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Blocking Analysis in Optical WDM network

Harpreet Kaur[1*], Munish Rattan[2]

[1]I.K. Gujral Punjab Technical University Jalandhar, Kapurthala, Punjab, India
[1]Dep. of Electronics & Communication, Baba Banda Singh Bahadur Engineering College Fatehgarh Sahib, Punjab, India
[2]Dep. of Electronics & Communication, Guru Nanak Dev Engineering College, Ludhiana, Punjab, India

Corresponding author: harpreet.mavi@bbsbec.ac.in

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***Abstract*:** Demand of enormous bandwidth is explosively increasing nowadays. It can be fulfilled with the use of wavelength division multiplexing technology(wdm). Using optical wdm network for data transfer applications involves establishing the light paths for the traffic requests. In this paper, traffic scheduling of irregular requests is done with the use of the hybrid heuristic technique of flower pollination and simulated annealing algorithm. Also, the effect of number of wavelength channels present is analyzed using full wavelength conversion and nil wavelength conversion capability at the intermediate nodes. The results obtained after extensive simulation proved that the wavelength count of 16 is the most optimum count of wavelength resulting in proper resource optimization. Also, the hybrid of flower pollination and simulated annealing produces more promising results relative to chaotic particle swarm optimization in the context of the blocking probability for irregular traffic.

Keywords: Irregular, Blocking Probability, Utilization, Channels, Bandwidth

I. INTRODUCTION

With the invention of WDM (wavelength division multiplexing) many applications for e.g. multimedia, video conferencing, internet etc. are gaining popularity in today's era. These applications require vast bandwidth which can be fulfilled using optical networks. WDM technology enables the optical fiber to exploit it huge capacity in proper manner which makes WDM as vital part of future generation networks [1][2]. In WDM technology, each fiber strand can be partitioned into number of channels carrying distinct wavelengths [3]. Multiple signals can be carried over a single strand of fiber simultaneously [4]. Each optical fiber link have a capacity to handle data at the rate of Tb/s but the end users exhibits limited electronic speed i.e. in the range of Gb/s so to provide the consistency in speed of end users and optical fiber ,WDM technology act as the solution model [5].To carry information using WDM Optical networks, traffic is needed to be routed over the optical medium and wavelength channel is to be assigned for the same so it's very important to efficiently address the issue of forming the light paths for incoming traffic.

The Routing and wavelength assignment (RWA) means to route the connection demands in the form of light paths and allocating wavelengths to them [6]. RWA can be described as static RWA and

dynamic RWA according to the type of connection demands they are routing [7].If the connection requests are in prior knowledge and one has to route them and assign them wavelength then its static RWA, whereas when connection requests are established and torn out at random times ,one has to establish the light path for them and assign them wavelength then it is dynamic RWA provided in both the cases one has to optimize any parameter like minimizing blocking probability, increasing throughput, minimizing the number of wavelengths etc.[8,9]

Static RWA is also known as offline RWA whereas dynamic RWA is known as online RWA. [10]. If all the light paths of the route have similar wavelengths, then it results to wavelength continuity constraint but it cannot be realized realistically so to maintain the same wavelengths wavelength converters are needed [11].

The remaining paper is catalogued as Section II presents related literature work, Section III presents problem formation and Section IV discusses the results obtained and Section V contains concluding remarks.

II. RELATED WORK

Both the problems i.e. static as well as dynamic RWA is solved in literature with various algorithms optimizing the parameter of interest.
In [6], Chaotic Particle Swarm Optimization (CPSO) based RWA algorithm had been proposed. The proposed algorithm leads to optimization of blocking probability.

In [8], an ant based approach for online RWA for optical WDM networks was formulated. From simulation results it was concluded that this approach can adapt to the traffic variations easily relative to fixed routing and fixed alternate routing. Moreover, the blocking probability was also optimized.

In [10], effectual algorithms were proposed for RWA with varying traffic both with no wavelength conversion(NWC) and full wavelength conversion(FWC) capabilities. The algorithms proved to be simple and potent.

In [12], the RWA problem was demonstrated with the conceit of partition coloring. A new tabu search heuristic algorithm was presented for this purpose. Experimentation results proved that proposed heuristic algorithm improves the results in the lesser computation time.

In [13], multi objective ILP approach had been proposed to optimize the throughput by routing the traffic on the widest paths. Resource consumption found nearly equal as for the shortest path algorithm whereas the blocking probability is found to be optimal.

In [14], LP-relaxation based algorithm had been proposed which leads to key for the offline RWA. The simulation results proved it to be good solution in minimum acceptable time for real world problems.

