Efficiency of RWA Algorithms In Optical Networks (Bus Topology, Ring Topology & Mesh Topology)

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Abstract- *It is a reviewed scenario for routing algorithms in RWA; as the technology is improving so are the demands of end users. The Fiber-optic technology is the only means to fulfill the desired need of hi-tech devices because of its limitless capabilities. This paper presents a reviewed survey of the available literature on Wavelength-division multiplexing and different type of topologies considered for Routing & Wavelength Assignment. A categorization has been provided based on the different routing techniques. It highlights the functional classification of RWA & handling the issues related to the feasibility of 3G & 4G technologies. Rough sets are suitable for handling different types of uncertainty in different topologies. But High-End resources need good algorithmic approach to send & receive data. So, performance analysis of RWA algorithm is required for different topologies to increase link utilizations and to reduce call blockage. The paper cosnsist of different case studies as predicted from the title of paper. Today, the tendency of several telecommunication companies is towards optical networks as the light has higher frequencies and the shorter wavelength. An extensive bibliography is also included.*

Keywords- Light-path rough sets, WDM, RWA Algorithms, Bus, Ring and Mesh Topologies.

I. INTRODUCTION

Although services such as Fax and Internet can be delivered over telephone lines today, its cleared that this might be a patchwork adaptation. Recent experiences with the World-Wide Web suggest that as soon as subscribers view images, they desire video clips. In optical networks data is converted to bits of light called photons and transmitted over fiber. These are faster than traditional networks because photons weigh less than electrons, and further, unlike electrons, photons do not affected one another when they move in a fiber. Light has higher frequencies and hence shorter wavelengths, and therefore more bits of information can be contained in a length of fiber versus the same length of copper [1, 5].

Now-a-days there are many services available on telecommunications network. These services may contain data, voice and video; that means there is a lot of information routed on the networks that demand high-speed networks. Wavelength Division Multiplexing (WDM) appears to be an effective solution to this problem. Using WDM, service providers can route several traffic flow using different wavelengths on the same optical fiber. Let a question be answered, "*Which of the proposed algorithm is best?*"; the basic requirement is to analyze and determine the best option to answer this question. Key-points may be considered as;

- The algorithm must be able to select routes and assign wavelength to connections in a manner which effectively utilize network resources and which maximizes the light-paths that can be established.
- The problem of RWA is critically important for increasing the efficiency of wavelength-routed all optical networks.

Wavelength-division multiplexing (WDM) [1, 2, 3, 5, 7, 8, 10] has been emerging as the dominated technology for the next generation optical networks. Configuring these optical devices across a network enables one to establish light-paths between source nodes and destination nodes.

II. ISSUES IN WAVELENGTH ROUTED NETWORKS

Some of the important issues in wavelength routed networks include routing and wavelength assignment, topology design, reconfiguration, control and management.

- *Routing and Wavelength Assignment (RWA):* In wavelength routed WDM networks, a connection is realized by a light-path. In order to establish a connection between a source-destination pair, a wavelength continuous route needs to be found between the node pair. An algorithm used for selecting routes and wavelengths to establish light-paths is known as a *Routing and Wavelength Assignment Algorithm* (RWA). Therefore, it is mandatory to use a good routing and wavelength assignment algorithm to establish light-paths in an efficient manner.
- *Static versus Dynamic Traffic Demand:* The connection requests can be either static or dynamic. In case of a static

traffic demand, connection requests are known a *priori*. The traffic demand may be specified in terms of source-destination pairs to assign routes and wavelengths so as to minimize the number of wavelengths used. In case of a dynamic traffic demand, connection requests arrive to and depart from a network one by one in a random manner. Dynamic RWA algorithms perform more poorly than static RWA algorithms because a dynamic RWA algorithm has no knowledge about future connection requests, whereas all the connection requests are known a priori to a static RWA algorithm.

