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Reduction in Blocking Probability for Prioritized Connection Requests in WDM Optical Networks

Uma Rathore Bhatt[1](corresponding author), Suruchi Dode[2], Tapesh Sarsodia[3]
[1,2,3]Institue of Engineering & Technology, Devi Ahilya University, Indore, India

Abstract: In this paper we have proposed routing and wavelength assignment algorithm with resource reservation with first fit and routing and wavelength assignment algorithm with resource reservation with first last fit algorithm for WDM optical networks. Both of the algorithms categorize connection requests into two categories namely short path length and long path length. Connection requests with short path length are given more priority as compared to long path length requests. Performance of proposed algorithm is compared with existing algorithm. Simulation results show that routing and wavelength assignment algorithm with resource reservation with first last fit algorithm gives best performance in terms of reduced blocking probability.

Keywords: WDM optical network, Blocking probability, RWA, First last Fit algorithm.

1. Introduction

In WDM networks the available huge transmission bandwidth is divided into several channels such that each channel can transmit data simultaneously. A wavelength routed network consists of optical switches or optical cross connects interconnected by fiber links[1]. When a connection request arrives in such kind of network, a routing and wavelength assignment algorithm (RWA) finds and selects the route and wavelength to establish the connection request. The connection request is realized in terms of light path hence a light path can be defined as the optical path on which data transmission takes place between source and destination node. In all optical networks, a light path occupies same wavelength on all the links of the selected route. Two traffic models namely static traffic model and dynamic traffic model are commonly used in wavelength routed networks. In static traffic model all requests are known in advance thus the aim is to minimize the wavelength usage. In dynamic traffic model requests arrives randomly and they are released after some finite period. Hence for such kind of model, the aim is to minimize blocking probability [2]. Routing and wavelength assignment algorithm affects network performance in terms of blocking probability and resource utilization. Hence selection of proper routing and wavelength assignment algorithm is the key concern for such kind of networks.

2. Literature Review

RWA problem can be solved by two ways either in integrated manner i.e. RWA problem or RWA can be split into two sub problems: routing problem and wavelength assignment sub problem. Routing sub problem searches route for connection request while wavelength assignment sub problem assigns wavelength to establish the connection request. Routing sub problem can be classified into three schemes namely fixed routing, fixed alternated routing and adaptive routing. In fixed and fixed alternate routing, routes are searched in off line mode (using any shortest path algorithm) while in adaptive routing routes are searched according to current state of networks. First fit, last fit, most used and least used are the most common schemes for wavelength assignment sub problem.

Numerous RWA techniques are proposed for routing and wavelength assignment in WDM Networks:

In [3] author consider MCRWA (Multicast routing and wavelength assignment algorithm) problem for a sparse splitting WDM networks. They aim to minimize blocking probability of multicast demands with their fixed number of wavelengths. They consider two different models for blocking probability; one is Full blocking probability (FB) and another is Partial blocking probability (PB). For solving such issues they proposed ILP (Integer linear programming) model for choosing optimum number of wavelength. Adding to this, they also suggested various adaptive MCRWA approaches to make proposed work more effective. Their results show that, they reduce blocking probability considerably as compared to light path tress approach. In [4] author discussed two different issues of an optical network, one is energy saving and other is to route the traffic efficiently by managing the links optimally. For achieving this, they proposes an algorithm

hybrid load-balancing and energy-aware routing and wavelength assignment (RWA) algorithm (*HyLERA*) which perform the function of both energy saving and efficient routing of traffic on a failure. The author used control plane strategies to utilize the network resources optimally. The strategy switches the paths based on number of requests and loading conditions dynamically. It shows very low blocking probability at heavy loads and also saves energy during light loads. Punam R Patil et.al. [5] proposed an efficient algorithm for RWA in optical networks. Along with different routing algorithms, they applied rerouting of traffic in the network at connection level to improve traffic management. They achieved this by introducing a new algorithm namely rerouting at connection level (RRCL) which outperforms among general approaches. They compared rerouting at light path establishment and at connection level and founds that at connection levelnetwork congestion, wavelength requirement, converter requirement and number hops are minimized. In [6] author proposed an algorithm based on natural water drops principle for an intelligent RWA scheme and named it as Intelligent Water Drops (IWD) algorithm. In this the routes were selected based on paths chosen by water drops with minimum soil contain path while moving from sea, river etc. Proposed algorithm aims to minimize the call connection blocking ratio. Simulation results show that proposed algorithm improves blocking probability at low traffic load but for high traffic load this algorithm shows stationary behavior. Majid F. et. al. [7] proposed an RWA on sparse multifiber wavelength routed optical network (SM-WRON). The proposed RWA chooses linksusing two choices namely first choice and random choice. First choice selects links with first numbered whereas random choice selects links randomly. In proposed work they calculate cost of each link individually and then assign multi fibers to links with high cost. Result shows that proposed RWA reduces blocking probability.

