Full Length Research Paper

Algorithm for wavelength assignment in optical networks

Gulzar Ahmad Dar*, Ifrah Amin and Hardeep Sing Saini

Department of ECE, Indo Global College of Engineering, Punjab Technical University, 141401, Chandigarh –India.

Wavelength division multiplexing (WDM) is a technology which multiplexes many optical carrier signals onto a single optical fiber by using different wavelengths. Wavelength assignment is one of the important components of routing and wavelength assignment (RWA) problem in WDM networks. In this article, to decrease the blocking probability, a new algorithm for wavelength assignment- Least Used Wavelength Conversion algorithm is introduced and is an enhancement to the previously used Least Used Wavelength assignment algorithm. The performance of this wavelength assignment algorithm is evaluated in terms of blocking probability and the results show that the proposed technique is very promising in future. The Least Used Wavelength Conversion algorithm is compared with algorithms such as first-fit, best-fit, random and most-used wavelength assignment algorithm.

Key words: Algorithm, wavelength division multiplexing (WDM), routing and wavelength assignment (RWA), first-fit, best-fit.

INTRODUCTION

Wavelength division multiplexing (WDM) is a very promising technology to meet the ever increasing demands of high capacity and bandwidth. The term wavelength-division multiplexing is commonly applied to an optical carrier. In a WDM network several optical signals are sent on the same fiber using different wavelength channels. WDM is used to address routing and wavelength assignment (RWA) problem. The first part of this problem is to route the network and the second is wavelength assignment. Wavelength assignment is one of the important issues in RWA. In general, if there are multiple feasible wavelengths between a source node and a destination node, then a wavelength assignment algorithm is required to select a wavelength for a given light path. Either distinct wavelength is assigned on each link of path or the same wavelength on each link can be used. When the wavelength conversion is not possible at intermediate routing nodes a light path must occupy the same wavelength on each link over its physical route. The clever algorithms are needed in order to ensure that RWA function is performed using a minimum number of wavelengths (Dar and Saini, 2013; Wason and Kaler, 2010).

The Least Used Wavelength Conversion Algorithm (LUWC) is an improvement over least used wavelength assignment algorithm. In LUWC, least– used wavelength assignment algorithm is executed until blocking. Also the

concept of wavelength conversion is used in this model. When the call is blocked, wavelength conversion is introduced and hence blocking probability is reduced. If the full wavelength conversion is used after least–used wavelength assignment algorithm, the blocking probability is reduced to a very large extent and its value reduces to a minimum possible value. Hence, the overall performance of the network increases. The Least Used Wavelength Conversion algorithm is compared with algorithms such as first-fit, best-fit, random and most-used wavelength assignment algorithm. Simulation results proved that the proposed approach is very effective for minimization of blocking probability of optical wavelength division multiplexed networks (Mukherjee, et al., 2004). All the results are taken using MATLAB.

WAVELENGTH ASSIGNMENT

There are two constraints that need to keep in mind while trying to solve RWA. One is distinct wavelength assignment constraint that is, all light paths sharing a common fiber must be assigned distinct wavelengths to avoid interference (Arun and Azizoglu, 2000). This applies not only with in alloptical networks but in access links as well. Another is wavelength continuity constraint which means the wavelength assigned to each light path remains the same on all the links while it traverses from source end-node to destination end-node (Murthy and Gurusamy, 2002; Qi and Chen, 2006). The most important wavelength assignment algorithms are as follows:

(i) First-fit algorithm: In this algorithm, firstly the wavelengths of the traffic matrix are sorted in non decreasing order. Then algorithm steps through this sorted list for selecting candidate chains joined. This process is carried on until all chains are considered to form a single chain representing linear topology. The idea of the first-fit scheme is to pack the usage of the wavelengths toward the lower end of the wavelengths so that high numbered wavelengths can contain longer continuous paths. By using first fit algorithm blocking can be reduced to a great extent as compared to random algorithm (Alyatama, 2005; Yuan and Zhou, 2000).

(ii) Random algorithm: In this algorithm, wavelength is selected randomly from available wavelengths. A number is generated randomly and the wavelength is assigned to this randomly generated number. As this technique chooses a random wavelength from the set of all wavelengths that are available along the path, the blocking probability cannot be minimized as much as compared to other wavelength assignment algorithms (Alyatama, 2005).

