An Overview of Routing and Allocation of Equalized Wavelength or Power Distribution in Optical Network Security

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ABSTRACT

Optical networks play an important role in information communication supporting both small-scale and large-scale networks through its capacity of seamless transmission of massive volume of data within a short time period. Some of the issues related to information communication using optical networks are routing, assignment of the wavelength and minimizing lightpath attack radius. By using adequate security measures and routing the lightpaths in an appropriate manner, we can decrease the potential damage like jamming attacks, flooding attacks occurred in the physical layer and we can overcome the congestion problems also. Routing in the optical networks needs to be dynamic as the wavelengths and its parameters are changing frequently. This paper presents a brief survey about the existing approaches in the Routing and Wavelength Assignment (RWA) using Wavelength Division Multiplexing (WDM) and optical cross connect switches which also provides solutions for the security threats in the physical layer of optical fiber networks. Based on the analysis carried out over the existing solutions we are proposing an equalized wavelength or power distribution using Wavelength Division Multiplexing (WDM), optical crossconnect equalization at the network nodes and power equalization placement in order to prevent jamming attacks and reducing LAR with minimum cost.

Keywords: Optical networks, Routing, Wavelength Assignment, Wavelength Division Multiplexing (WDM), Physical layer, Security.

1. INTRODUCTION

In recent days with the emergence of optical fibers the scope of optical network based services are increasing and it provides better results compared to the traditional networks like circuit switching and packet switching policies. By using optical fibers the nature of transmitting data is high and fast when compare to the above traditional approaches using copper cables, twisted pairs as a communication medium. In the optical networks the data is converted into the bits of light called photons and then transmitted over fibers which are faster than the traditional networks in which the data is converted into the electrons that travel through the copper cable. The data transmission using optical fiber is fast because photons weigh is less when compare to the weight of electrons. And further, unlike electrons, photons do not affect one another when they move in a fiber because they have no electric charge and they are not affected by stray photons outside the fiber. Light has higher frequencies and hence shorter wavelengths, and therefore more "bits" of transmission can be contained in a length of fiber versus the same length of copper.

The optical fiber can carry more communications signals than the large copper cable in the background and over much longer distances. The copper cable has about 1000 pairs of conductors. Each pair can only carry about 24 telephone conversations a distance of less than 3 miles. The fiber cable carries more than 32,000 conversations hundreds or even thousands of miles before it needs regeneration. Then each fiber can simultaneously carry over 150 times more by transmitting at different colors (called wavelengths) of light. The cost of transmitting a single phone conversation over fiber optics is only about 1% the cost of transmitting it over copper wire and hence fiber is used as the exclusive medium for long distance communications. The demand for bandwidth has been increasing significantly; the network capacity has also increased and applications like Video applications (video download, video telephony), IP telephony, Multimedia applications and remote employment are the main drivers for this increased demand.

Presently, Wavelength Division Multiplexing an enabling technology for high-speed backbone networks are used in optical networks. The optical connection between the nodes in a network is called as lightpaths. A lightpath is established before the communication between the wavelength routers. To establish a lightpath the same wavelength channel should be allocated on all the links along the route. The set of established lightpaths are called as virtual topology and it is used to route the higher layer traffic. So, these lightpaths need to be set up dynamically by determining a route across the network connecting the source to the destination, and allocating a free wavelength channel on each fiber link along the chosen route. In this paper, we assume that existing lightpaths cannot be re-routed to accommodate new lightpath requests until they are released. Some of the lightpath requests could be blocked if there is currently no common free

wavelength along any route. One of the primary design objectives of wavelength-routed all-optical WDM networks is to minimize the blocking probability, i.e., the probability that a lightpath connection request cannot be accepted.

The rest of the paper is organized as follows. In Section 2 the background of RWA, WDM, Dynamic RWA, Security Issues ILP and Proposed System. And Finally Conclusion in Section 3 and In Section 4 References.

