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Research Article

Design and Implementation of Network Routing by Genetic Approach in WDM Networks

Geetika Galhotra[Ȧ*] and Praveen Kumar[Ȧ]

[Ȧ]Electronics & Communication Engg. Department, Institute of Science and Technology, Klawad, Yamunanagar, India

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Abstract

According to a fast growth of bandwidth capacity of WDM network, traffic loss due to a failure of the network components is becoming unacceptable. To overcome this difficulty, a safety method that prepares backup light-paths for each working path is now considered to improve the reliability of networks. So, this thesis proposes a network routing using genetic approach in wavelength-division-multiplexed passive optical network (WDM-PON) subject to requirements of fairness, efficiency, and cost. It proposes a network design problem for the traffic grooming and routing in WDM networks. A dynamic subcarrier assignment algorithm that respects quality of service by offering reduced average delay is proposed. 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 rate. This work deliberates the development in blocking probably for incoming requests while performing routing by proposed algorithm and shortest path algorithm.

Keywords: *Efficient Routing, Routing in Networks, shortest path, Blocking Probability.*

1. Introduction

In order to meet exploding bandwidth requirements of existing and emerging communications applications, optical networks have been gaining momentum. These networks have a marvellous bandwidth of around 50 terabits per second. However, demand for point to point communication per application is not typically as much. Therefore, to better utilize capabilities of all-optical networks, the bandwidth of an optical fiber is divided into multiple communication channels. Each channel corresponds to a single wavelength. In other words, these optical networks employ wavelength division multiplexing [G.K. Chang *et al*.,2009].

WDM (Wavelength Division Multiplexing) has a capability of providing a large transmission capacity by multiplexing wavelengths on the fiber. Recently, an IP (Internet Protocol) over WDM network where IP packets are straight carried over WDM network is expected to offer an infrastructure for next generation Internet. A currently available product for IP over WDM networks only provides large bandwidth on point–to–point link. That is, each wavelength on fiber is treated as a physical link between the conventional IP routers. In this way, link capacity is certainly increased by number of wavelengths multiplexed on the fiber, but it is insufficient to resolve network bottleneck against an explosion of traffic demands since it only results in that bottleneck is shifted to an electronic router [N. J. Frigo *et al*.,1994].

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 [M. Feuer *et al*.,2000].

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 [T. H. Wood *et al.*,1998].

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

In literature, several proposed Rayleigh noise drop in wavelength-division-multiplexed passive optical network. Then they suggest a novel scheme to effectively suppress

*Corresponding author: **Geetika Galhotra**

carrier backscattering problem in carrier-distributed WDM-PONs. By simply replacing upstream modulation arrangement of conventional on-off keying with differential phase-shift keying (DPSK), the system tolerance to carrier RB is substantially improved by 20 dB, as carrier backscattering can be considerably rejected by notch filter-like destructive port of delay-interferometer at optical line terminal, which is used suddenly to demodulate the upstream DPSK signal. As no thoughtful spectral up-shifting is required in this scheme, neither other modulator nor complicated modulation/demodulation circuit is needed at ONU/OLT. In terms of optical notch filter used to decrease backscattering light, the standard Delay interferometer used in future arrangement is also more favourable than non-standard filters [P. T. Legg *et al*.,1996].

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 photosensitive coupler and amplifier. Through cross-gain modulation in amplifier, the upstream data from pump light are imposed onto a continuous-wave probe light provided from central office. An optical delay interferometer at CO tailors the chirp of upstream signal to increase bandwidth of the system and dispersion tolerance. The proposed optical transmitter is based on fast gain recovery of amplifier governed by carrier-carrier scattering and carrier-phonon relations [E. Wong *et al.* 2011]. End-to-end real-time optical orthogonal frequency-division multiple-access passive optical networks (PONs) with adaptive dynamic bandwidth allocation (DBA) and colourless optical network units (ONUs) are experimentally established, for first time. Next generation Passive Optical Network (PON) technology has been developing to consolidate metro and access networks in order to offer improved capacity, high split ratio and compact deployment cost per subscriber. However, transmission of signals to long distances up to100km leads to increased propagation delay whereas high split ratio may lead to long cycle times resulting in large queue occupancies and long packet delays.

This paper investigates 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 [N. Suzuki *et al.* ,2011].

3. System Architecture and its Components

In optical networks, the wavelength division Multiplex-ing 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 1.