(iii) Most-used: The most-used scheme furthers the idea of the first-fit scheme in packing the usage of wavelengths. In this scheme, all the available wavelength

that can be used to establish a connection are considered, the wavelength that has been used the most is selected for the connection. The wavelength usage using the most-used scheme is more compact than that using the first-fit scheme. Studies have shown that with precise global network state information, the most used scheme performs slightly better than the first-fit scheme (Yuan and Zhou, 2000).

(iv) Best-fit algorithm: Among all the wavelengths from the list, this algorithm chooses an efficient wavelength for the assignment and is known to be the best fit wavelength assignment. According to the previous study the best fit algorithm performs better than other existing algorithms. Depending upon the number of wavelengths and load given to the path per unit link, the blocking probability of the best fit increases and decreases respectively (Yuan and Zhou, 2000).

BLOCKING PROBABILITY

If there is no free wavelength available on any link, the call will be blocked. In simple terms blocking probability as per Poisson's formula can be calculated as the ratio of calls blocked to the total number of calls generated as given below

$$P_{Bavg} = \frac{Total\ no.of\ calls\ blocked}{Total\ no.of\ calls\ generated} \qquad (1)$$

The network performance of any network can be measured through blocking probability, which is the statistical probability that a telephone connection cannot be connected due to insufficient transmission resources in the network. Also, the blocking probability on the link can be calculated by famous Erlang-B formula as given by Wan et al. (2003) Equation (2).

$$P_{b(L,W)} = \frac{\frac{L^W}{W!}}{\sum_{i=0}^{W} \frac{L^i}{i!}} \qquad (2)$$

Where, $P_{b(L,W)}$ is blocking probability for L load and W wavelengths.

MODELING SETUP

Here, the enhanced algorithm is given and is evaluated in terms of blocking probability. Following assumptions are made to design the model:

(i) The network is connected in an arbitrary topology. Each link has a fixed number of wavelengths.
(ii) Point to point traffic.
(iii) There is no queuing of the connection request. The connection blocked will suddenly be discarded.

Table 1. For scenario 1.

S/No.	No. of nodes	No. of links	No. of wavelengths	Load per unit link (Erlang's)
1	20	20	20	20
2	20	20	20	20
3	20	20	20	40

Table 2. For scenario 2.

S/No.	No. of nodes	No. of links	No. of wavelengths	Load per unit link (Erlang's)
1	20	20	10	10
2	20	20	30	10
3	20	20	50	10

(iv) Link loads are mutually independent.
(v) Static routing.
(vi) Each station has an array of transmitters and receivers, where W is the wavelengths carried by the fiber.

Firstly, a source to destination pair is selected. Then using the shortest path routing algorithm, a route is selected. After that with the help of proposed algorithm, wavelength is assigned to the route. Until blocking, least–used wavelength assignment algorithm is executed. If the call is blocked, the concept of wavelength conversion is introduced which is done with the help of wavelength converters and hence blocking probability is reduced.

RESULTS AND DISCUSSION

Here, the simulation results of proposed algorithm are shown. The simulation is carried out on simulation software MATLAB 7.2 of The Mathworks, Inc. The blocking probability of network is compared according to the number of channels, load, wavelength and the number of links. Depending upon the varied values of these parameters, two scenarios have been set for obtaining results.

Scenario 1

In this scenario load per unit link is increased from 20 to 40 Erlang's and value of all the other three parameters remain fixed to 20. This scenario is set for comparison of proposed algorithm and existing algorithm (Table 1). Now we analyze that how well our wavelength assignment algorithm performs in comparison to existing wavelength assignment algorithm. In this we have fixed the number of nodes to 20; the total number of links used in the network is also fixed to 20; and the load is varying with the per unit link (Figures 1 to 4).

The graphs represent that the blocking probability of our proposed algorithm is increasing with respect to the increase in load. Further it is clear that our proposed algorithm is having less blocking probability as compared to conventional algorithms.