2. BACKGROUND

2.1 The Routing and Wavelength Assignment (RWA) Problem

In transparent optical networks the important problem is Routing and Wavelength Assignment (RWA). The problem in RWA is again divided into two sub problems:

- Routing
- Wavelength Assignment

(i) The routing is the path (lightpath) from the source to destination or routing is the act of moving information across an inter-network from a source to destination and (ii) The Wavelength Assignment is the wavelength which is assigned along that path. The traffic types subjected to the optical networks are two types:

- Static
- Dynamic

In the static case, according to the requirements, before when we know the specific source and destination. And its path is stable then the static case is used. And another case is the dynamic phase when the requirement is from one node to another node and we want to setup the lightpath then it may be taken it down dynamically. And there are two versions of Routing and wavelength assignment is realized depending on the characteristics of the traffic applied. The basic terminologies used in this service are:

- Static light path establishment (SLE)
- Dynamic light path establishment (DLE)

The Static Lightpath Establishment objective is to minimize the total number of wavelengths to connect the maximum number of nodes. And the other objective is the load in the most loaded link, the total number of optical switches (i.e.; total length) etc. The Dynamic Lightpath Establishment objective is to maximize the acceptance of the number of incoming communication requests.

2.2 The WDM – Wavelength Division Multiplexing

The information carrying capacity over an optical fiber is increased by using the multiplexing technique. There are three types of multiplexing techniques:

- TDM – time division multiplexing
- FDM – frequency division multiplexing
- WDM – wavelength division multiplexing

Here, we are mainly concentrating on the WDM – wavelength division multiplexing. TDM and FDM techniques are operated in the electrical domain and are widely used in the conventional radio wave communication. WDM technique is very useful in the optical domain and by using WDM the bit rate can be increased beyond 10 Tb/s in the optical fiber communication. (See Figure 1) shows the basic principle of WDM technique. Here different wavelengths carrying separate signals are multiplexed by the multiplexer and then they are transmitted through a single fiber. At the receiver end, the separate signals at different wavelengths are demultiplexed by the demultiplexer and are given to separate receivers. From the receiver side also the signals can be transmitted in the same manner through the same fiber. Thus instead of handling a single channel with single wavelength and limited bit rate (10 GB/s), the bit rate is raised to about 10 Tb/s, hence the information capacity of the fiber is increased by WDM technique. An optical wavelength demultiplexer can also be used as multiplexer.

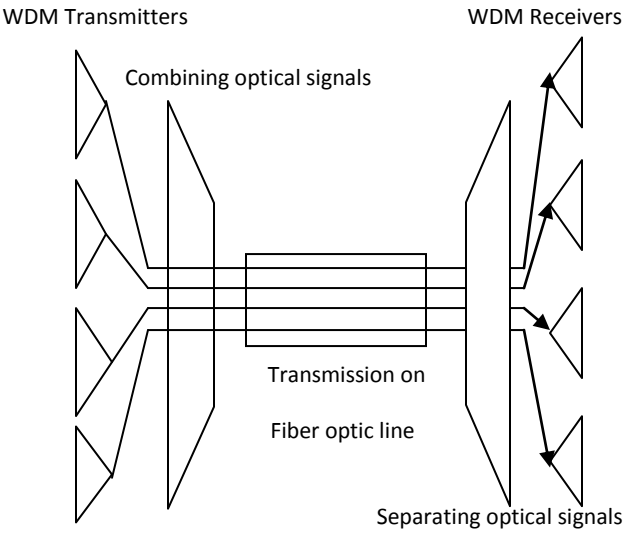

Fig 1: Wavelength Division Multiplexing

Thus for simplicity the word ‘multiplexer’ is often used as a general term to refer to both multiplexers and demultiplexers, except when it is necessary to distinguish the two devices or functions.

In this survey we are mainly focusing on the WDM technique. So we can achieve the better performance. Transparent optical networks which are based on wavelength division multiplexing (WDM) can exploit the huge capacity of optical fibers by dividing it among different wavelengths.

The most important challenges in transparent optical networks is to solve the routing and wavelength assignment (RWA) problem. Given a physical topology and a set of lightpath demands, the RWA problem consists of finding a physical route for each lightpath demand and assigning wavelength to each route. The same wavelength must be assigned along the entire lightpath (i.e., the wavelength continuity constraint). Then the lightpaths share a common physical link cannot be assigned the same wavelength (i.e., the wavelength clash constraint).