Praphan p. et.al. [8] proposed an algorithm to solve RWA for wavelength-reusable multi-carrier-distributed (WRMD) mesh networks. The author proposed an ILP (Integer linear programming) model which minimizes the number of wavelength required for lightpath request. Author introduced two policies to achieve his proposed work; one is nearest optical carrier first with full optical carrier application (NCF-FCR) and less number of required wavelengths first with full optical carrier replication (LWF-FCR). Along with this author also used KSP algorithm and heuristic codes to realize alternate routings. In wavelength assignment algorithm, they initially created chains of light paths and then assigned wavelength to each lightpath by using NCF-FCR and LWF-FCR. Simulation results show that proposed algorithm perform well as compared to conventional schemes in terms of number of wavelengths required. They also compared NCF-FCR and LWF-FCR for no regeneration and one or two regenerations in the network.Akhtar Nawaz Khan [9] proposed an algorithm to solve routing and dimensioning problems in WDM networks at pre-optimization stage only. They proposed to covert integer constraints used in optimizationto linear constraints (LP) using relaxation method to converge results with minimum iterations and more optimally, which will be used in post optimization stage. They reduced blocking probability by considering them as factor of quality of service and reduced it significantly as compared to other conventional methods.In [10] author introduced an efficient algorithm viz. Energy and Fatigue Aware Heuristic with Unnecessary Reconfiguration Avoidance (EFAH-URA) to make a balance between lightpath assignment, energy saving and fatigue of devices due to thermal ageing. This algorithm works for both protected and unprotected light path network services. The author evaluated the network scenario in two different modes, one for services with least protection and acquiring more energy saving and other for services with strict protection.Results shows that they achieved significantly reduction in unwanted light path reconfigurations which helps in increasing life time of optical devices along with required energy saving for the network which is better as compared to other conventional approaches of RWA schemes.

3. Notations and System Model:

To implement existing and proposed algorithms following notations is used. Underlying system model is also presented in this section.

3.1. Notations:

n: Total number of nodes numbered from 1 to n

w: Total number of wavelengths numbered from 1 to w

I: Total number of connection requests numbered from 1 to I

s: The source for the connection request

d: The destination for the connection request

Lsd: Total number of links along the route for s–d pair of connection request

sd(i): The source-destination pair for i^{th} connection

R_{ij}: Route for the connection when s = iand d = j

w^k_{ij}:k^{th} wavelength assigned to the connection when s = iand d = j

w^{sd}_{ij}=0, if s–d pair does not occupy any wavelength on all the links of route

3.2 System Model:

The WDM network with n nodes, l optical links and w number of wavelengths is taken for analysis. Total number of connection requests at a given time is considered as I. If a connection request is honored then resources used by that connection request will be busy for a particular finite time. Network parameters like number of nodes, number of links, number of connection requests per unit time, average call holding time, simulation interval and number of available wavelengths per link are the required parameters to run the simulation.

4. Proposed and Existing Algorithms

This section gives a detailed description of existing and proposed algorithms. We proposed two algorithms namely RWA with reservation using first fit and RWA with reservation using first last fit. To implement both algorithms, likewise existing algorithm,we used Dijkstra algorithm to find shortest path. For wavelength assignment first fit and last fit strategy have been used. In first fit strategy, all wavelengths of spectrum are indexed and for establishment of a connection request, wavelength with lowest index is assigned while for last fit algorithm wavelength with highest index is assigned for connection request.

4.1 Existing algorithm: RWA (without reservation) with First fit (FF):

In this routing is done using shortest path routing and wavelength assignment is done using first fit strategy. All connection requests are given equal priorities. No resource reservation is considered for this scheme.

