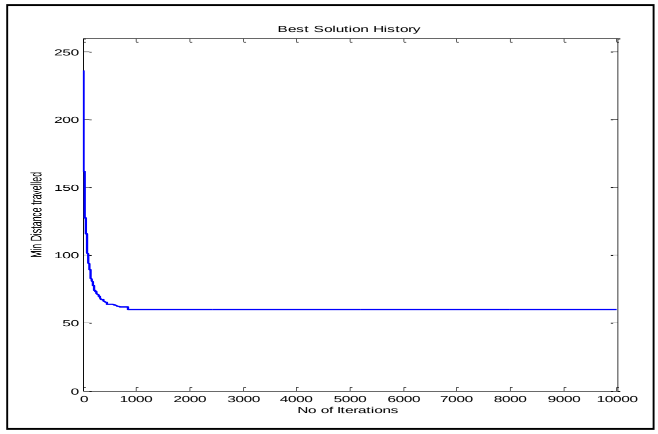

Figure 10: Distance Optimization by Proposed System

From the above results it can be stated that with the help of genetic approach we can find an optimum solution to the routing problem in a WDM Passive Optical Network. From the observed results, we find that by using Genetic approach for routing in an optical network the path so obtained is shortest and therefore it minimizes the distance between the source and destination in the network.

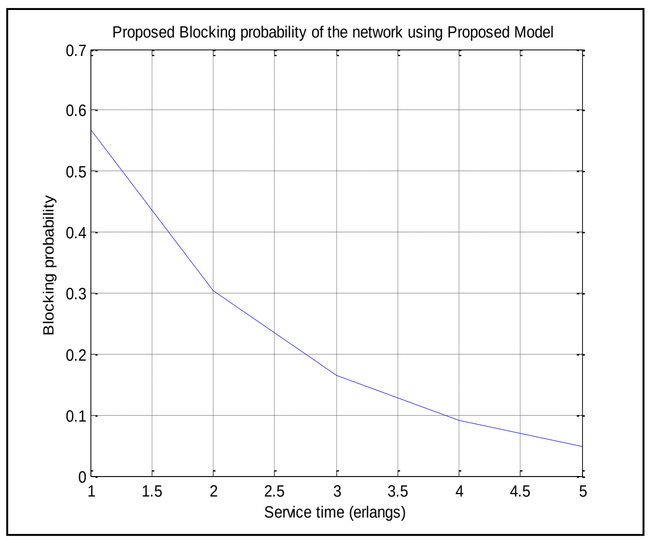

Figure 11: Proposed Blocking Probability of System

5. CONCLUSION

This paper proposes the closed circuit routing without any error using the genetic approach. An effective GA representation and meaningful fitness evaluation are the keys of the success in GA applications. The appeal of GAs comes from their simplicity and elegance as robust search algorithms as well as from their power to discover good solutions rapidly for difficult high-dimensional problems. It used dynamic routing technique to solve the shortest path problem. The dynamic routing technique is better than the static routing technique in the way that former can found the shortest path for any number of nodes in small time, but the later require to change the code for finding the shortest path for different number of nodes every time. Static routing also does not handle failures in external networks well because any route that is configured manually must be updated or reconfigured manually to fix or repair any lost connectivity. The proposed technique shows better results than link state routing or fixed routing. it is proved that the results obtained are satisfactory and the WDM optical network works efficiently by using the Genetic Approach for Routing the traffic.

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