Scenario 2

Wavelength is changing by 10, 30 and 50 in this case. Number of nodes and number of links are constant as 20. Load per unit link is also fixed to 10. This case is also set for comparison between proposed algorithm and conventional algorithm (Table 2). Graph represents that there is a huge difference between the blocking probability of our proposed algorithm and other conventional algorithms. That means our proposed algorithm has less blocking probability (Figures 5 to 7).

It is clear from the graphs that the blocking probability of proposed algorithm is low in comparison to the conventional algorithms when we increase the wavelength. Scenario 1 graphs show that blocking probability of our proposed algorithm is much lower than the existing algorithms such as first fit, random, most used and best fit wavelength assignment algorithms. In the case of Scenario 2, blocking probability of proposed algorithm decreases as we increase the number of wavelengths. In this scenario, blocking probability of proposed algorithm is also reduces by the other conventional algorithms.

CONCLUSION

In this research paper, Least Used Wavelength Conversion algorithm has been proposed for wavelength assignment and its performance is evaluated in terms of blocking probability. In the first phase, the number of wavelengths is varied, keeping the other parameters
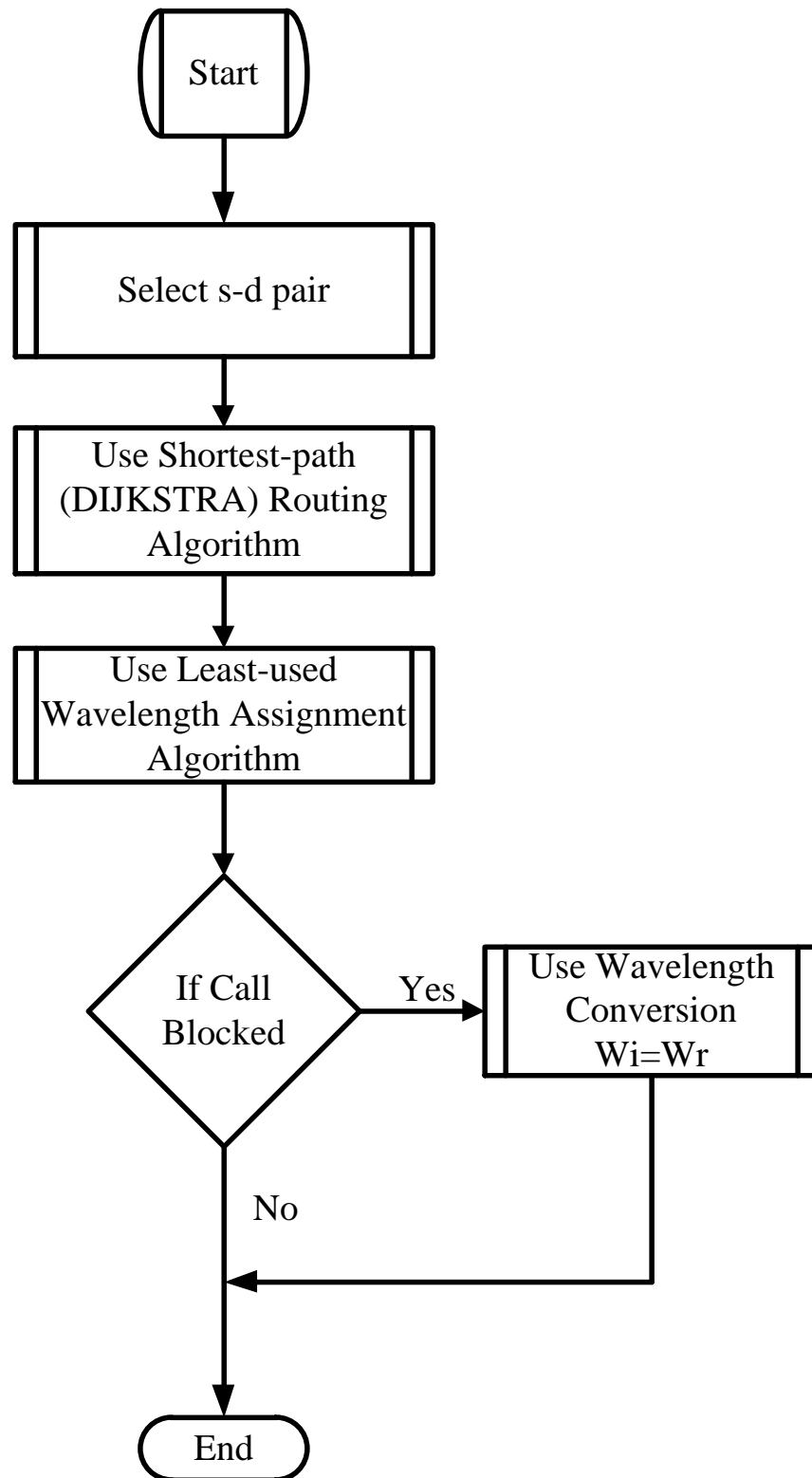
Figure 1. Flowchart of least used wavelength conversion algorithm.