- *Light-Path Establishment In Wavelength-Routed WDM-Optical Networks[5]:* The Static RWA problem applies to the case in which the set of connections is known in advance and a light path must be established for each connection. Each source-destination pair is considered individually, and the route for the pair of nodes is switched to an alternate shortest-hop path. In the Dynamic RWA problem, connections arrive to the network dynamically and remain for some amount of time before departing. The objective in the dynamic situation is to choose a route and wavelength which maximizes the probability of setting up a given connection, while at the same time attempting to minimize the blocking for future connections. The Dynamic RWA problem can also be decomposed into a routing sub-problem and corresponding wavelength assignment sub-problem. The following approaches are being under consideration:

  In the Routing Aspect [1], there are three basic types of routing approaches:
  1) Fixed Routing,
  2) Fixed Alternate Routing
  3) Adaptive Routing Based on Global
  4) Adaptive Routing Based on Local Information [1]

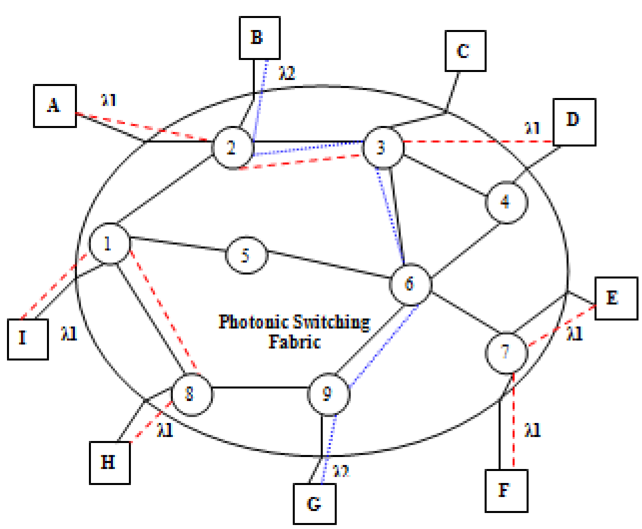
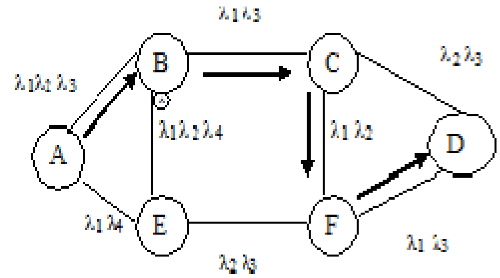


Figure 1 Light-Path routing in a Wavelength-Routed Network [4].



Deflection routing: Available wavelengths are shown on each link [1]

III. WAVELENGTH ASSIGNMENT APPROACH [1,2,5,6]

- *First Fit Wavelength Assignment:* This strategy is implemented by predefining an order on the wavelengths. The list of used and free wavelengths is maintained. The assignment scheme always chooses the lowest indexed wavelength λ_1 from the list of free wavelengths and assigns it to the request. When the call is completed the wavelength λ_1 is added back to the free wavelength set. The disadvantage of this approach is that the lower indexed wavelengths are hardly used. Hence, for certain wavelengths the utilization is very low. Further, an increase in the number of wavelengths per fiber does not result in improvement in performance as the highest numbered wavelength per fiber does not result in improvement in performance as the highest numbered wavelengths are rarely used.

- *Most Used Wavelength Assignment:* In this strategy the free wavelength that is used on the greatest number of fibers in the network is assigned to the request. This algorithm requires that the actual or estimated global state information of the network be known to determine the usage of every wavelength. It is more suitable for centralized implementation and is not easily amenable to distributed implementation.

- *Least Used Wavelength Assignment:* It is similar to the most used wavelength strategy, but in this strategy the least used wavelength in the network is assigned. This technique is also called Spread Scheme Assignment. The main purpose of this approach is to achieve a near uniform distribution of the load over the wavelength set. The assignment of wavelength is implemented using the random wavelength assignment algorithm.

- *Random Wavelength Assignment:* In this strategy the node maintains a list of free wavelengths at every instant. Whenever a call is generated, the node randomly chooses a wavelength λ_1 from the set of free wavelengths and assigns that wavelength to that call. The set of free wavelengths is updated by removing λ_1 from the free list. When the call is completed, then wavelength λ_1 is removed from the list of used wavelengths and is added again to the set of free wavelengths.

- *Greedy Algorithm (NWC and WC)*: In this algorithm firstly search is for a light-path for the s-d node pairs. Secondly, the pilot study is done for Non-Wavelength Continuity networks and Wavelength Continuity networks. As aforesaid in above metioned case of Deflection Routing WC must be prevailed.

IV. FUNCTIONAL CLASSIFICATIONS OF RWA

In what follows, a light-path is defined as an end-to-end connection request between two end nodes, which may span multiple links. A route is a selected path along the multiple optical fibers, which may be located far from each other in the physical network topology. A wavelength is a circuit -switched path for the route that constitutes an interconnected routing path between two nodes. We need to determine the routes and the wavelengths that should be assigned to the light-paths so that the maximum number of light-path may be established. Wavelength Continuity acts as an integral driving force for fast data communications.