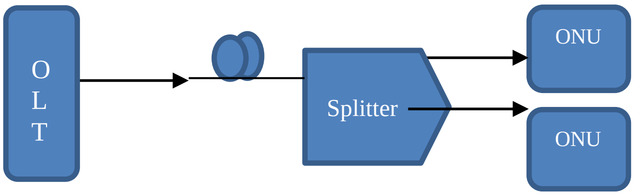

Figure 1: System Architecture of a System

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 [M. Matsuura and E. Oki,2010].

A. Optical Line Terminal

The OLT is located in a central office and controls the bidirectional flow of information across the ODN. An OLT must be able to support transmission distances across the ODN of up to 20 km. In the downstream direction the function of an OL T is to take in voice, data, and video traffic from a long-haul or metro network and broadcast it to all the ONT modules on the ODN. In opposite direction (upstream), an OLT accepts and distributes multiple types of voice and data traffic from the network users. four independent passive optical net-works. In this case, A typical OLT is designed to control more than one PON gives an example of an OLT that is capable of serving if there are 32 connections to each PON, the OLT can distribute information to 128 ONTs. As described OLT equipment must adhere to specific PON standards, so it can interface with ONT modules from different manufacturers. In addition, the OLT typically is located within a central office [B. Ramamurthy., Mukherjee,1998]. OLTs include the following features:

1) A wavelength division multiplexing means for performing an electro/optical conversion of the serial data of the downstream frame and performing a wavelength division multiplexing thereof.
2) An upstream frame processing means for extracting data from the wavelength division multiplexing means, searching an overhead field, delineating a slot boundary, and processing a physical layer operations administration and maintenance (PLOAM) cell and a divided slot separately.
3) A control means for controlling the downstream frame processing means and the upstream frame processing means by using the variables and the timing signals from the control signal generation means [T. Yoshida et al.,2006].

B. Optical Network Terminal

ONT is located directly at the customer's premises. There its purpose is to provide an optical connection to the PON on the upstream side and to interface electrically to the customer equipment on the other side. Depending on the communication requirements of the customer or block of users, the ONT typically supports a mix of telecommunication services, including various Ethernet rates, T1 orE1 (1.544 or 2.048Mbps) and DS3 or E3 (44.736 or 34.368Mbps) telephone connections, ATM interfaces (155Mbps), and digital and analog video formats. A wide variety of ONT functional designs and chassis configurations are available to accommodate the needs of various levels of demand. At the high-performance end, an ONT can aggregate, groom, and transport various types of information traffic coming from the user site and send it upstream over a single fiber PON infrastructure [P. Urban et al., 2009].

C. Optical Network Unit

An ONU normally is housed in an outdoor equipment shelter. These installations include shelters located at a curb or in a centralized place within an office park. Thus, the ONU equipment must be environmentally rugged to withstand large temperature variations. The shelter for the outdoor ONU must be water-resistant, vandal-proof, ACTIVE PON MODULES 105 and be able to endure high winds. In addition, there has to be a local power source to run the equipment, together with emergency battery backup. The link from the ONU to the customer's premises can be a twisted-pair copper wire, a coaxial cable, an independent optical fiber link, or a wireless connection. An alternative approach is to allow ONUs to adjust their transmitter powers such that power levels received by OLT from all ONUs become the same [R. D. Der and Y. J. Jhong,2010].

4. Design and Implementation

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 [U. Hilbk *et al*.,1996]. 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. Routing algorithms often have one or more of the following design goals:

- Optimality
- Simplicity and low overhead
- Robustness and stability
- Rapid convergence
- Flexibility

A. Shortest Path Approach

The Dijkstra's algorithm computes shortest path between two points on a network using a graph made up of nodes and edges. It allocates to every node a cost value. Set it to zero for source node and infinity for all other nodes. The algorithm splits the nodes into two sets: tentative and permanent. It selects nodes, makes them tentative, inspects them, and if they pass the criteria, makes them permanent. It computes length of the shortest path from the source to each of the remaining vertices in the graph. Breadth-first-search is an algorithm for finding shortest (link-distance) paths from a single source vertex to all other vertices. Dijkstra's algorithm uses the greedy approach to solve the single source shortest problem. It repeatedly selects from unselected vertices, vertex v adjacent to source s and declares the distance to be the actual shortest distance from s to v. The edges of v are checked to see if their destination can be reached by v followed by the relevant outgoing edges. Therefore, assume that G (V, E) is the network with E is the number of edges and the V is the number of vertices [M. Matsuura and E. Oki, 2010].

The algorithm can be well-defined by the following steps [M. Matsuura and E. Oki, 2010]:

1. Start with the source node: the root of tree.
2. Assign a cost of 0 to this node and make it first permanent node.
3. Examine each neighbor node of node that was last permanent node.
4. Assign a cumulative cost to each node and make it tentative.
5. among the list of tentative nodes

a. Find node with the smallest cumulative cost and mark it as permanent. A permanent node will not be checked ever again; its cost recorded now is final.

b. If a node can be reached from more than one direction, select the direction with shortest cumulative cost.

