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A Novel Approach for Improving Communication by Wavelength Utilization

Shrangesh Dahat[1], Maneesh Shreevastava[2]
M-Tech, Information Technology[1], Professor, Information Technology[2]
Lakshmi Narayan College of Technology Bhopal (M.P.), India[1,2]

Abstract

Optical networks using wavelength division multiplexing (WDM) technology modulate multiple channels over a single fiber. The most common architecture utilized for establishing communication in WDM optical networks is wavelength routing, where the communication between a source and a destination node is performed by setting up optical channels between them, called light-paths from the network perspective. In optical WDM networks, transmission of information along optical lines is advantageous since it has high transmission capacity, scalability, feasibility and also high reliability. But since large amount of information is being carried, any problem during transmission can lead to severe damage to the data being carried. In this paper, we propose to develop a routing and wavelength utilization algorithm which considers two constraints for selecting the best path. The two constraints are based on the available free load and the number of wavelength used in the link. Based on these constraints, two cost functions on load and wavelength are determined, which yields a combined cost function. For each pair of source and destination, the path with the minimum combined cost function is selected as the primary path for data transmission, allocating the sufficient wavelength. This study paper proposes a RWU algorithm for the problem of establishing the set of efficient light paths for a given set of connection requests. The effectiveness of the proposed RWU algorithm is demonstrated by simulation. This study divides the routing and wavelength allocation process in two step problem with a goal of minimizing Number of wavelength channel and number of wavelength conversion required. This algorithm thus provides a reliable path for the data transmission.

Keywords

High transmission capacity, Optical networks, Wavelength, Wavelength division multiplexing (WDM) technology.

1. Introduction

Day to day growth in telecommunication network needs functionalities like dynamic data-path selection with guaranteed quality of service, which are essential for any optical network. At the present times, telecommunication networks still experience tremendous amount of traffic. In order to cope with traffic growth, telecom operators turned to optical fiber as a transmission medium having huge capacity in terms of bandwidth. Wavelength Division Multiplexing (WDM) in optical networks has made possible high throughput backbone networks. In deploying a WDM network based on dynamic light-path allocation, we have to take into consideration the physical topology of the WDM network and the traffic requirements. The physical topology is defined by the nodes, typically computers that generate data to be transmitted or computers where data is needed, the optical routers that determine how the optical signals are sent towards their respective destinations, and the fiber connections that provide the physical medium for communication. We have considered power-budget and finally computed Q-Factor, which is used for the selection of a light-path for a set of applications. The main objective is to select the best light-path from a number of all possible light-paths. The selection criteria are dependent on the Q-Factor parameter for every light-path in between the source and destination pair.

The most common architecture utilized for establishing communication in WDM optical networks is wavelength routing [1], where the communication between a source and a destination node is performed by setting up optical channels between them, called light-paths. From the network perspective, establishing a light-path for a new connection requires the selection of a route (path) and a free wavelength on the links that comprise the path. The problem of selecting appropriate paths and wavelengths for a set of requested connections is called routing and wavelength utilization (RWU), and its objective is to minimize the network resources used, or the network cost, or to maximize the traffic served for a given set of resources.

WDM technology is being extensively deployed on point-to-point links within transport networks in the United States, while WDM point-to-point links are soon to be deployed within Europe[2] .WDM promises advantages for switching and routing as well as for transmission, with the advent of recent advances in optical technologies like optical cross-connect that are currently being developed which can switch an entire wavelength from an input fiber to an output fiber so that large-bandwidth circuits can be routed through the network according to wavelength. High-speed, fixed-bandwidth, end-to-end connections called light-paths can then be established between different nodes. Networks which use optical cross-connects to route light paths through the network are referred to as wavelength-routing networks. Wavelength routing optical core networks are expected to evolve from the existing separate WDM transmission systems to form optical layers in future transport networks. The advent of Dense WDM (DWDM) in optical networks has further increased the bandwidth available on a single fiber.

1.1 Routing and wavelength Assignment

In a wavelength –routed WDM network, a channel may be established from a source node to a destination node and it may span multiple fiber links. End-users are connected with one another via all-optical channels referred to as light-paths that require no processing or buffering at intermediate nodes and preferably no intermediate electric/optic conversion. Routing and wavelength assignment algorithms, for establishing this light path can optimize transmission bandwidth over fiber infrastructure so that DWDM network users can get maximum throughput through optically multiplex channels. The RWU problem can be formulated as follows: “given a set of light path that need to be established on the network, and given a constraint on the number of wavelength, we need to determine the routes and wavelengths that should be assigned to the light paths so that minimum light-path blocking probability is achieved.” [3] .Optimized routing and wavelength assignment can result in improved performance, eliminating conversion delay, possible signal degradation and also reducing the number of converters needed in network.

