International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 02 Issue: 03 | June-2015 www.irjet.net p-ISSN: 2395-0072

Implementation of Genetic Algorithm for Combined Routing and Dimensioning for Dynamic WDM Networks

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Abstract - ***As compared to the Static operation of WDM networks, the dynamic operation of WDM networks might lead to significant wavelength savings, at the expense of facing nonzero blocking probability. Hence, for this network efficient dimensioning (i.e., determining each link capacity) is required. Typically, the dimensioning of WDM networks is done only after defining the routing algorithm. but doing this way results in inefficient solutions in terms of wavelength requirements. So this paper proposes a novel genetic algorithm to solve the combined routing and dimensioning problem in dynamic WDM networks, with the aim of minimizing the network cost. This algorithm determines which route should be used for each potential connection and also dimensions the number of wavelengths required in each link. The performance of the algorithm is analysed using mesh topologies, providing wavelength savings when compared with the best existing algorithm. Since the routes provided by the genetic algorithm are stored in routing tables, It helps in fast online network operation. The Same algorithm is simulated using MATLAB software.***

Keywords-*WDM, dimensioning, genetic algorithm.*

1. INTRODUCTION

The size and speed of information exchange needs to be increase to meet the current trends in multimedia communications include voice, video, data and images. Recent advances in optical switching and in particular wavelength division multiplexing (WDM) have enabled next generation networks to be able to operate at several Terabits per second. The high bandwidth demands enforced on transport networks by the ever-increasing amount of network traffic can only be met by using wavelength division multiplexing (WDM) networks. Such networks, now successfully used throughout the world, and can transmit data at multiple carrier wavelengths (channels) over a single fibre reaching transmission speeds in excess of 25 Tb/s [2].

Although the cost of an optical network depends on many factors (e.g., number of transmitters/receivers, optical amplifiers, wavelength converters, regenerators, OADMs, number and type of fibres), to make this model independent of technological advances, we represent the network cost by the total wavelength requirements since the cost of most optical network components is affected by this parameter.

The main reason for migrating from static to dynamic operation is that for the efficient use of wavelengths. The fundamental importance of dynamic WDM network is that efficient dimensioning (i.e. in the network link how many wavelength channels are required). But efficient dimensioning is strongly dependent on the Routing algorithm we use. solving routing and dimensioning problem together, complexity increases [1].

This paper focuses on combinedly routing and dimensioning (i.e. determining link capacities) of dynamic WDM networks by genetic algorithm.

2. BACKGROUND

Solving the routing and the dimensioning problems separately an optimal solution cannot be guaranteed. Hence, Vallejos *et al.* demonstrated in Ref. [4] proposed to jointly solve the routing and dimensioning problems by means of an Integer Linear Programming (ILP) formulation that depends on an improved version of the dimensioning method developed in Ref. [3]. The results obtained for ILP formulation definitely minimizes the network dimensioning, but the results can be obtained for nodes less than 10(<10). But in this paper the results can be obtained for node count greater than 10. In [1] the joint routing and dimensioning is done for traffic load (ρ) varying from 0.1 to 0.9 by using genetic algorithm. The results are compared with the ILP formulation and BR-AD values explained in [1].

In this paper titled Implementation of Genetic algorithm for dynamic WDM networks by genetic algorithm obtains results when it is run for different traffic load varying from 0.1 to 0.4 (only 4 values have been taken, because most savings there in this range) and values are compared to BR-AD (Balanced routing and adaptive dimensioning) as given in [1].

3. PROPOSED MECHANISMS

Genetic algorithm is a search technique, where the fittest one will survive. The term Genetic algorithm is a biological term in which initial chromosomes are generated and undergoes genetic operators such as crossover, mutation. The proposed mechanism for combined routing and dimensioning of dynamic WDM networks by genetic algorithm solves the routing together with dimensioning for different mesh topologies. Here I've considered two mesh topology, they are EUROCORE net and NSFNet.

Eurocore network is a standard network for both in Europe and Asia. It is 11 nodes network. here i've considered 50 available links. NSFNet is standard 14 node mesh network and available links taken here is 42 links. In both the cases Maximum connection are N*(N-1), where N is Number of nodes. In this proposed paper the routing is found out in connection with dimensioning (wavelength requirement) for traffic load varying from 0.1 to 0.4. Keeping the target blocking probability of 10^-6. Routing and dimensioning is done together for efficient use of wavelengths. Routing is done with min. no of hops.