In [15], an adaptive routing algorithm has been proposed for online RWA in optical network. This algorithm has better blocking probability compared to other existing algorithm.
In [16], an ant colony based technique for RWA in wdm networks with inadequate wavelength conversion was demonstrated which results in almost optimum solution. But, increased iterations may lead to high execution time.

In [17], the hybrid of flower pollination and simulated annealing(FA+SA) was used to perform offline RWA for fixed number of connection requests both in 14 and 20 node network using different number of channels available i.e. 8,16,32. Also, RWA with varying connection demands was analyzed with wavelength count of 8 with FWC and NWC in 14 node network. The results obtained are more efficient than algorithms present in [18] and [19] but in this, the effect of differing the wavelength count is not shown for uncertain traffic conditions.

The hybrid of Flower pollination and simulated annealing was proposed by Baset and Hezam in 2016 for providing optimized solution for engineering issues [20]. In this paper, the heuristic algorithm based on Flower Pollination and Simulated Annealing algorithm(FA+SA) is employed to tackle the RWA problem for dynamically alternating connection demands with FWC and NWC in 20 node network. Number of available wavelengths are also varied to analyze their effect on network performance. The simulation results are evaluated in terms of the blocking probability.

III. PROBLEM FORMULATION

Firstly, a network is considered on which traffic demands are to be routed. Traffic is routed on the EON (20 nodes) network in which type of traffic taken is poisson in nature. The irregular connection requests are sent over the network. The performance metric taken in consideration is the blocking probability. The algorithm comprising of flower pollination and simulated annealing optimized the performance of RWA with and without wavelength continuity constraint where traffic conditions are uncertain. Matlab coding is used to perform the simulations.

IV. RESULTS AND DISCUSSION

Flower pollination was proposed by Yang, X.S. [21] and Simulated Annealing was proposed by Kirkpatrick et al. [22]. The algorithm based on flower pollination and simulated annealing is utilized to combine the best of their features to obtain optimization. Here, in this paper the irregular traffic is routed on the EON (20 node) network with FWC and NWC capability. Also the number of wavelength channels available are varied to check it influence on the network outcome. The analysis of the blocking probability is done w.r.t load (in erlangs) and w.r.t to normalized load. To highlight the effect of the hybrid(FA+SA) technique used for the irregular traffic conditions the blocking probability obtained is compared with the blocking probability obtained using CPSO in [6]. The blocking probability variation w.r.t loads in erlangs for irregular traffic in 20 node network with wavelength count of 8,16,32 is shown in Table 1 to Table 3 and Fig 1 to Fig 3.

Table 1: The blocking Probability for irregular traffic in 20 node network using the hybrid(FA+SA) w.r.t load (erlangs) [wavelength count 8]

With Wavelength Count =8				
Load (erlangs)	10	12	14	16
Average Blocking Probability (FWC)	**0.0004**	**0.0263**	**0.0395**	**0.0714**
Average Blocking Probability (NWC)	**0.0016**	**0.0147**	**0.0490**	**0.0603**

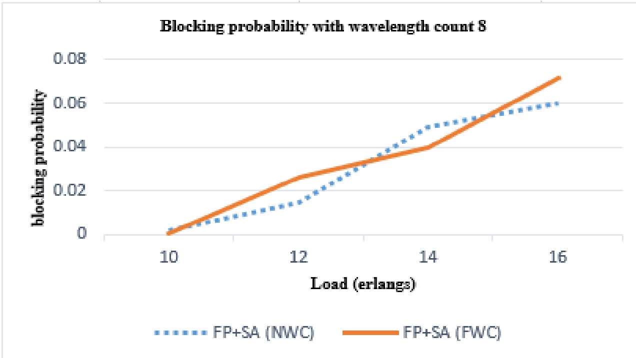

Figure 1: The blocking probability for irregular traffic in 20 node network with FWC and NWC(wavelength count 8)

Table 2: The blocking Probability for irregular traffic in 20 node network using the hybrid(FA+SA) w.r.t load (erlangs) [wavelength count 16]

With Wavelength Count =16				
Load (erlangs)	10	12	14	16
Average Blocking Probability (FWC)	**0.000**	**0.0048**	**0.0355**	**0.0610**
Average Blocking Probability (NWC)	**0.0004**	**0.0052**	**0.0438**	**0.0601**