constant. The results prove that the blocking probability of the proposed algorithm decreases with the increase in the number of wavelengths. In the second phase, the load per unit link is increased keeping the other
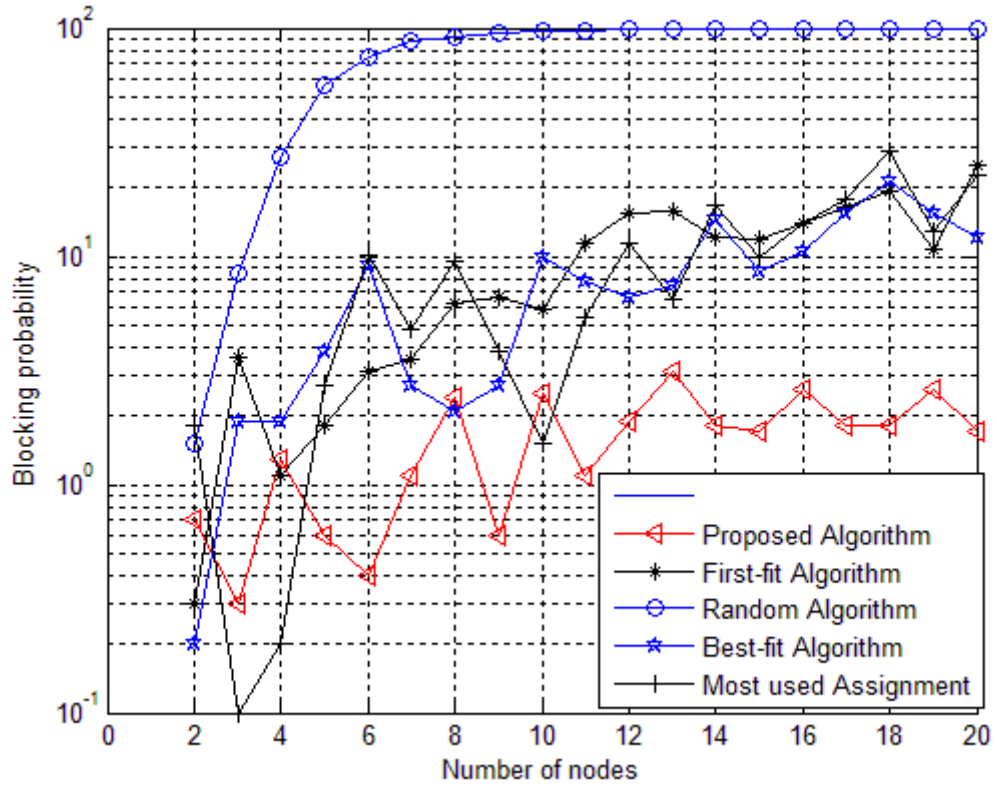
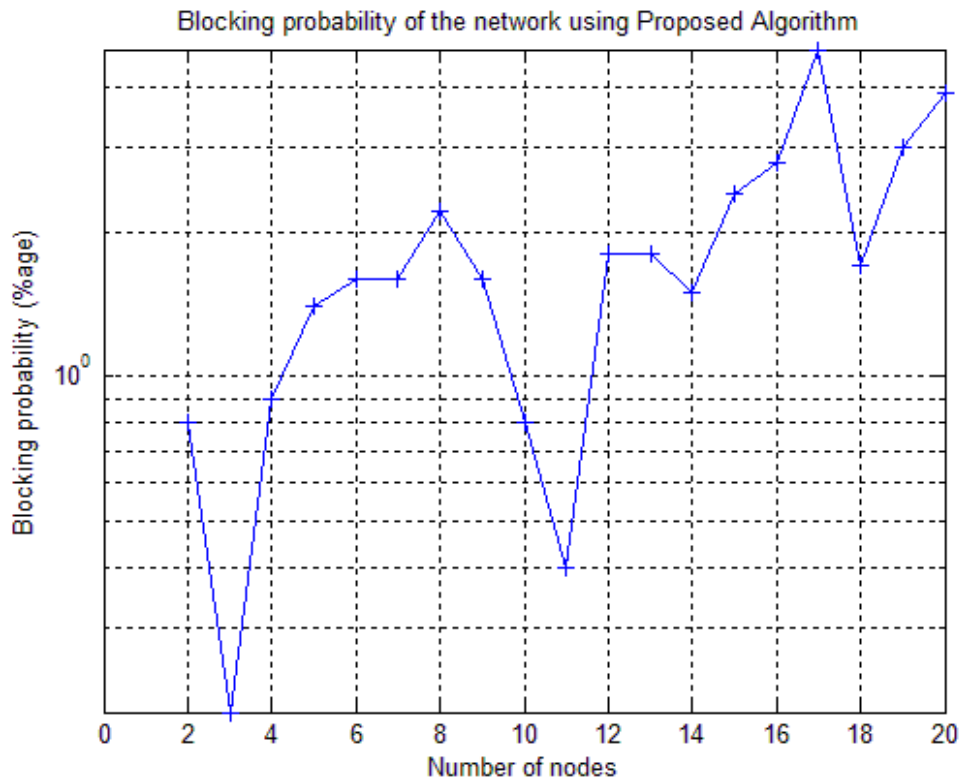**Figure 2.** Comparison of the algorithm for load=10 Erlangs; W=20.