3.1 Network Model

In this paper the topology of dynamic WDM networks is represented by a graph G=(N,L).
Where N= No. of nodes in the network
L= Set of unidirectional links
The Mesh topologies considered here are

a. EUROCOREnet (11 nodes, 50 links)
b. NSFnet(14 nodes, 42 links)

3.2 Cost Model of network

The network cost, C_{net}, is the sum of all wavelength resources required, i.e.

$$C_{net} = \sum_{l \in L} Wl \qquad (a)$$

Eventhough network cost depends on different network elements like no. Of wavelength converters, no. Of transmitters/receivers, optical amplifiers etc. These elements cost is indirectly affected by the total wavelength requirements. So if we try to save the wavelength that is indirectly saving bandwidth.

3.3 Traffic and Routing Model

Source of each connection generates traffic according to ON-OFF process. The ON period corresponds to data transmission time. OFF period represents time between successive data transmission. The mean duration of ON and OFF periods is denoted by t_{ON} and t_{OFF} respectively. The traffic load (ρ) is given by

$$\rho = \frac{ton}{ton + toff} \qquad (b)$$

3.4 Problem definition

For the given input parameters:

- G= (N,L), the network topology, consists of N nodes and L unidirectional links.
- ρ, the traffic load of a connection.
- B_{c_target}, the target value of blocking probability per connection, i.e., no connection should experience a blocking probability greater than B_{c_target}.

Find the values of the variables:

- R={r_c},the set of routes.
- W={w_l}, set of capacities of links, in terms of no. of wavelengths required.

The objective of minimizing the network cost is given by

$$\text{Min } C_{net} = \sum_{l \in L} Wl \qquad (c)$$

Subject to:

$$B_c \le B_{c\_target}\,,\ \forall\ c \in C \qquad (d)$$

Where B_c= Blocking probability of connection C and B_c is the function of the set of routes determined, the no.Of wavelengths in the network links and the traffic load.

$$B_c \equiv B_c(c, \rho, R, W),\ \forall\ c \in C \qquad (e)$$

For each connection, wavelengths (W_l) is provided, so that network cost (C_{net}) is minimized but guaranteeing that B_c does not exceed the given target (B_{c_target}). Solving eqns. (c), (d), (e) complexity increases, because the no. Of possible routes b/w a given set of source-destination pair is very large. Therefore in order to decrease the complexity, a new formula is provided which aims at selecting the best route from the set of precalculated candidate routes for each connection c∈C. Let K_c be the no. of precalculated candidate routes to connect source and destination nodes.

3.5 Steps in the proposed method for genetic algorithm.

Genetic algorithms are search methods. It will search over a large geographic area, where the stronger individuals or chromosomes will survive. In Genetic algorithm the solution to any problem is individuals or chromosomes. The fitness function is defined. Initial population is created randomly and then evolved through crossover and mutation operation.

3.5.1 Individuals:

Individuals or chromosomes are a vector of C genes, one gene per connection c∈C.

3.5.2 Fitness Evaluation:

We say that the individuals or chromosomes are fitter, if their network cost is lower. The dimensioning method proposed in this paper aims at B_c does not exceeds a given target blocking probability (B_{c_target}). This subsection is given in [1, 6-9].

The blocking probability of connection C is given by the following equation,

$$B_c = 1-\prod_{\forall l \in r_c}(1-B_l),\ \forall\, c \in C \qquad \text{(f)}$$

Where B_l is the blocking probability of link l. And is given by,

$$B_l \le 1- \sqrt[\hat{H}_l]{1 - B_{c\_target}},\ \forall\, l \in L \qquad \text{(g)}$$

Where $\hat{H}_l$= length of the (in no. Of hops) longest route using link l.

On the other hand blocking probability of the link l is given by,

$$B_l = \lambda_l(W_l)P_l(W_l)/\ \lambda_l,\ \forall\, l \in L \qquad \text{(h)}$$

Where

W_l= no. Of wavelengths of link l.

$\lambda_l(W_l)$= mean arrival rate of connection requests to link l when W_l wavelengths are in use.

$P_l(W_l)$= the probability of W_l wavelengths are in use.

λ_l= mean arrival rate of connection requests to link l.

i.e.,

$$\lambda_l(W_l)=(T_l - W_l)\lambda,\ \forall\, l \in L \qquad \text{(i)}$$

T_l= The no. Of routes in R that use link l.

λ= Mean burst arrival rate of connections.