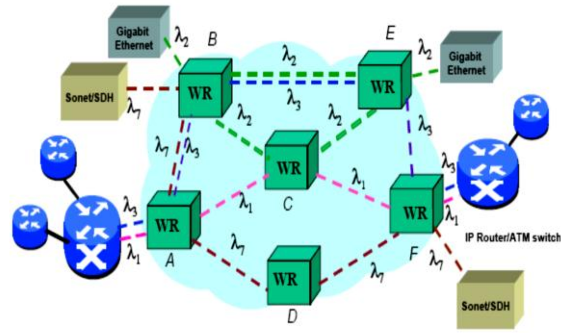

Figure 1: A general wavelength routed network

1.2 Wavelength Routed network

Fig 1 shows the general structure of wavelength –routed network. These optical networks are consist of interconnected wavelength routes .The wavelength router in responsible for multiplexing an de-multiplexing of wavelength channels sp that the wavelength as the incoming port can be routed to desired output ports. Figure 2 shows architecture of a basic wavelength router. [4]

An access node can transmit signals on different wavelength which are coupled into fiber. In the wavelength-routing architectures, the optical switching nodes are equipped with passive wavelength-selective components which, based on wavelength, can select a signal from one of its input port and can route that signal to a different output port. In all-optical networks, a certain number of optical connections or light paths are established between the desired source-destination node pairs. Each optical connection provides a dedicated path between its two end points via one of the available wavelengths. The optical connection may be routed via several passive wavelength routers before reaching the destination.

However, the information travels in optical format throughout the optical connection without undergoing any Intermediate electro-optic conversion or other processing. The primary goal in such networks is to maximize the number of light paths that can be established from a given set of desired connection and for a given network configuration.

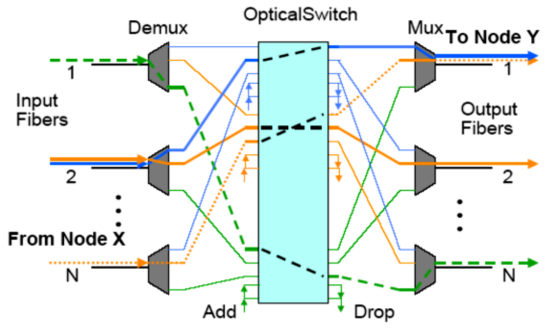

Figure 2: Architecture of the wavelength routed network

2. Related Work

Konstantinos Christodoulopoulos, Konstantinos Manousakis, and Emmanouel (Manos) Varvarigos [5] consider the problem of planning a mixed line rate (MLR) wavelength division multiplexing (WDM) transport optical network. In such networks, different modulation formats are usually employed to support transmission at different line rates. In previously proposed planning algorithms have used a transmission reach bound for each modulation format/line rate, mainly driven by single line rate systems. However, transmission experiments in MLR networks have shown that physical layer interference phenomena are more severe among transmissions that utilize different modulation formats. Thus, the transmission reach of a connection with a specific modulation format/line rate depends also on the other connections that co-propagate with it in the network.

To plan an MLR WDM network, they present routing and wavelength assignment algorithms that adapt the transmission reach of each connection according to the use of the modulation formats/line rates in the network. The proposed algorithms are able to plan the network so as to alleviate cross-rate interference effects, enabling the establishment of connections of acceptable quality over paths that would otherwise be prohibited.

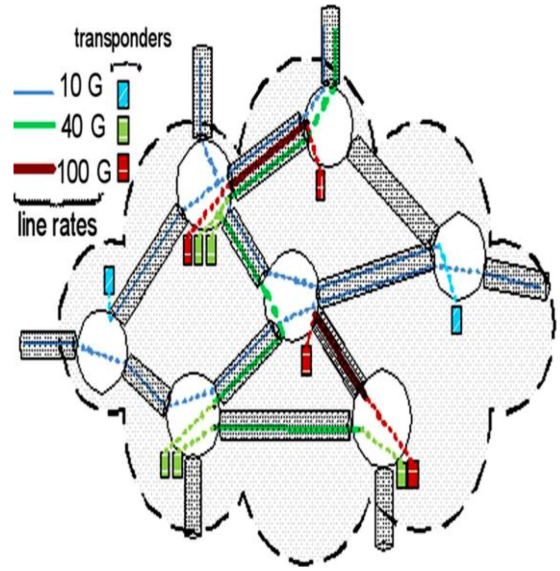

Figure 3: Part of a network that supports mixed line rates (MLRs).

They modeled the cross-rate interference due to the different modulation formats/rates used in an MLR system by defining an effective length metric that helps us adapt the transmission reach of the connections based on the utilization state of the network.

They used the effective length metric to formulate the adaptive reach planning problem for transparent and translucent MLR optical networks. They initially presented optimal ILP algorithms for the MLR planning problem for both transparent and translucent networks. They also gave sequential heuristic algorithms, proposed a specific ordering policy and also used Simulated Annealing (SimAn) to find even better orderings. There results indicated that the proposed algorithms can efficiently utilize the wavelength domain to absorb cross-rate interference effects.