2.3 Security

Optical fiber is more secure when compare to the copper cables from tapping because the light does not radiate from the fiber. Now a day the optical networks employing with WDM – wavelength division multiplexing technology is increasing globally. Major cities, Corporate and Government sectors are now using the optical fibers [6]. So the transmitting data along the optical fiber is literally at high speed. Demand for the optical fiber cable is increasing widely and it is growing exponentially because of its

- High Speed
- Cost Effectiveness
- Disaster Recovery
- Outsourcing

2.3.1 Security from physical layer attacks

There are some difficulties, in detecting and locating failures in both component faults and deliberate attacks are enhanced since monitoring must be performed in the optical domain. Secure mechanisms are used in optical fiber for example including alarming the fiber in case of tampering or incorporating automatic gain control and power limiting amplifiers to thwart power-jamming attacks.

EDFA's - Erbium-doped fiber amplifiers is the most commonly used amplifiers in TONs, have a finite amount of gain available (i.e., a limited pool of upper state photons) which is divided among the incoming signals. Detection techniques (e.g.,[7] and [8] in detecting and localizing attacks based on information received from specialized optical monitoring equipment, which can be quite expensive. So the optical fiber reduces the cost effectiveness using the above techniques. The gain competition in amplifiers and intrachannel crosstalk in switches is shown in Figure (See Figure 2). The Interchannel crosstalk in fibers is shown in Figure (See Figure 2).

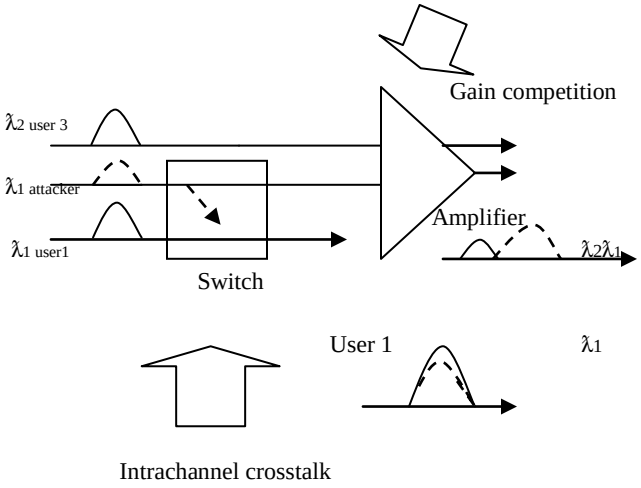

Fig 2: Gain competition in amplifiers and intrachannel crosstalk in switches

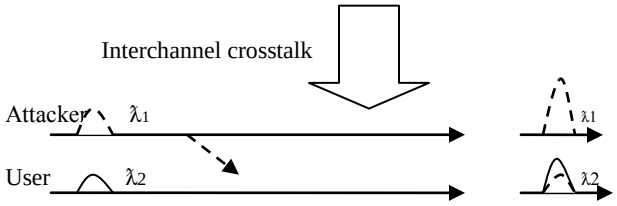

Fig 3: Interchannel crosstalk in fibers

Reaction mechanisms restore the proper functioning of the network by isolating the source of the failure and reconfiguring the connections. Such techniques can use preplanned backup paths or reactive rerouting schemes, creating a tradeoff between speed and utilization of network resources [9]. In general, the higher the reliability performance required, the more spare resources are needed and, consequently, the higher the cost of the network equipment involved.

2.4 Integer Linear Program

The routing problem is formulated using the integer linear programming (ILP). It solves using wavelength assignment by an existing graph coloring heuristic algorithm refer to as the Greedy Graph Coloring algorithm that minimizes the number of colors used and a tabu search [9] heuristic for the same problem. The tabu search that "memorizes" a certain number of previously visited solutions to prevent the algorithm from cycling and getting stuck in local optima. Tabu search is an iterative meta-heuristic that guides simpler search procedures through various areas of the solution space, preventing them from remaining in local optima. In each iteration, the search begins with a current solution, explores all its neighboring solutions, and chooses the

best neighboring solution (which is not forbidden by the tabu list) to become the current solution in the next iteration. A tabu list is one of the memory structure to identify the optimal solution.