Algorithm: RWA (without reservation) with First fit algorithm

1. Define network topology V(N,W)

N= no. of nodes W=no. of links

2. Calculate path for all possible SD pairs.

3. Generate random SD pairs and find out the path for SD pair.

4. Assign spectrum to corresponding demand of SD pair using first fit algorithm.

4.2 Proposed Algorithms:

In this section two algorithms namely RWA with resource reservation with first fit algorithm and RWA with resource reservation with first last fit algorithm is proposed. In both of the algorithm connection requests and available spectrum of wavelengths is partitioned into two parts. Connection requests with one or two hops are termed as short path length connections while connections with more than two hop count length are long path length requests. A detailed description of these two algorithms is given as follows:

Proposed Algorithm1: RWA with resource reservation with first fit algorithm

1. Define network topology V (N, W)

N= no. of nodes W=no. of links

2. Calculate all possible SD pairs.

3. Determine shortest distance using Dijkstra's algorithm for all possible SD pairs.

4. Classify all pair into two categories namely shortest path and longest path on distance basis.

5. Partition spectrum of wavelengths into two parts namely 70% of total spectrum and 30% of total spectrum. 70% of total spectrum is assigned for shortest path length and 30% of total spectrum is assigned for longest path length. For shortest as well as for longest path First Fit is used for wavelength assignment.

6. Generate random SD pairs and find out the category of SD pair.

7. Assign wavelength to corresponding demand of SD pair using step [5]

8. For shortest path category if allocated spectrum is busy assign spectrum from long path category with first fit.

9. Repeat the process

Proposed Algorithm2:RWA with resource reservation with first last fit algorithm

1. Define network topology V(N,W)

N= no. of nodes W=no. of links

2. Calculate all possible SD pairs.

3. Determine shortest distance using Dijkstra's algorithm for all possible SD pairs.

4. Classify all pair into two categories namely shortest path and longest path on distance.

5. Partition spectrum into two parts namely 70% of total spectrum and 30% of total spectrum. 70% of total spectrum is assigned for shortest path length and 30% of total spectrum is assigned for longest path length. For shortest path use first fit while for longest path last Fit is used for wavelength assignment.

6. Generate random SD pairs and find out the category of SD pair.

7. Assign spectrum to corresponding demand of SD pair using step [5]

8. For shortest path category if allocated spectrum is busy assign spectrum from long path category with last fit.

9. Repeat the process

5. Simulation and Results

In the simulation we construct 1000*1000 square area. We randomly place number of nodes in the network which cover whole are of network. We set the location of nodes on x-axis and Y-axis, and then calculate the path for demands. We took three different random topologies in which number of nodes is taken as 30, 40 and 50.We took fix number of resources in terms of wavelengths for all topologies. Figure 1 shows Number of connection requests vs. Blocking Probability for 30 nodes topology. It is clear from the figure that as number of connection requests is increasing blocking probability is also increasing for all the routing and wavelength assignment strategies. It is due to the limited number of wavelengths undertaken. It is also observed from figure that RWA with first fit and RWA with resource reservation with first fit exhibit almost same performance in terms of blocking probability while RWA with resource reservation with first last fit exhibit best performance in terms of reduced blocking probability.

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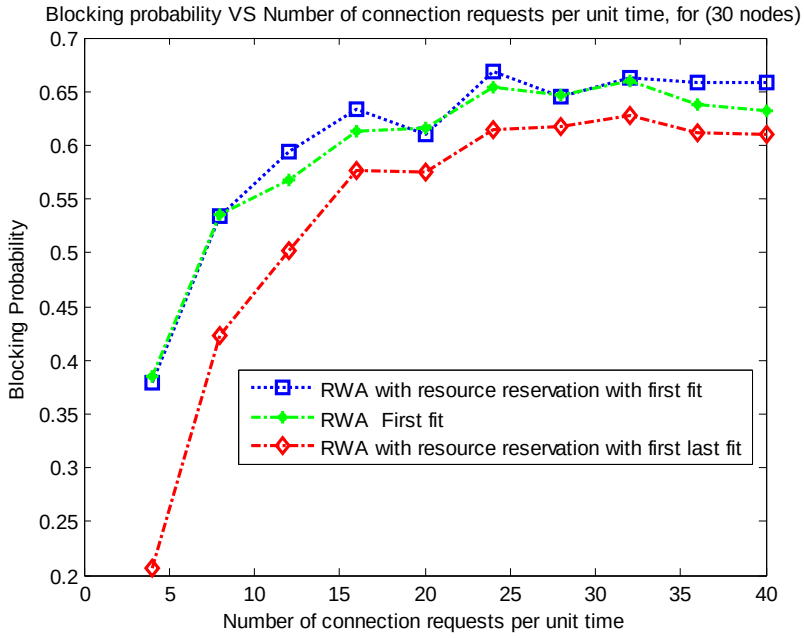

