Design and Analysis of Routing and Wavelength Assignment Algorithms in MatPlan WDM

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Abstract— Most challenging problem in an optical network is Routing and Wavelength Assignment (RWA) problem. It is the most important problem in optical WDM networks. By solving this problem wavelength can be routed efficiently in all optical WDM networks. Different algorithms are proposed to solve this RWA problem. These algorithms depend upon several factors such as degree of node, hop count, number of channels, transmission rates, etc. The main objective of these algorithms is to reduce the rejections request during congestion period. On the basis of these algorithms different parameters are compared, which are extracted using proposed algorithms. The algorithms were implemented in MatPlan WDM simulator. The result shows that the performance of algorithms is dependent on the parameters and behaves distinctly.

Key words: MatPlan WDM, RWA, Lightpath, shortest path, WDM, MILP, MinTranseiver

I. Introduction

With increase in the transmission capacity of optical networks by Dense Wavelength Multiplexing (DWDM) Technology has increased the data transfer rate or existing networks. The data that can be processed electronically is called electronic switches bottle neck. The objective of Optical Networks is to decrease the switching node and increase the capacity of existing networks. There are several techniques to improve the electronic switches bottleneck, which increases the capacity of existing networks and to decrease the number of switching node. It can be achieved by using Optical Packet Switching (OPS) and Optical Burst Switching (OBS). Both of these technologies are still in testing stage. The only alternative to achieve better performance is by implementing wavelength routing switches.

In WDM several optical signals with different wavelengths are carried by an optical fiber link. Optical signals are processed at a very low speed. Hence conversion of signals from optical to electrical is necessary. These signals are again back converted to optical signals to transmit through optical fibers. This optic-electro-optic (OEO) requires electronic processing facility which is very expensive. The solution to this problem is to process signals directly in the optical domain by building an optical network. In such a network the link between two nodes is called lightpath. In lightpath a free wavelength is allocated to each path. In this way a signal can be transmitted without any intermediate processing. In this type of network, signal can extend over multiple fiber links while using single channel per link. If wavelength conversion ability is not used then lightpath will occupy the same wavelength over all fiber links. Hence the problem of routing a lightpath requests and wavelength assignment to each link is known as Routing and Wavelength Assignment (RWA) problem. This problem is significant in increasing the efficiency of wavelength routed optical problem. By solving this problem a given system can accommodate more customers and fewer customers will be rejected during congestion periods.

The paper is organized in different sections: Section 2 describes the virtual mode of MatPlan WDM tool, Section 3 includes WhatIF Analysis, Multi Hour Analysis is discussed in Section 4 and the performance of Dynamic Analysis mode is evaluated in Section 5.

II. RWA Problem

In this problem a simplified route is assigned to a given network with minimum number of wavelengths. This problem is known as Routing and Wavelength Assignmet (RWA) problem. There are two constraints that should be consider while designing a RWA problem. These are Wavelength Continuity Constraints (WCC) and Distinct Wavelength Continuity Constraint (DWCC). RWA problem is of two types:

- Static RWA: In static RWA problem, the traffic requirements are known in advance.
- Dynamic RWA: In dynamic RWA problem, requests came in random number and traffic requirements are not known in advance.

RWA problem is a set of two sub problems which has to be solved separately. These problems are described in sections below:

A. Routing Problem

In this problem request between source and destination is routed among all the existing routes. The shortest path between source and destination is calculated using shortest path algorithms such as Dijkistra's algorithm and Bellman-Ford algorithm.

B. Wavelength Assignment Problem

In this problem wavelength is assigned to a path connected from source to destination. By solving this problem the system cost can be reduced by reducing the number of wavelength converters. When a call is made by source node it sends the request to controller because controller has the information regarding network. Controller comprised facts about the busy and free wavelngth of networks. The controller then selects a wavelength from the free wavelengths and a call is assigned to that wavelength. First-Fit assignment strategy is the most common asignment strategy. In this strategy, a list is prepared regarding free and used wavelength and connection is established between source and destination using available wavelength through which data flow will take place. If this wavelength fails excess on their entire path then it will again try to established a connection with the second free waveength and this process is continue till the last free wavelength. After completion of data transfer the same process is repeated.

III. LINK WEIGHT ASSIGNMENT ALGORITHMS

In all the strategy for solving RWA problem, the algorithm described above is most commonly used. In this algorithm resources are used efficintly for finding the shortest path between the source and destination. There may be some networks where the factor of considering the shortest path is not sufficient. So, there are some other factors that should also be considered. Degree of node and hop count are the important factors that should be considered. Degree of node is the number of links that is connected to each node and hop count is degree of a particular node. There are infinite numbers of topology for a particular networks. Hence considering only single for all of them is not a good criteria. Hence these factors are introduced.

