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Algorithm for Minimizing Network Cost in WDM Network

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Abstract

This paper is based on a novel heuristic algorithm for routing and wavelength assignment in virtual wavelength path routed WDM network. In this paper, we have considered a wavelength routed WDM optical network and the Heuristic algorithm is implemented on it. The term heuristics is used for algorithm, which finds solution among all possible ones, but they do not guarantee that the best solution will be found. Therefore they may be considered as approximate and not accurate algorithms. Heuristic algorithm has its own structure, so it never runs slowly and never gives very bad results. The results are always close to the best solution.

In this paper the objective of this algorithm is to minimize the requirement of wavelength in any network topology demanded by network traffic. It also minimizes the hop length between source and destination nodes in the traffic. As wavelength and number of hops get reduced, the cost of the network also gets reduced and the resource utilization is maximized.

In the first phase of this algorithm, we assigned minimum hop length to each route demanded by traffic and also assigned wavelengths to each route. In second phase of algorithm effective rerouting is performed to reduce the number of wavelengths required in the network and it also minimizes the hop length of each rerouted route. By minimizing wavelength requirement, the need of wavelength converter gets reduced, so that the network cost is also reduced. Along with the implementation of heuristic algorithm, we have found out few more parameters such as Network Congestion and Network wavelength converter requirement. This Network Congestion on each link of network is used for calculation of Network Wavelength Requirement, and Network wavelength converter Requirement.

Keywords

WDM optical network, hop, No. of wavelength, Dijkstra's algorithm, routing & wavelength assignment algorithm (RWA), Network Congestion, Network Converter Requirement (NCR), Network Wavelength Requirement (NWR).

1. Introduction

An algorithm which used for finding out solution for a given problem is called a Heuristic Algorithm. But its result sometimes may not be accurate. Nowadays, for many solutions heuristic algorithms are used, because it never runs slowly nor give bad result. Always its results are close to optimum. There are various heuristic algorithms present in literature. In this paper we have presented a heuristic algorithm for minimizing different parameters in routing and wavelength assignment (RWA) problem in wavelength routed WDM network.

Here we have considered a WDM network, because it is used widely due to its huge advantages [1]. WDM is capable of multiplexing different signals at different wavelengths and transmits as well as receives it on same cable at the same time. So the wastage of bandwidth is avoided. It gives bandwidth up to 50 Tbits/sec.

There are three architectures of WDM network, viz. Broadcast-and-select-network, Wavelength routed network (WRN) and Linear light phase network [2]. Out of these three architectures we have considered WRN because of its advantages over the other two, such as lack of wavelength use, low power splitting losses and scalability to WAN. So the performance of WRN is better than other architectures.

On this WRN network we have implemented heuristic algorithm in two phases. First phase is routing and wavelength assignment phase and second is rerouting phase. The routing and wavelength assignment is explained in section 2 and its algorithm is explained in section 3. Basics of WRN are explained in section Implementation, comparison and simulation result is given in section 5 & 6. WRN is one of the architectures of WDM [2] [5], which has advantages such as: 1) packet switching [3], 2) wavelength converter,[1], 3) Scalability to WAN, 4) possibility of reuse of wavelength and 5) use of high bandwidth. Because of these advantages WRN performance better as compared to other architectures. There are two constraints on the network [2]. These are: 1) wavelength continuity constraint and 2) Distinct wavelength constraint.

2. Routing Algorithm

We have used Dijkstra's shortest path- finding algorithm. We plot the graph of network by using shortest path algorithm and then find out the shortest route between source and destination pair.

The steps for routing algorithm are as:-

1) Consider a network with distance between each node of network.
2) Enter source & destination pairs.
3) Consider first source & destination pair.
4) Store all number of nodes in variable.
5) Initialize length of nodes to infinity.
6) Consider length of source as zero.
7) Calculate minimum path by using the formula,

$$L(i) = \min \{Old(i), L(a) + w(a, i)\} \quad \text{--- (1)}$$

Where,

i = Total number of nodes 1 to N.

a = Source of link

W (a, i) = Weight (distance) between a and i.

8) Calculated the Number of Hops required for each route using formula,

Number of Hops of individual source destination pair = (Total Number of Nodes in Route – 1)

9) **C**alculate Network Congestion on each link by using formula,

$$L_{max} = \max_{(i, j)} L_{i, j} \quad \text{------- (2)}$$

Where,

Lmax = Maximum used link,

i = Source node of link,

j = Destination node of link

3. Wavelength Assignment Algorithm

After that we have apply wavelength assignment algorithm to find out network wavelength requirement and number of hops.

The steps for wavelength assignment algorithm are as:-

1) Assign wavelength to 1.
2) Assign wavelength to source, destination pair by consider in each link.
3) Consider first link, check network congestion of that link :-

a) If network congestion is one, then apply same wavelength to the source destination pair as previous.

b) If network congestion is greater than one, then apply different wavelengths to the source destination pairs, where this particular link is used.

4) Apply same process up to the end of all source destination pairs.
5) Find the maximum number of wavelengths assigned for network traffic, by using the formula,

NWR (max) = Max (number of wavelengths in the network)

6) Consider first link and check network congestion of link:-

a) If network congestion is greater than one then network converter is required at either of the nodes.

b) If network congestion is one, then network converter is not required.