6. Repeat steps 3 to 5 until every node becomes permanent.

B. Genetic Algorithm

In proposed algorithm, any path from the source node to the destination node is a feasible solution. The optimal solution is shortest one. Genetic Algorithms (GA) are straight, parallel, stochastic method for global search and optimization, which imitates the evolution of living beings, described by Charles Darwin. GA are part of group of Evolutionary Algorithms (EA). The evolutionary algorithms use the three main principles of the natural evolution: reproduction, natural selection and diversity of species, maintained by the differences of each generation with the previous. Genetic Algorithms work with a set of individuals, representing possible solutions of task. The selection principle is applied by using a criterion, giving an evaluation for individual with respect to desired solution. The best-suited individuals create next generation [R. D. Der. and Y. J. Jhong *et al.*,2010].

The EA holds a population of individuals (chromosomes), which progress by means of selection and other operators like crossover and mutation. Every individual in the population gets an assessment of its adaptation (fitness) to the environment. In terms of optimization this means, that the function that is maximized or minimized is assessed for every individual. The selection chooses best gene combinations (individuals), which through crossover and mutation should drive to better solutions in the next population. One of the most often used schemes of GA is shown on Figure 2.

1. Generate initial population – inmost of algorithms the first generation is arbitrarily generated by selecting genes of the chromosomes among allowed alphabet for gene. Because of easier computational procedure it is accepted that all populations have same number (N) of individuals.

2. Calculation of the values of function that we want to minimize or maximizes.

3. Check for termination of the algorithm – as in most optimization algorithms, it is possible to stop genetic optimization by:

a) Value of the function – the value of function of the best individual is within defined range around a set value. It is not recommended to use this standard alone, because of the stochastic element in search the procedure, optimization might not finish with insensible time;

b) Maximal number of iterations – this is most widely used stopping criteria. It assurances that algorithms will give some results within some time, whenever it has touched the extreme or not;

c) Stall generation – if within initially set number of iterations (generations) there is no improvement of value of the fitness function of best individual the algorithms stops.

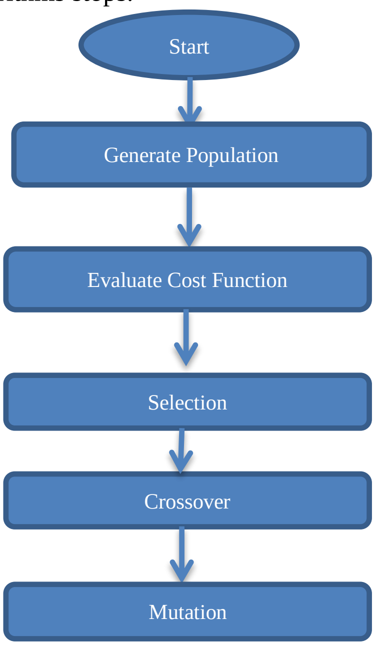

Figure 2: Proposed Genetic Algorithm

4. Selection – between all individuals in current population are selected those, who will continue and by means of crossover and mutation will produce offspring population. At this stage elitism could be used – best individuals are directly transferred to the next generation. The superiority guarantees, that the value of optimization function cannot get worst (once the extreme is reached it would be kept) [R. D. Der. and Y. J. Jhong *et al.*,2010].

5. Crossover – the individuals chosen by selection recombine with each other and new individuals will be created. The aim is to get offspring individuals that receive best possible combination of the characteristics (genes) of their parents.

6. Mutation – by means of random change of some of the genes, it is guaranteed that even if none of personalities contain the necessary gene value for extremum, it is still possible to reach the extremum.

5. Results and Discussion

A. Simulation Tool: MATLAB

MATLAB is a high-performance language for technical computing. It mixes computation, visualization, and programming in an easy-to-use atmosphere where problems and solutions are expressed in familiar mathematical notation. It is given by fig 3.

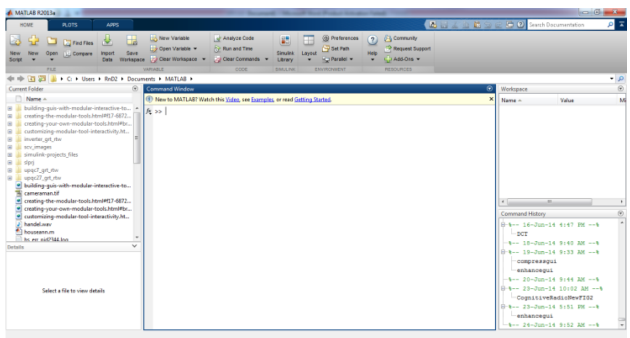

Figure 3: MATLAB Tool

B. Graphical User Interface

In computing graphical user interface is a type of user interface that allows users to interact with electronic devices using images rather than text commands.