2.5 Dynamic RWA algorithm

There are different types of algorithms which are used for wavelength routing in wavelength division multiplexing networks with centralized and distributed control. A wavelength algorithm selects a good route and a wavelength to satisfy a connection request so as to improve performance of the network. It is also referred as a Routing and Wavelength Assignment (RWA) algorithm. And a new dynamic RWA algorithm is called as Weighted Least-Congestion Routing and First-Fit Wavelength Assignment (WLCR-FF), which considers the distribution of free wavelengths and the hop length of each route. And the performance of the WLCR-FF algorithm is a variety of topologies. The results conclusively demonstrate that the proposed WLCR-FF algorithm can achieve much better performance than the fixed routing (static routing), fixed-alternate routing, exhaust routing and least-loaded routing, specially in the environment with sparse or/and full wavelength conversion. The fixed routing refers to router-provided networking services. These services use routers (devices used to link networks) fixed over a network link to provide different data paths for fast and reliable transmission. Fixed routing is not used for real-time processing. Alternate routing is another route which provides an alternate alignment for a route. Adaptive routing refers the capability of a system, through which routes are characterized by their destination, to alter the path that the route takes through the system in response to a change in conditions. The adaptation is intended to allow as many routes as possible to remain valid (that is have destinations that can be reached) in response to the change. This is highlighted by the significant performance gain in term of blocking probability observed from extensive numerical studies in using the proposed WLCR-FF algorithm. Our contribution lies in the development of WLCR algorithm and the analysis of WLCR with random wavelength assignment.

The routing and wavelength assignment algorithms play an important key role in improving the blocking performance of all-optical WDM networks. Shortest path routing (SPR) strategy is widely used in telephone networks and Internet mainly because it consumes fewer resources. Many variations of SPR have also been investigated in the domain of optical networks. Generally these routing strategies can be classified into two categories: static routing, and dynamic (or adaptive) routing. In static routing, the routes are determined under a prior-given traffic matrix without considering the ongoing network status (e.g., the current traffic load distribution); while in dynamic routing, the route selection is based on the current network status.

To find the blocking probabilities for Shortest Path Routing [4], a generalized reduced load approximation scheme is used. It shows that the blocking probabilities grow with the number of hops much faster than for circuit-switched telephone network due to the wavelength continuity constraint. The performance of SPR is, however, very limited because the traffic is likely to be distributed to the links that belong to some short paths. These links are heavily loaded whilst the other links are comparatively lightly loaded, resulting in a low link utilization on average. To solve this problem fixed-alternate routing (FAR) algorithm is used and investigated its performance by extending the analytical model. FAR algorithm can improve the blocking performance by considering more candidate routes between each pair of nodes. If there is no available wavelength on the primary route, an alternative route will be considered. Thus the traffic can be distributed to more fiber links, and the overall blocking performance can be improved. A new analytical technique for the analysis of ball-optical networks without wavelength conversion has been proposed in [14], it is based on the inclusion-exclusion principle from combinatorics and has a lower computational complexity.

2.6 Proposed: New Approach in RWA using WDM – Wavelength Division Multiplexing

In the optical networks the wavelength division multiplexing technology which multiples a number of optical carrier signals into a single optical fiber using different wavelengths (colors) of a signal. Using this technique we can join the signals at the transmitter side referred as multiplexer and it splits the signals at the receiver side referred as demultiplexer.

By using the wavelength division multiplexing only the wavelength is dividing and we don't know how much wavelength is dividing and how much wavelength is assigning to the next node. During this process the chromatic dispersions will take place. The chromatic dispersions are three types:

- Low
- Medium
- High

The losses are non-uniform for the different wavelengths (i) loss may be more for one particular wavelength (ii) less loss for second wavelength (iii) loss may be medium for another wavelength. So, the differential losses will occur at different frequencies. Then the shape of the pulses will change. And the different spectral components of a pulse will travel at different velocities.So the proposed system of the paper is using wavelength division multiplexing technology, if we maintain equalized wavelength or power distribution in routing and choosing the alternative routes if attacks occurs. Then we can achieve the better performance of the network. And the transmission of data over optical networks using wavelength

division multiplexing technology will be secure. In the transparent optical networks by using the some principle we can do it. It can be done by the following:

- Inclusion and Exclusion principle
- Cross switching network
- Attack: Alternative route
- Optical network switching specification process