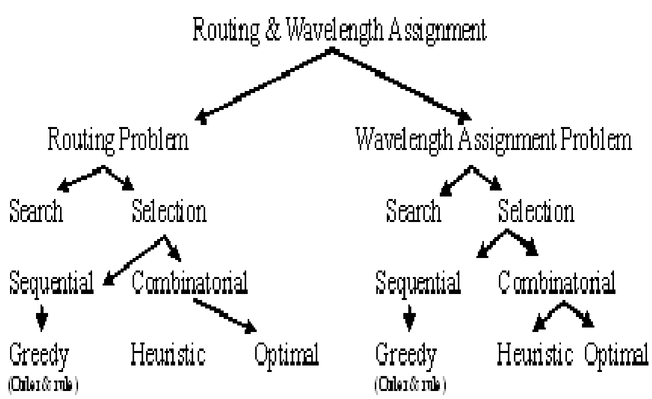


Figure 2 Functional classification of RWA Algorithms

Hence, the RWA problem can be defined as an optimization problem in a number of ways using various cost functions as depicted above in figure 2.

Likewise, taking into account all possible source and destination pairs for routing are impractical because the state space is exponentially increased with the number of network nodes and links. Hence, search function is usually performed by well known techniques such as shortest-path algorithm and its variations as shown in the figure below (Figure 3 [15]).

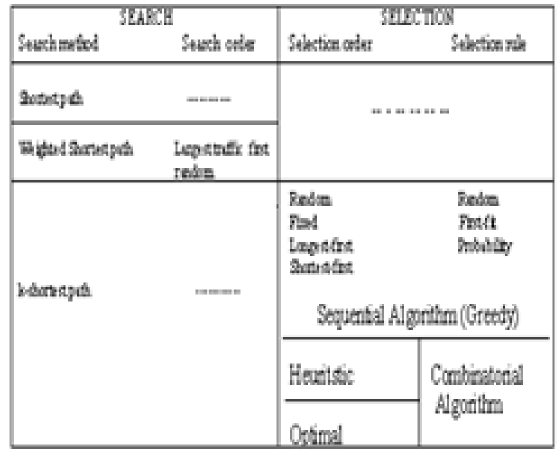


Figure 3 Functional Elements of Routing Algorithm

V. PERFORMANCE MEASURES & CONSIDERATIONS [9,10, 11,16]

The goals of the performance metrics are to provide tools for the classification, comparison, and evaluation of the features of the studied topologies. Numerous metrics exist in literature. The performance measures involved in a topological design problem could be classified into two categories: *structural metrics* and *functional metrics*. Structural metrics are designed to characterize the topology without any knowledge of traffic engineering (flows on the links, routing schemes, etc.). For example, the considered number of nodes within a topology is a structural metric. On the other hand, functional metrics take into account the traffic engineering within the network, and the expression of a functional metric is a function of parameters such as flows on the links, routing schemes, node functionalities, etc. Thus, the total amount of traffic within a network is considered as a functional metric.

- The number of Nodes (n) known as order of the network.
- The Diameter is expressed as fibre length and the Degree is directly linked to the number of ports at a node. The degree is related to the capacity of nodes and is an index of the node complexity.
- Cable type is an integral issue as Multimode fibre optic cable is best suitable for small networks but Single mode fibbers optic is best suitable for large sized networks.
- Data Rate 128000 bits/sec
- Fibre Bandwidth 25 THz with 1.55 low attenuation
- Delay 0.0018 sec at each channel
- The overall transmission delay could also be due to Attenuation and Dispersion. But WDM have very little insertion loss.