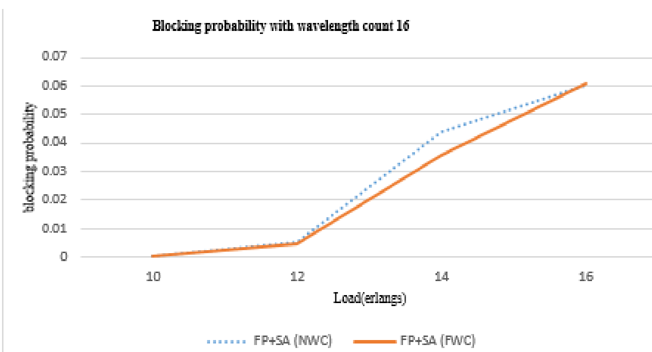

Figure 2: The blocking probability for irregular traffic in 20 node network with FWC and NWC(wavelength count 16)

Table 3: The blocking Probability for irregular traffic in 20 node network using the hybrid(FA+SA) w.r.t load (erlangs) [wavelength count 32]

With Wavelength Count =32				
Load (erlangs)	10	12	14	16
Average Blocking Probability (FWC)	**0.000**	**0.0040**	**0.0370**	**0.0540**
Average Blocking Probability (NWC)	**0.00016**	**0.0098**	**0.0419**	**0.0682**

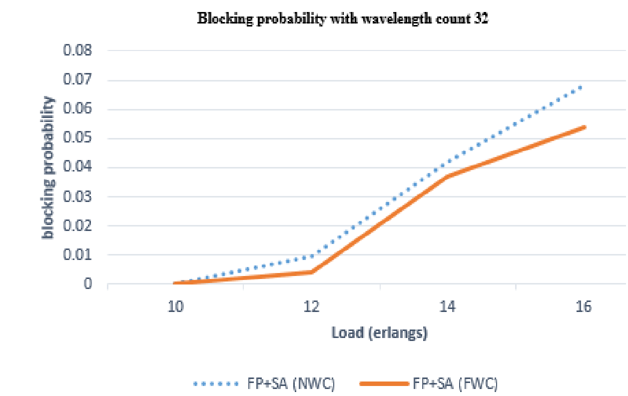

Figure 3: The blocking probability for irregular traffic in 20 node network with FWC and NWC (wavelength count 32)

From Figure 1 to 3,it can be concluded that as the wavelength count increases, FWC results in effectual results as compared to NWC.

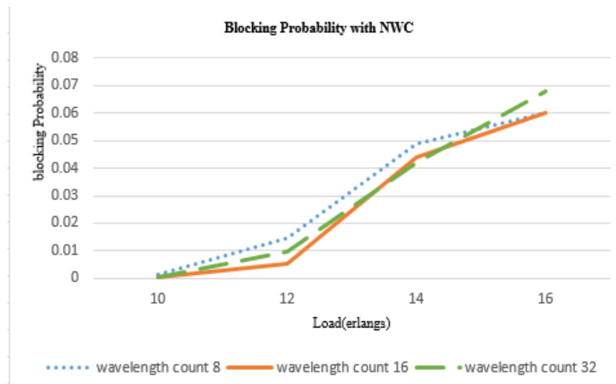

Figure 4: Comparison of the blocking probability for irregular traffic with NWC in 20 node network with wavelength count of 8,16,32

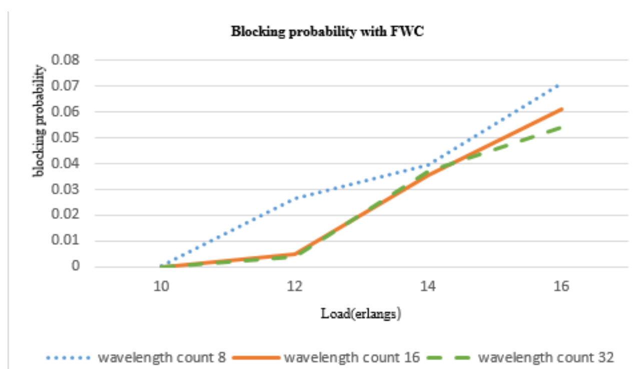

Figure 5: Comparison of the blocking probability for irregular traffic with FWC in 20 node network with wavelength count of 8,16,32

Figure 4 and Figure 5 shows the effect of wavelength count on blocking in the network. From results, the wavelength count of 16 can be stated as the optimum one.

To check the cogency of the technique used, the blocking probability with reference to normalized load is also plotted with nil wavelength conversion and compared to the CPSO technique used in [6].