To determine the $P_l(W_l)$, Initially assume that link l has T_l no. Of wavelengths (i.e., $W_l=T_l$). Given that each connection is in the ON state with probability, $\rho = \frac{t_{on}}{t_{on}+t_{off}}$, The state of connection is given by Bernoulli experiment with parameter ρ. Hence the probability of having W connections in the ON state in link l, i.e., the probability of having W used wavelengths in link l, $P_l^*(w)$ is given by a binomial distribution with parameters (T_l, ρ).

$$P_l^*(w)=\binom{T_l}{w}\rho^w(1-\rho)^{T_l-w},\ \forall\, l \in L \qquad \text{(j)}$$

$$P_l(w_l)=\frac{\binom{T_l}{w_l}\rho^{w_l}(1-\rho)^{T_l-w_l}}{\sum_{n=0}^{W_l}\binom{T_l}{n}\rho^n(1-\rho)^{T_l-n}},\ \forall\, l \in L \qquad \text{(k)}$$

$$\lambda_l=\sum_{W=0}^{W_l}\lambda_l(W)P_l(W),\ \forall\, l \in L \qquad \text{(l)}$$

3.5.3 Initial population:

In the proposed method, the initial population consists of 'P' chromosomes, and are generated randomly between 0 to k_c-1.

3.5.4 Evolution:

In the proposed method pair of chromosomes are randomly selected according to roulette wheel selection technique [5]. Here the parent chromosomes undergo crossover operation, either partial genetic material exchange or full crossover operation and produces children which may be fitter than parent chromosomes or not. If the parent chromosomes are fitter, then they are copied to the next generation. If the children's are fitter then they becomes the parents and they produce the subsequent generation. Like this generations are produced until the predefined criteria is met (no. of generations). Elitism is incorporated in the algorithm.

4. PERFORMANCE ANALYSIS

4.1 For EUROCORE network

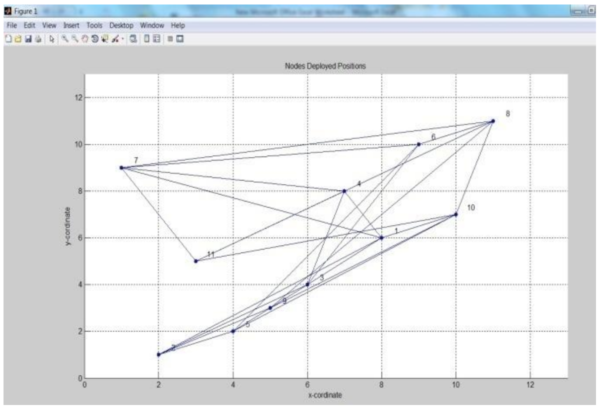

Fig-1: Network topology for EUROCORE net with 50 available links

Traffic load(ρ)	Proposed method	BR-AD Algorithm[1]
0.1	26	174
0.2	94	174
0.3	108	174
0.4	126	174

Table-1: Wavelength Requirement (network cost) for EUROCORE network.

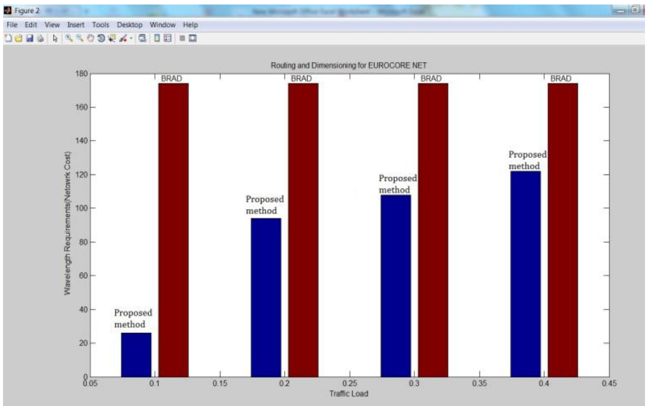

Fig-2: Routing and dimensioning for EUROCORE net topology.

As we can see from the Table.1 and fig.2 graph, the wavelength requirements for EUROCORE mesh topology from the proposed method at 0.1 traffic load is 26, but for the same traffic load the wavelength requirements is 174 in case of BR-AD [1]. For other traffic load the values are mentioned in table.