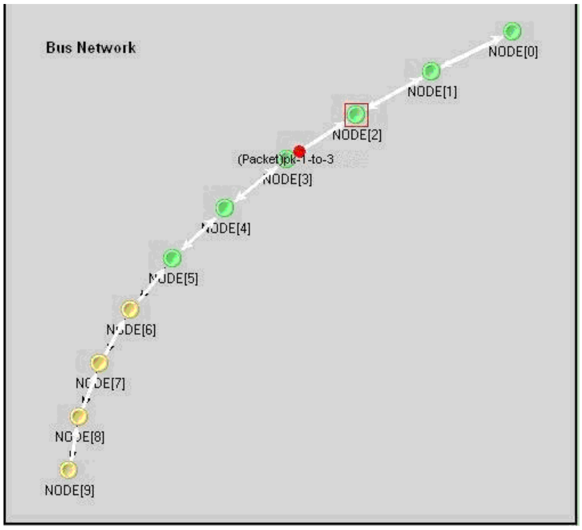


Figure 4.1 Bus Topology

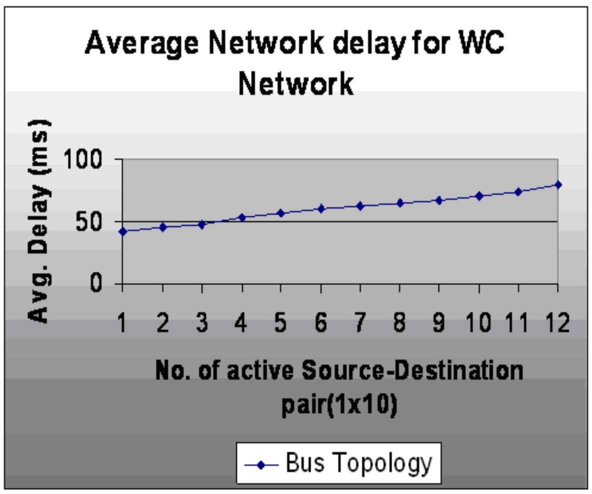


Figure 4.2 Bus Network

As depicted in Figure 4.1; ten nodes are connected one after one, with a bi-directional link. The structural behaviour of the bus optical topology has the great advantage of being simple and preferable. Moreover, it requires a few numbers of links (n-1) to be operational and to be extended with a low cost.

Here, the diameter is equal to the number n-1 and degree is 2. The mean hop distance in a bi-directional bus topology is of n/3.

It can be concluded as the test case shown in figure 4.2 that in case of bus topology using the First Fit approach the over all average network delay also increases gradually. More appropriately it is increasing linearly. Here the average network delay is 44 ms when the numbers of active source destination pairs are 10. The highest delay value is 78ms when number of nodes are 120 and linear structure posses high congestion. All these considerations have been analysed using OMNet++ simulator and First Fit Wavelength Assignment Algorithm. A large body of literature review considers bidirectional ring topology with no wavelength conversion.

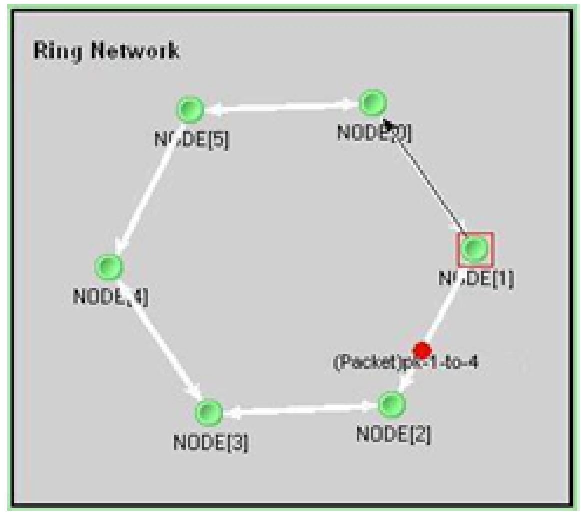


Figure 5.1 Bus Topology

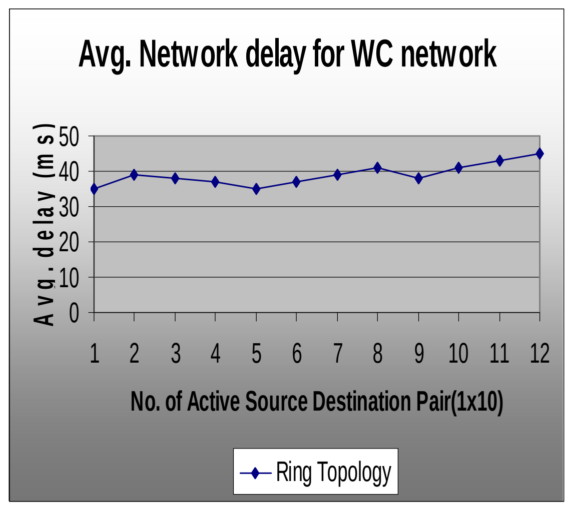


Figure 5.2 Ring Topology

The Ring configuration is given in Figure 5.1, where the six nodes are connected one after another, with a bidirectional link [11]. The nodes are connected in a loop configuration. The structural behaviour of the ring allows all nodes equal access to the network, even when the number of nodes increases. However, the lack of reliability is an important drawback as ring topologies do not provide enough alternative paths between their nodes. An implication of the token ring design is that the ring itself must have a sufficient delay to contain a complete token to circulate when all stations are idle. But every node is a critical link as all nodes work as a server and repeat the signal.