Figure 1. Number of connection requests vs. Blocking Probability for 30 nodes topology

We also simulated these RWAs for 40 node and 50 node topologies. Results are shown in Fig. 2 and 3 respectively. This figure also depicts the same conclusion as for 30 node topology. It is also observed from fig. 1, 2 and 3 that as number of nodes are increasing blocking probability for constant value of number of connection requests per unit time is decreasing. This is due to the fact that for large number of nodes and constant value of connection requests, availability of free resources in the network is increasing. Hence resulting in reduced blocking probability.

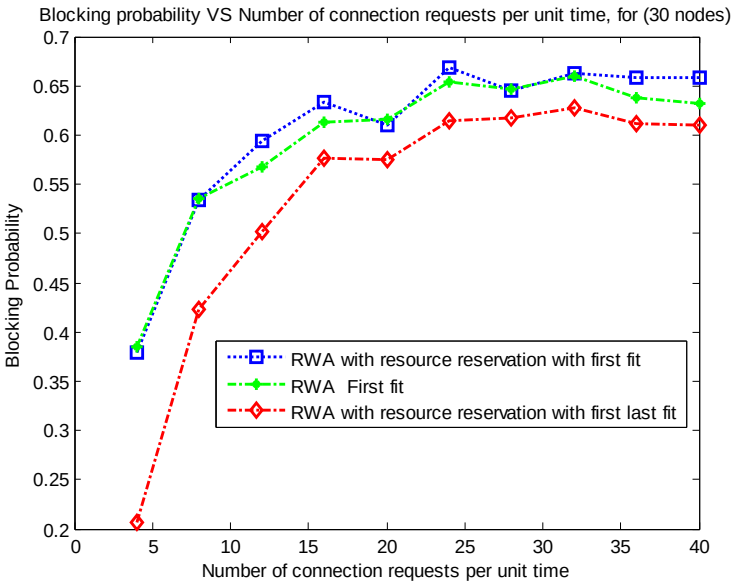

Figure 2. Number of connection requests vs. Blocking Probability for 40 nodes topology

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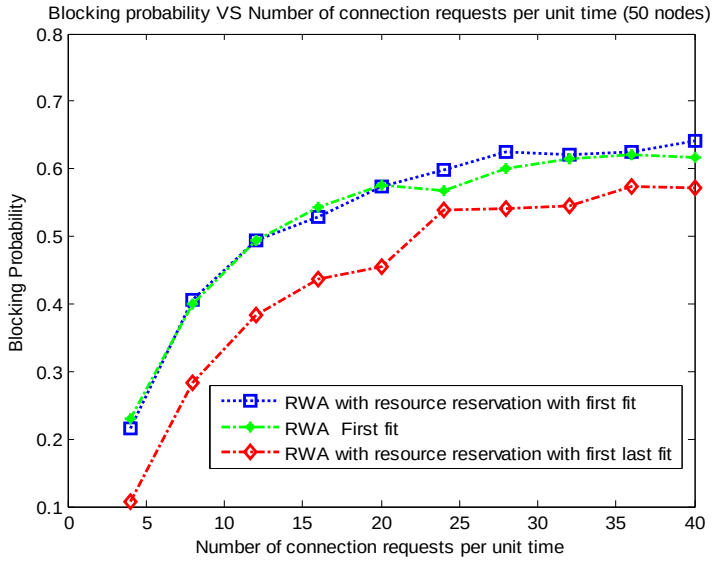

Figure 3. Number of connection requests vs. Blocking Probability for 50 nodes topology

6. Conclusion

In this paper we simulated three different kinds of RWAs for WDM network. We took 30, 40 and 50 node network topologies for the performance evaluation of existing and proposed RWAs. Simulation results show that RWA with first fit and RWA with resource reservation with first fit give comparable performance. RWA with resource reservation with first last fit gives best performance in terms of reduced blocking probability for all size (in terms of number of nodes) of networks.

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