A. *Existing Algorithm*

In existing strategies the link weight in a network and connection that is established between source and destination remains the same. The disadvantage of this strategy is inefficient utilization of links between source and destination. Hence there can be a situation where some links are over utilized and some links remain under utilized. So the decision should be made optimally that is on the basis of network requirement.

B. *Proposed Algorithm*

In this work, a virtual topology by optimizing a certain cost function subject to a set of constrain is designed and number of transceivers are minimized using mintransceiver algorithm. Two algorithms are proposed and their performance is compared with existing algorithms. The proposed algorithms are:

- Mixed Integer Linear Programming (MILP)
- MinTransceiver Algorithm

The objective of MILP is to design a virtual topology by optimizing a certain cost function, subject to a set of constraints. The values of output variables of MILP will yeild optical virtual topology. MILP is performed by following steps:

- Reduce the problem size using LPP.
- Solve the initial problem by using LP.
- Perform MILP.
- Try to further reduce the problem.
- Search the nodes systematically for optimal solution.

In Mintransceiver algorithm the number of transceiver in optical network are minimized. The algorithm is divided into following four sub-algorithms:

- Virtual topology
- Lightpath routing
- Wavelength Assignment
- Traffic Routing (Over Virtual Topology)

IV. SIMULATION RESULTS

The proposed algorithms are implemented in MatPlan WDM Simulator in MATLAB. The three most common parameters that are considered are average wavelength used, fraction of lost traffic, average routed traffic. The following graphs are made by extracting the above mentioned parameters. The results shown in fig.1 to fig.3 below are based upon four algorithms: Shortest path, degree testing, MILP, mintransceiver.

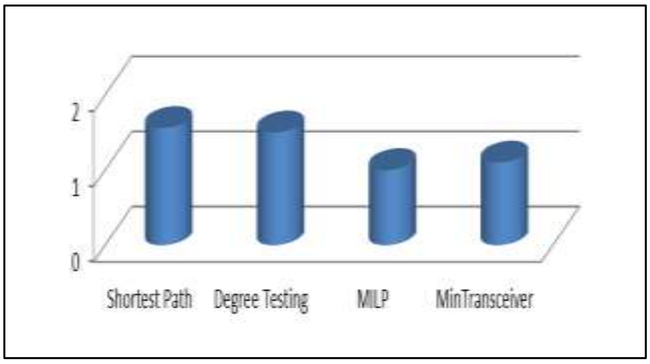

Fig. 1: Graph showing average wavelength used for different algorithms

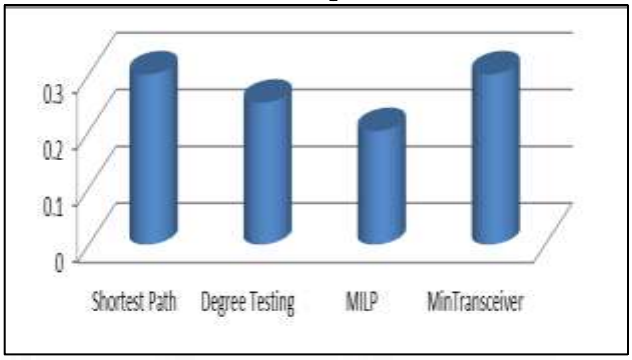

Fig. 2: Graph showing fraction of lost traffic used for different algorithms

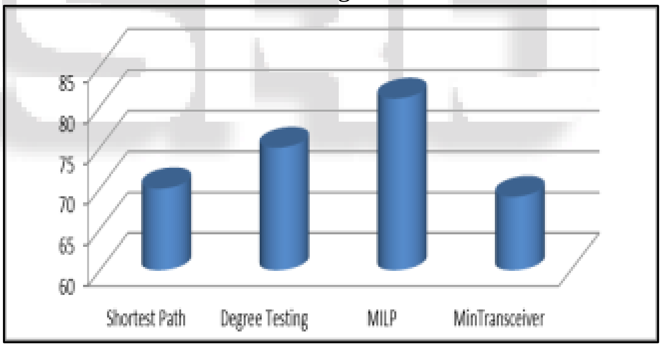

Fig. 3: Graph showing average routed traffic used for different algorithms

The graphs are plotted for various parameters mentioned above. As seen from the graphs in MILP the wavelength used and traffic lost is minimized. While average routed traffic is maximized in MILP algorithm.

V. CONCLUSION

When results are analysed for different algorithms it was observed that fraction of lost traffic is minimum in MILP while fraction of routed traffic is maximum. In WDM, the routing problem and wavelength assignment problem as mentioned above is minimized by using MILP. It has solved the problem by providing the shortest route between source and destination without using any OEC converters. Thus, based upon different parameters considered the MILP served the best. So, if one is concerned with message propagation delay, MILP has to be followed. In other words, the performance of different algorithms was based upon parameters under consideration.

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