4.2 For NSFnet

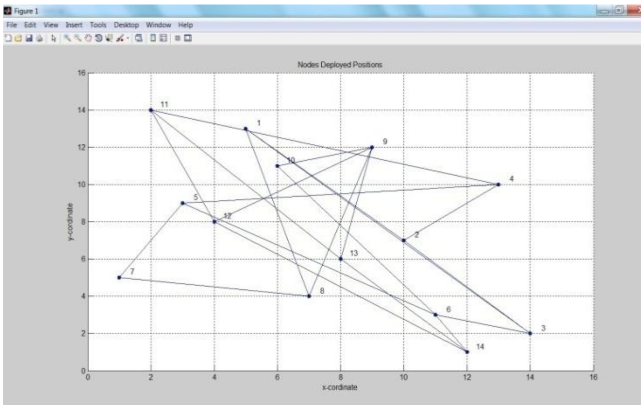

Fig-3: Network topology for NSFnet with 42 available links

Traffic load(ρ)	Proposed method	BR-AD Algorithm [1]
0.1	84	322
0.2	130	370
0.3	246	390
0.4	298	390

Table-2: Wavelength Requirements (network cost) for NSFNet topology.

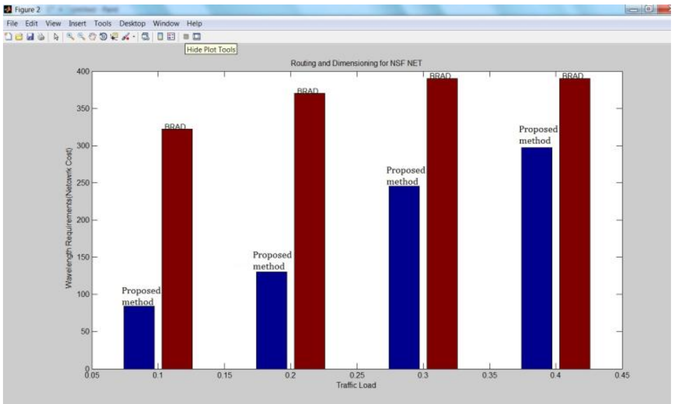

Fig-4: Routing and dimensioning for NSFnet topology

For NSFNet mesh topology, for traffic load of 0.1 the wavelength requirements are 84 from the proposed algorithm whereas for BR-AD algorithm [1] it requires 322 at the same traffic load. Other values are shown in table.

5. CONCLUSION

The proposed method solves the Routing and dimensioning problem in dynamic WDM networks together by genetic algorithm. The values obtained with this method are compared with the values given for BR-AD in [1]. The result shows that there is a significant wavelength savings (Network cost) compared to the existing methods. Most savings are observed in the traffic load range from 0.1 to 0.4. The mesh topologies considered here for the analysis are EUROCORE and NSFnet.

REFERENCES

[1] Ignacio de Miguel, Reinaldo Vallejos, Alejandra Beghelli, and Ramón J. Durán, "Genetic Algorithm for Joint Routing and Dimensioning of Dynamic WDM Networks", J. OPT. Commun. Network. /VOL. 1, NO. 7, pp 608-621, Dec 2009.

[2] A. H. Gnauck, G. Charlet, P. Tran, P. J. Winzer, C. R. Doerr, J. C. Centanni, E. C. Burrows, T. Kawanishi, T. Sakamoto, and K. Higuma, "25.6 Tb/s WDM transmission of polarizationmultiplexed RZ-DQPSK signals," *J. Lightwave Technol.*, vol. 26, no. 1, pp. 79–84, Jan. 2008.

[3] R. Vallejos, A. Zapata, and V. Albornoz, "Optimal routing for minimum wavelength requirements of end-to-end optical burst switching rings," *Lect. Notes Comput. Sci.*, vol. 4534, pp. 443–457, 2007.

[4] R. Vallejos, A. Zapata-Beghelli, V. Albornoz, and M. Tarifeño, "Joint routing and dimensioning of optical burst switching networks," *Photonic Network Commun.*, vol. 17, no. 3, pp. 266–273, June 2009.

[5] D. E. Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning, Addison-Wesley, 1989.

[6] R. Vallejos, A. Zapata, and M. Aravena, “Fast and effective dimensioning algorithm for end to end optical burst switching networks with ON-OFF traffic sources,” *Lect. Notes Comput. Sci.*, vol. 4534, pp. 378–387, 2007.

[7] R. Vallejos, A. Zapata, and M. Aravena, “Fast blocking probability evaluation of end-to-end optical burst switching networks with non-uniform ON-OFF input traffic model,” *Photonic Network Commun.*, vol. 13, no. 2, pp. 217–226, Apr. 2007.

[8] D. K. Hunter and D. Marcenac, “Optimal mesh routing in fourfibre WDM rings,” *Electron. Lett.*, vol. 34, no. 8, pp. 796–797, Apr. 1998.

[9] S. Baroni and P. Bayvel, “Wavelength requirements in arbitrarily connected wavelength-routed optical networks,” *J. Lightwave Technol.*, vol. 15, no. 2, pp. 242-251, Feb. 1997.