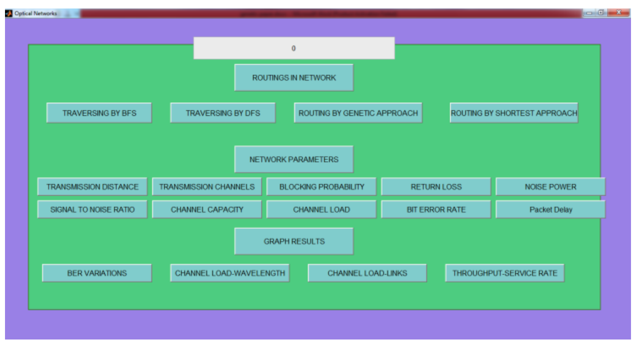

Figure 4: Proposed GUI

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. The proposed GUI is given by fig 4.

C. Graph Traversing

The most fundamental graph problem is to traverse every edge and vertex in a graph in a systematic way. BFS visits the sibling nodes before visiting child nodes. Usually a queue is used in search process as shown in fig 5. It's usually used to find the shortest path from a node to another. The two approaches are used: BFS and DFS. BFS uses queue for traversing while DFS uses stack. The traversing order is shown in graph as well with node number.

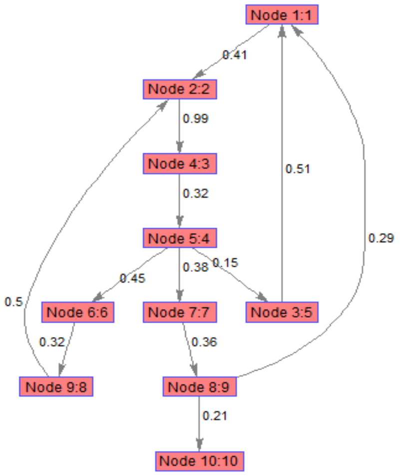

Figure 5: Traversing in Networks by BFS Approach

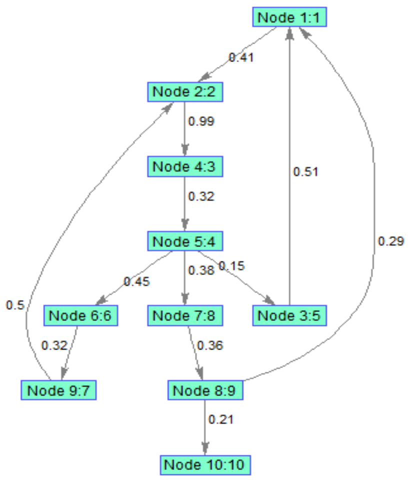

Figure 6: Traversing in Networks by DFS Approach

D. Routing in Network

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 6 & 7. The fig 6 shows the shortest path routing for directed graph from node 1 to node 8 while fig 8 shows the routing for undirected graph.

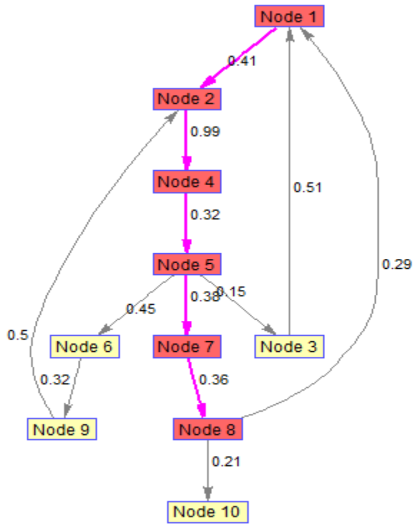

Figure 7: Routing in Networks by Shortest Path Approach

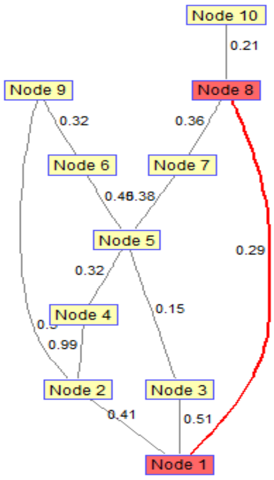

Figure 8: Routing in Networks by Shortest Path Approach for Undirected Graph

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 in fig 9 & fig 10.