7) Repeat this step for all of the physical links in the network.

4. Rerouting Algorithm

Rerouting algorithm is used to minimize Network Congestion, Network Converter Requirement (NCR), Network Wavelength Requirement (NWR) and Number of Hops.

The steps for Rerouting algorithm are as:-

1) For this, first we have considered first route of Source Destination pair, and found out, if any optional node is available for the route or not.
2) If any optional node is found, then consider it as destination node for link and update the link in current route, in such a way that this link should not affect the traffic of other Source Destination pairs.
3) This process is continued till Destination of first route is reached.
4) The same process is applied for all routes in the given traffic.
5) After changing possible routes, we have again calculated all parameters such as NWR, NCR, Number of Hops, and Network Congestion.

5. Result and justification

We have implemented the Heuristic algorithm on WRN of 10 nodes and 12 link network [6], and second network has 7 nodes and 14 physical links. As shown in Fig.1,2,3,4.respectively. For both networks shortest path for source to destination pairs are calculated before rerouting and after rerouting. We have considered some traffic on the network and assigned route from the source node to destination node. Then calculated parameters like Network Congestion, Network Wavelength Requirement, and Wavelength Converter Requirement were calculated. After this we have applied Rerouting algorithm on the network to minimize Network Congestion, Network Wavelength Requirement, and Wavelength Converter Requirement parameters.

10 node and 12 link network:-

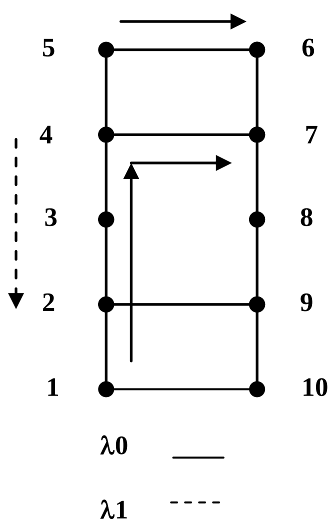

Fig. 1: Network before re-routing.

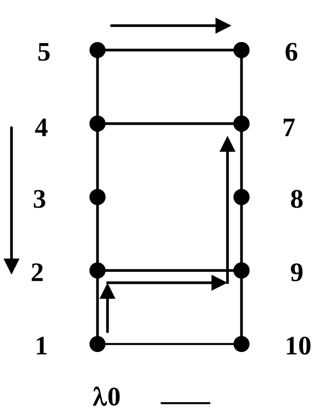

Fig.2 : Network after re-routing.

07 Nodes and 14 links network:-

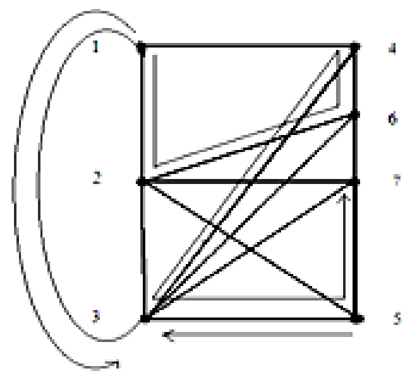

Fig.3: Network before re-routing.

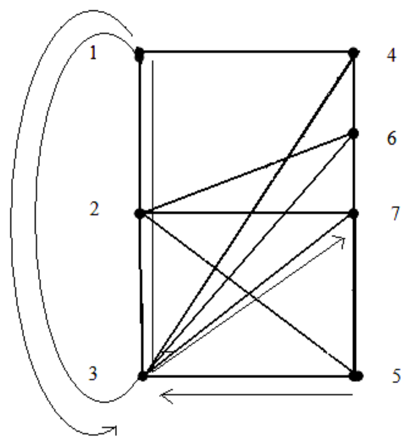

Fig.4: Network after re-routing.

For network congestion, also called as traffic, for first network which has 10 nodes and 12 physical links has traffic 2 on link between 2 - 3 and 3 - 4 also traffic 1 on rest of links before rerouting. After rerouting network traffic 1 on all links. For second network, traffic 2 on 3 – 5 nodes and 1 on rest of links.For network wavelength requirement before rerouting requires 2 wavelengths and after rerouting requires 1 wavelength for first network. For second network requires two wavelengths before rerouting and 1 wavelength after rerouting. For first network, wavelength converter before rerouting requires one converter and after rerouting requires no converter. For second network, network converter requires 1 converter before routing and no converter after rerouting. For first network average no of hops are 2.33 before and after rerouting average no. of hops are 2.33. For second network average no of hops are 2.66 before rerouting and 2.33 after rerouting.

6. Conclusion

In this paper we have considered the problem of routing and wavelength assignment (RWA) in virtual-wavelength-path (VWP) routed networks and took up the novel approach of not only minimizing the network cost, in terms of wavelengths and number of wavelength converters, but also maximizing the resource utilization, measured by the average weighted hop count. We proposed a heuristic algorithm for routing which not only tries to minimize the number of wavelengths required (NWR) but also minimizes the average number of hops taken up by a light-path as well as Network Congestion, so that all these parameters get reduced resulting we minimizes the cost of the optical network. We also presented a wavelength assignment procedure, which minimizes the number of wavelength converters requirement. Algorithm is implemented on two different network and obtained simulation result highly encouraging for number of parameters.

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