using integer linear programming and graph colouring problem for the small scale networks, heuristic and graph colouring algorithm for the large scale networks. We can maintain the security by the on demand Adhoc distance vector (AODE) which is a reactive and resilient property in transparent optical network. The physical layer attacks, jamming attacks, congestion problem and flooding attacks in which more number of attacks or requests occurred in a single route. Wavelength conversion can eliminate the wavelength continuity Constraint and improve the blocking performance [10] and [13]. A wavelength router with wavelength conversion capability is called a wavelength convertible router (WCR). If all the wavelength routers can support wavelength conversion, this is referred to as full wavelength conversion. Because wavelength converters are still very expensive at the current stage, much research work focuses on sparse wavelength conversion, in which only part of the wavelength routers have the capability of wavelength conversion. By using sparse wavelength conversion, a relatively small number of WCRs can achieve satisfactory performance. The main issue in sparse wavelength conversion architecture is the wavelength converter placement problem, i.e., In a given network topology, a number of WCRs, and the traffic statistics, how WCRs be placed so as to minimize the overall blocking probability. The algorithms for optimal converter placement for simple topologies such as bus and ring topologies. However, optimal converter placement for arbitrary mesh is considered to be very hard. An efficient algorithm for optimal converter placement has been proposed in [11], which is more efficient than exhausted search solution. A large number of heuristic algorithms are in the literature [3]. The existing research demonstrates that an effective routing and wavelength assignment (RWA) strategy and wavelength conversion are the two primary vehicles for improving the blocking performance [5] and [8]. However, these two issues are investigated in the existing RWA algorithms by considering the presence of wavelength conversion, and the wavelength converter placement algorithms have largely assumed that a static routing and random wavelength assignment algorithm is employed. The Different types of algorithms and technology's which are used in optical networks are shown in Table 1.

Table 1. Different types of technology's and approaches in Optical Networks

Paper Title	Technology/ Algorithm used	Proposed System	Advantages
Lightpath communications : An Approach to High Bandwidth Optical WM's	The Lightnet Architecture	Lightnet Architecture which use emerging transmission and switching capabilities in photonic domain. It overcomes the limitations of electronics based networks by introducing the concept of lightpath.	Transmission between light path endpoints requires no processing or buffering at intermediate nodes. It addresses the mismatch between optical transmissions.
An Approach in Optical Networks Security: Attack-Aware Routing and Wavelength Assignment	Wavelength Division Multiplexing technology and heuristic algorithm.	The equalized wavelength or power distribution in WDM and power equalization placement to prevent jamming attacks. Reduce lightpath attack radius with minimum cost.	RWA is done in simple. Equalized wavelength in WDM. Minimizing the Lightpath Attack Radius. Preventing jamming attacks, physical layer attacks and congestion problems.

The impact of Transmission Impairments on the Teletraffic Performance of WL-R Optical Networks	Wavelength Routed optical Networks novel hybrid simulation	By introducing the models of multiwavelength optical Devices (XCs'S and EDFA 'S) lightpaths can be calculated in advance.	Blocking performance of WL-Routed optical Network is reduced using saturation of amplifier gains and ASE generations in EDFA'S.
The Dynamic RWA in Wavelength Conversion for all Optical Networks	Weighted Least-Congestion Routing and First Fit	W LCR-FF for Current load traffic and route lengths.	Improves blocking performance by Wavelength Conversion
A Biased Random Key Genetic Algorithm for fibre installation in Optical Network Optimization.	A Genetic Algorithm with Random Key.	Proposed a genetic algorithm with the random key.	Optical network optimization. It Eliminates O/E and E/O (Optical to Electrical signals and vice versa) conversions at intermediate nodes.
The Heuristic Algorithms for the RWA of Scheduled Lightpath Demands in Optical Networks.	Tabu Search.	An iterative meta heuristic algorithm provides sub optimal solutions.	It has good lower bounds in order to assess the quality of the sub-optimal solutions. Perform successful RWA on a set of Scheduled lightpath demands.

3. CONCLUSION

In this paper we considered about the existing techniques addressing the problem of routing and wavelength Assignment (RWA). By using Wavelength Division Multiplexing (WDM) the Equalized Wavelength or Power Distribution in routing and assigning the wavelength along the lightpath in the optical networks is proposed. So that we can improve the performance of the network and the network security issues from physical layer attacks through careful network planning. The optical cross connects (OXC) switches between the intermediate nodes are also used. This method will provide with reduced minimum cost by performing against the jamming attacks and physical layer attacks in the network. By the equalized wavelength, we can achieve the better performance of the network without any delays and chromatic dispersions. Out of all those approaches Equalized Wavelength or Power Distribution in Routing approach is emerging one and the research is going on this area. We anticipate that, especially in practical applications, additional requirements will be imposed onto an optical fiber. So, in order to achieve the better performance of the network the Equalized Wavelength or Power Distribution in Routing approach is the best one.

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