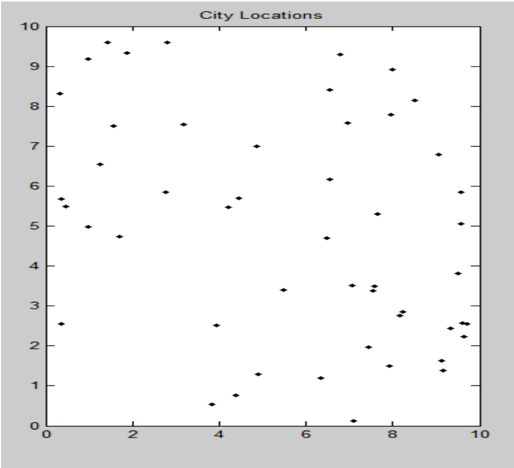

Figure 9: Node Locations in Genetic Approach

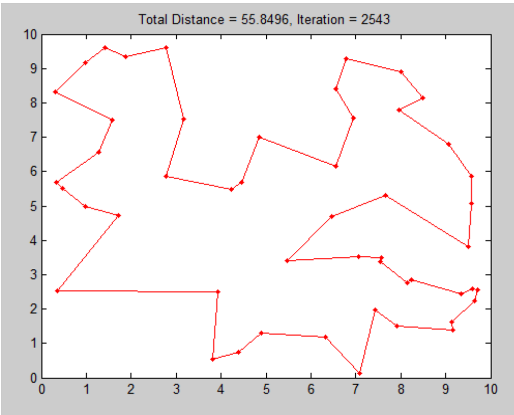

Figure 10: Network Routing by Genetic Approach

E. Effect on Performance Parameters

In fig 11, it shows the relation between channel load and wavelength of signal. As wavelength increases, channel load also increases and vice-versa.

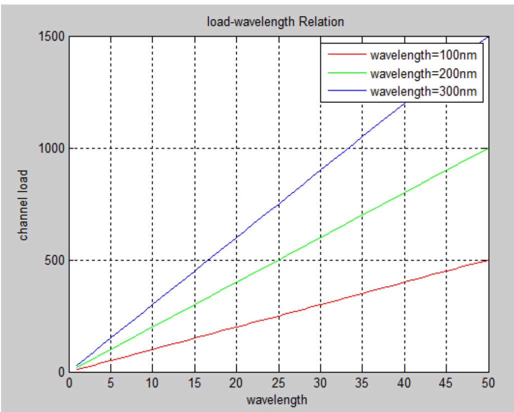

Figure 11: Channel Load-Wavelength Relation

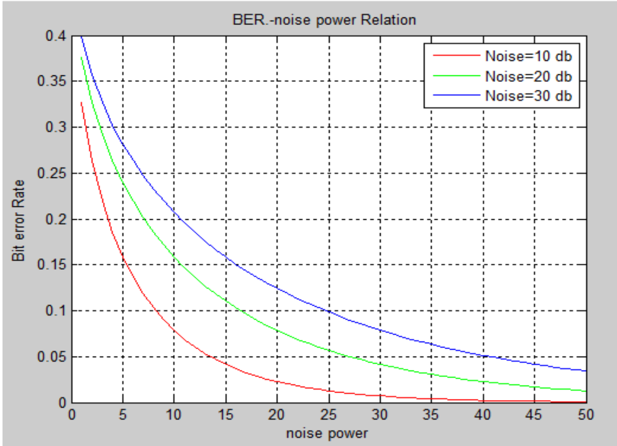

Figure 12: BER-Noise Relation

The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit-less performance measure quantity. The graph shows the relation between bit error rate and noise power. As noise increases, BER also increases exponentially and vice-versa as shown in fig 12.

Conclusion

This paper investigated the routing problem by genetic approach and shortest path in WDM networks. Genetic Algorithms are easy to apply to a wide range of problems, from optimization problems to inductive perception learning, scheduling, and layout problems. The results can be very decent on some problems, and rather poor on others. If mutation is used, algorithm is very slow. Crossover makes the algorithm significantly faster. GA is a like hill-climbing search; more especially it is very similar to a randomized beam search. As with all hill-climbing algos, there is a problem of local maxima. It assigns upstream bandwidth in rectangles trying to minimize the average delay of each reservation. It is proved that the results for the transmission through the two hop networks are successful with reduced BER. The simulation results show that the proposed algorithm improves the network cost compared to a simple placement heuristic. It also calculates the performance parameters like channel load and BER. The relation between load and wavelength is also plotted.

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