The algorithms assign wavelengths to the light-paths so as to reduce or avoid cross-rate interference and yield solutions that have the same transponder cost and utilize the same number of wavelengths as if no cross-rate interference was present in the network. The performance of the proposed reach-adapting algorithms was shown to be superior to that of other planning algorithms that are based on the worst transmission reach assumption

3. Proposed Technique

This study proposes a sequential routing algorithm with optimization function set to minimizing number of wavelengths channels used on a single link of the network. The main Objective is function of minimizing the number of wavelengths can be translated into minimizing number of times a link is used in a path establishment .As each link would use precisely one wavelength channel for watch route it is used for.

Once the route has been chosen for each light-path, the number of light-paths going through a physical fiber link defines the congestion on that particular link .We need to assign wavelength to each lichgate such that any two light-paths passing through the same physical link are assigned different wavelength. .A multi-step wavelength allocation scheme has been proposed in this study. As a comprehensive definition of problem we can divide it onto two parts, search and selection. Search is simple since any wavelength can be assigned on a link the bigger and more challenging problem is the selection among available wavelength, which can minimize the wavelength utilization.

This novel strategy that we introduce strategically minimizes the number of wavelength used on each link, thereby minimizing total channel we would need to allocate for static path allocation. Unlike the wavelength allocation scheme described above, the scheme we study takes into account the channel allocation on all the other links, irrespective of their direct involvement in the selected path. With a little price of slightly more complex selection algorithm our scheme provides tremendous saving in resources. As this scheme focuses on finding static paths, we can assume that a central machine would have been the controlling entity of the network and this machine would be capable of storing information about all the links.

The aim of our wavelength selection algorithm is to find out the most efficient path. As by optimizing selected route we have already minimized upper bound on number of wavelength channel, we can now choose to concentrate on optimizing number of converters. For a hypothetical network having all nodes equipped with optical converters, we can choose to optimize number of wavelength channels for static paths.

Some of the proposed wavelength-assignment algorithms are:

- Random wavelength assignment allocates a new connection to a wavelength which is randomly chosen from among the set of available wavelengths.
- First-fit wavelength assignment is implemented by predefining an order on the wavelengths. Wavelengths are searched in this order and a new connection is established on the first available wavelength.
- Most-used wavelength assignment, also referred to as the pack scheme allocates a new connection to the wavelength that is used on the greatest number of fibers in the network. If several available wavelengths share the same maximum usage, the wavelength with, say, the lowest index is chosen. If instead of using the most-used wavelength, we allocate a connection to the least-used wavelength, we implement least-used wavelength assignment.
- The MaxSum wavelength assignment attempts to minimize network blocking by minimizing the effect of establishing a new connection. Using the MaxSum algorithm, the effect of establishing a new connection is measured in terms of the number of routes whose capacities decrease by one.

3.1 Proposed algorithm

a) First searches for wavelengths which are available on all links of path calculated by Load balanced routing.
b) From this set of wavelength channels
c) Select a channel which is being used by maximum number of disjoint links on the network.
d) If a wavelength continuous light-path cannot be established on the network
e) Look for channel available on all the links.
f) If wavelength converters is the resource.
g) Then want to conserve
h) Select longest wavelength continuous sub-path
i) If wavelength channel are scarce resource
j) Select most-used wavelength on disjoint links.

4. Test Results and Analysis

Assumption taken here are we have a set of 6 available wavelengths (λ1, λ2 λ3, λ4, λ5, λ6). Using the paths selected by Routing algorithm we will apply proposed allocation scheme for routes selected previously by proposed routing scheme. Hand crafted routes using the above allocation scheme is tabulated below for each source and destination pair for the 6 node asymmetrical example network. While calculating this path, our goal for first section is to minimize number of wavelength channels and in second section, to minimize number of wavelength conversions.

And find shortest path, which is the most popular algorithm for finding routes from a given source to destination in a network graph. The shortest path algorithm detects and is independent of other selection. An analysis of routes provided by shortest-path (Dijkastra) and number of wavelength used is provided to demonstrate the efficiency of proposed algorithm.

5. Conclusion

In this paper proposed RWU algorithm to shortest-path/first fit algorithm. The performance analysis of algorithm will be show after simulation performed. The combination of the proposed algorithm results in substantial reduction in blocking probability compared to shortest-path/first-fit wavelength allocation scheme, which studies have proved, provides best performance compared to other proposed RWU scheme. Also lower number of converters is required for a targeted probability of blocking. The proposed algorithm also accepts more connection without additional wavelength converters. This would have twofold affect on revenue. Less number of wavelength converters make core network more inexpensive, more number of connection increase the revenue generated.

And also a natural and very efficient extension of the algorithm would be to minimize and conserve channels in a space time wavelength router. In this kind of transport network, a connection is established by constructing a time-slot based light-path between two STW routers.

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Shrangesh Dahat, M.Tech.(Scholar) Information Technology,Lakshmi Narain College of Technology Bhopal (M.P), India.