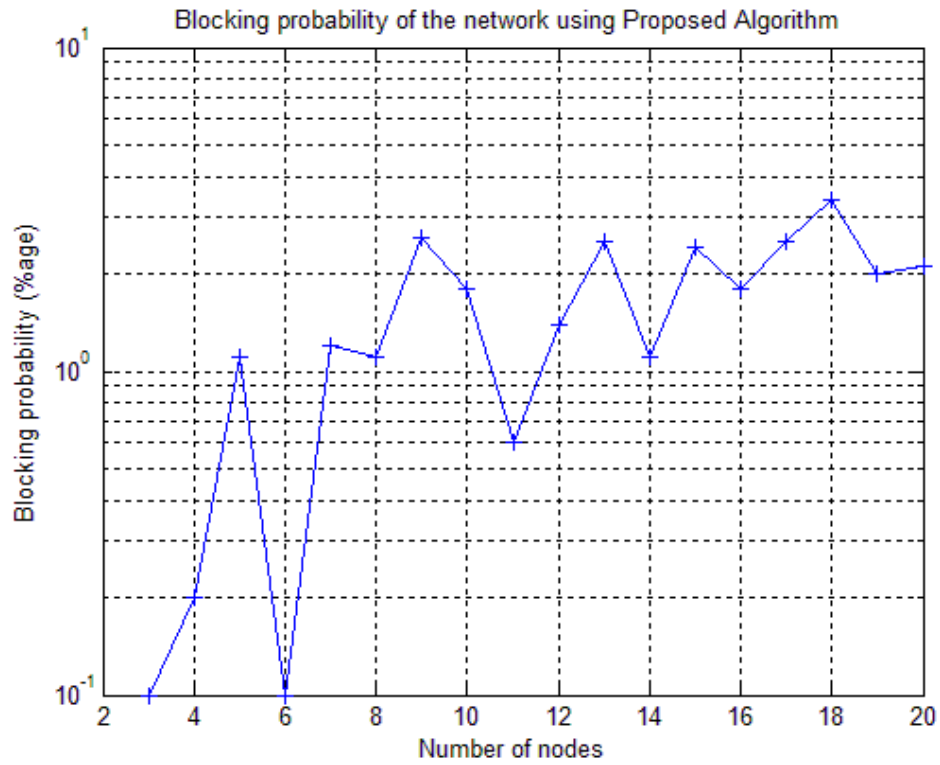**Figure 3.** Comparison of the algorithm for load=20 Erlangs; W=20.