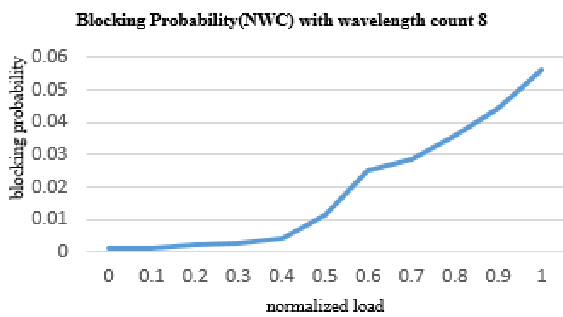

Figure 6: The blocking probability for irregular traffic w.r.t normalized load in 20 node network with wavelength count 8

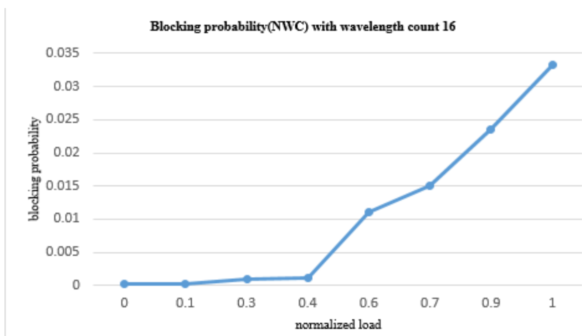

Figure 7: The blocking probability for irregular traffic w.r.t normalized load in 20 node network with wavelength count 16

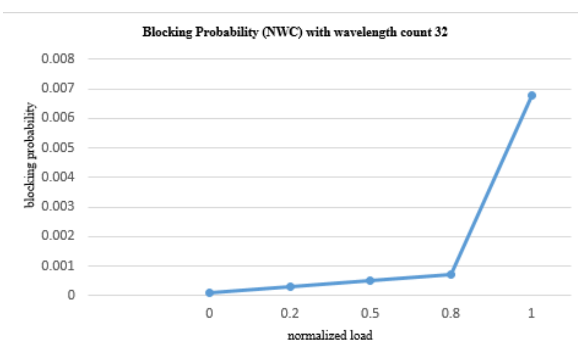

Figure 8: The blocking probability for irregular traffic w.r.t normalized load in 20 node network with wavelength count 32

Extracting the blocking probability from [6], the average blocking probability obtained with CPSO[6] in 20 node network with wavelength count of 8 is approx. (0.532) for the normalized range of load from (0 to 0.5) and with wavelength count 16 it is (0.512) approx for the normalized load from (0 to 1) with nil wavelength conversion. From Figure 6 and 7 the average value of the blocking probability obtained for dynamic traffic in 20 node network with no wavelength conversion with wavelength count of 8 and 16 is less than (0.1) for the complete range of normalized load shown in graphs.Hence,the hybrid of flower pollination and simulated anealing produces proficient results for uncertain traffic in context of the blocking probability as compared to CPSO[6] .

V. CONCLUSION

The routing of irregular traffic is performed using hybrid of flower pollination and simulated annealing in the 20 node optical network. From simulation results,concluding remarks can be made that as the number of available wavelengths channels increases the performance of optical network is enhanced i.e. the blocking with wavelength count of 16 and 32 is optimum as compared with the wavelength count of 8.But the performance in context of blocking probability with wavelength count of 16 and 32 are almost same so it can be concluded that the hybrid of flower pollination and simulated annealing optimize the performance with wavelength count of 16 such that the resources are efficiently utilized. Moreover,the hybrid of Flower pollination and simulated annealing results are more favourable if the blocking in the network is taken under consideration relative to CPSO[6] algorithm for wavering traffic conditions.

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Authors Profile

Mrs. H Kaur is currently working as Assistant Professor in the Department of Electronics and Communication Engineering, Baba Banda Singh Bahadur Engineering College, Fatehgarh Sahib, Punjab, India. She received the M. Tech (Electronics and Communication Engineering) degree from Guru Nanak Dev Engineering College, Ludhiana, Punjab, India and presently she is doing PhD. Degree from I.K. Gujral Punjab Technical University, Jalandhar, Kapurthala. She is having more than 12 years of teaching experience. Her area of interest is optical WDM networks and Burst switching networks.

Dr. M Rattan is currently working as Assistant Professor in the Department of Electronics and Communication Engineering, Guru Nanak Dev Engineering College, Ludhiana, Punjab, India. His area of specialization is Antennas, Wireless Communication, and Nature inspired Computing. He completed B.Tech. in 2002, M.E. in 2004 and Ph.D. in 2010. He has more than 14 years of teaching experience. He has guided one Ph.D. student and currently guiding 4 Ph.D. students. He is Life member of IETE, ISTE, IE(I). He has published several research papers in international and national journals and conferences.