The disadvantage of Ring Topology is that if one node stops working, the entire net is affected or stops working

[12]. The Figure 5.2, shows that the delay 35ms is introduced in the ring at initial stage; resulting lower average value obtained when the numbers of nodes are 50.

Over and above metioned cases, the MESH-Topology case is very typical one as here all the s-d pair have a special significance since all s-d pairs have direct connection from source pair to destination pair provided the wavelength must be available accordingly.

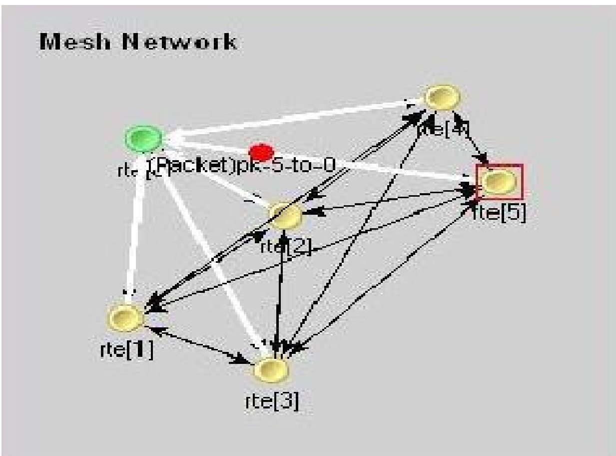


Figure 6.1 Mesh Topology

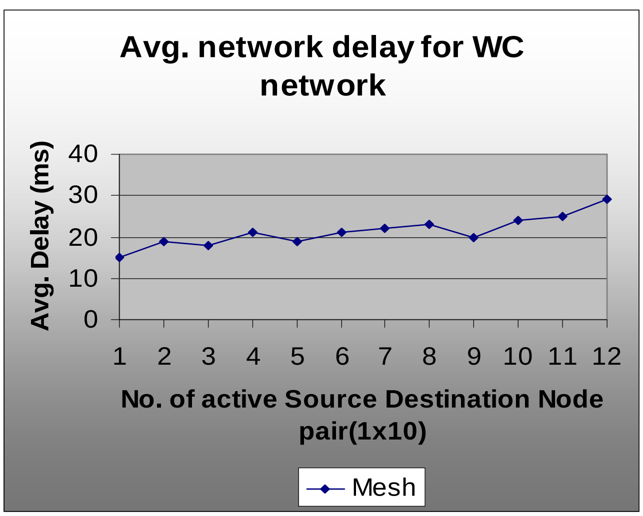


Figure 6.2 Mesh Network

VI. FUTURE ASPECTS [2,6,7, 10, 11]

WDM point to point links, being deployed by several telecommunication companies due to the increasing demand on communication bandwidth. WDM systems are popular with telecommunications companies because they allow them to expand the capacity of the network without laying more fiber. By using WDM, they can accommodate several generations of technology development in their optical infrastructure without having to overhaul the backbone network. Nowadays, the concept of 3G & 4G has also been enhanced with the latest technology. Wireless networks are becoming more and more ubiquitous in recent years, ranging from Digital Cellular telephony up to satellite broadcasting. 4G refers to the next generation of wireless technology that promises higher data rates and expanded multimedia services. The case study of Ring Topology restricts to one hop only.

So, the Bus Topology proves best result as the average delay introduced linearly rather than the Ring Topology have varied factors. It depends upon what type of load is going to prevail in the network. Most of the best results are supposed to be obtained with high end resources. It is hereby emphasized that the end to end data rate is achieved with fiber optics using Bus Topology only. Moreover, the Bus case study performs best at blocking probability as compared to others. Whence, in case of Mesh topology the Dijkstra's algorithm gives limited results with highest wavelength number and lowest delay. In Figure 6.2, it is clear that the average network delay increases partially in linear fashion.

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