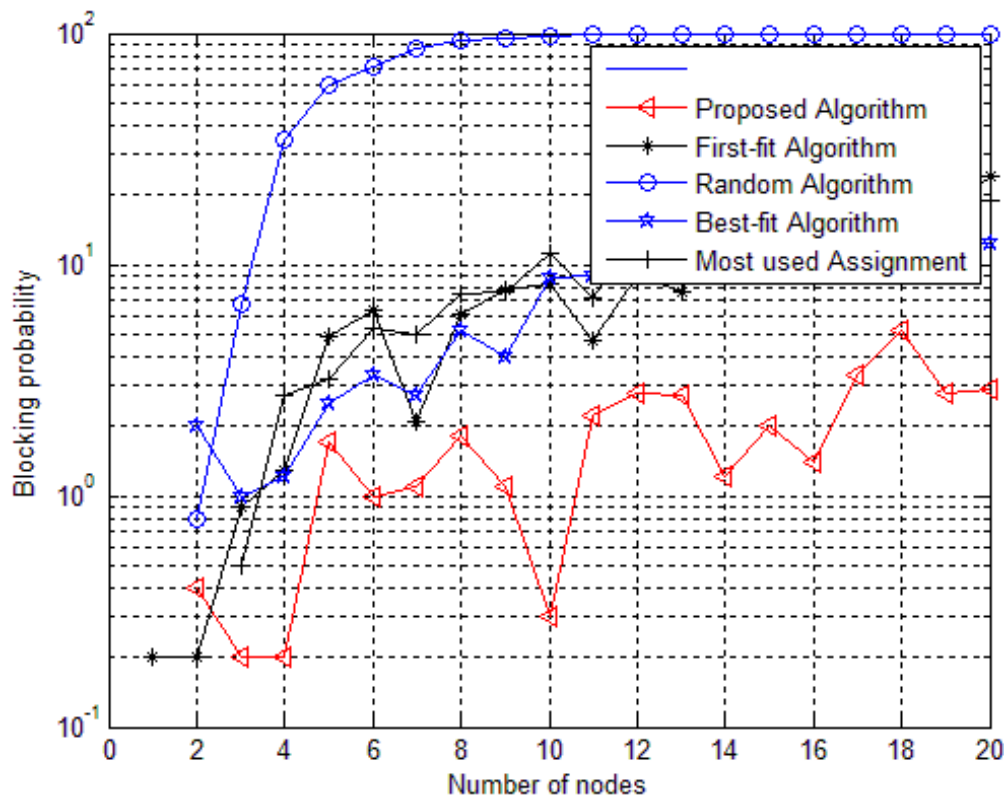**Figure 4.** Comparison of the algorithm for load=30 Erlangs; W=20.

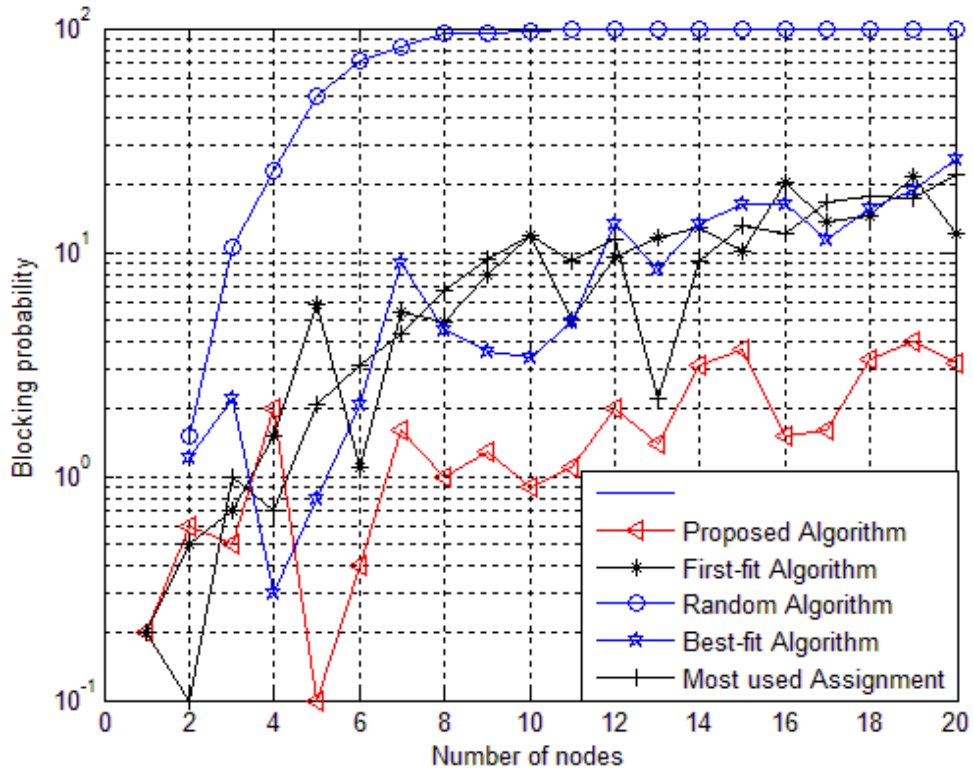**Figure 5.** Comparison of the algorithm for load=10 Erlangs; W=10.

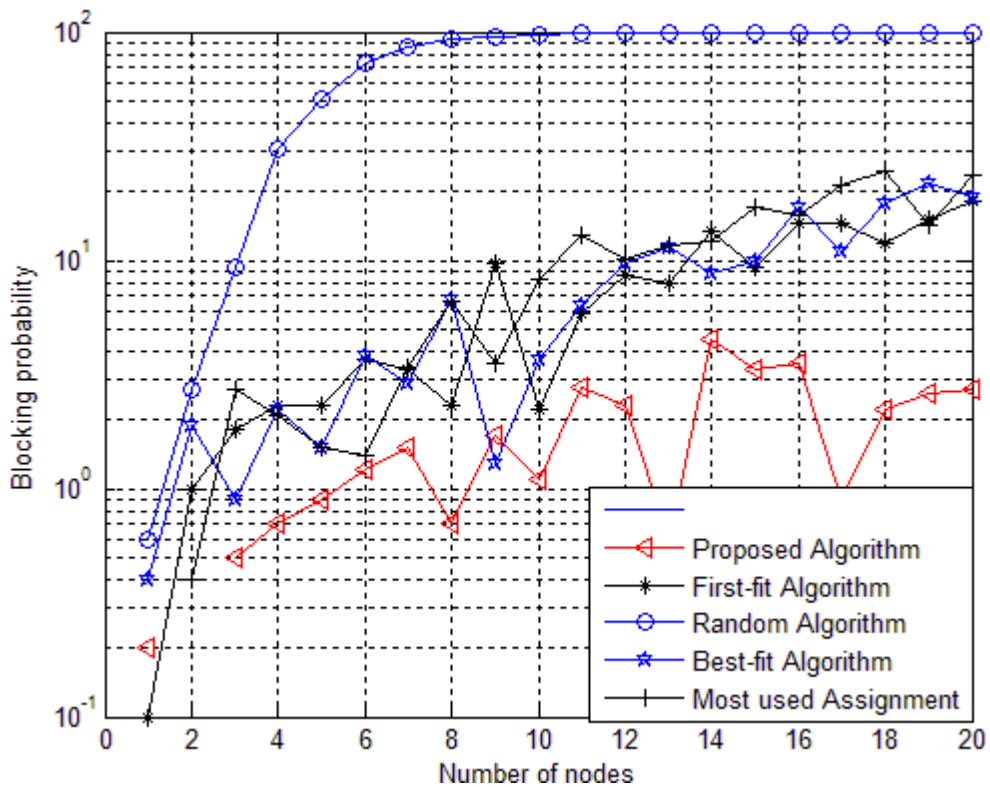**Figure 6.** Comparison of the algorithm for load=10, Erlangs; W=30.

Figure 7. Comparison of the algorithm for load=10, Erlangs; W=50.

parameters constant. The results show that as the load is increased, the blocking probability of the network increases for the network. Clearly, the algorithm will prove to be a promising technique in near future when the requirement of keeping blocking probability low is a must. Hence the use of Least Used Wavelength Conversion algorithm is proposed.

Conflict of Interest

The authors have not declared any conflict of interest.

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