Research on Optimization Policy Routing Technology of Optical Fiber Communication Network

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Abstract. With the development of global informatization, information has penetrated into every corner of human society. With the popularization of Internet, the transmission bandwidth of information becomes more and more important. Nowadays, people's demand and dependence on information are becoming stronger and stronger. It is urgent to expand the capacity of wide area backbone communication network, and the optical network composed of wavelength division multiplexing (WDM) can just take this role. In WDM network, it can transmit multiple optical signals of different wavelengths in one fiber at the same time. WDM has the advantages of large transmission capacity, strong technical adaptability, simple implementation and easy expansion. In addition, WDM optical network can also make full use of the huge bandwidth of optical fiber itself to carry out high-speed transmission. Now, the optical network using WDM technology has become the backbone network of long-distance transmission. This paper studies the optical fiber communication system and analyzes the structure of the optical fiber network. For the optical network, how to find the appropriate routing is a very important technology. After analyzing all kinds of basic routing technologies, this paper proposes a new policy based routing technology, and carries out relevant experiments. The experimental results show that the new routing technology has some advantages compared with the old routing technology.

1. Introduction

In the information age, huge information data are transmitted through the network. Because the general network can not transmit such a huge amount of information and data, the optical fiber communication network with unlimited bandwidth capacity just plays the role of transmitting this huge amount of information[1]. Optical fiber communication technology has been developed for decades. In the development process of optical fiber communication technology, the development of optical devices greatly promotes the comprehensive development of optical fiber communication technology[2]. Therefore, it can be said that the development of optical fiber communication is inseparable from the development of related optical devices. Optical fiber, as a transmission medium, is one of the most important devices in optical communication system[3]. In addition, light source and photodetector are also the key devices in optical fiber communication system. Here, we must talk about the light source problem in the optical fiber communication system, that is, semiconductor laser. The semiconductor laser was invented in 1962. When the semiconductor laser first appeared, it was not stable and its power was relatively small, and it could only work in the way of pulse under low
temperature liquid nitrogen. The threshold value of the laser is high, but its life is relatively short. Later, due to the use of a new heterojunction structure, this makes the threshold of semiconductor laser rapidly reduced, and can work at room temperature. In the 1970s, due to the use of double heterojunction structure in the structure design of semiconductor lasers, semiconductor lasers can work at ordinary temperature without cooling the laser, which has laid a good material foundation for the practical application of semiconductor lasers. The progress of semiconductor laser technology also directly promotes the practical road of optical fiber communication. At first, because of the shortage of material and technology, the working time of semiconductor laser is too short. It can only work for one or two hours, which makes the semiconductor laser completely unable to meet the requirements of optical fiber communication. Optical fiber communication requires semiconductor lasers to work for a long time. Later, after continuous efforts, the semiconductor laser was technically reformed. Finally, in the early 1980s, a long-life semiconductor laser was successfully produced, which provided a reliable light source for optical fiber communication. At this time, the optical fiber communication is really moving towards the era of all-round development. In the history of optical fiber communication, another important milestone is the invention of erbium-doped fiber amplifier (EDFA). The amplifier EDFA was made in 1986 in the laboratory of University of Southampton. With EDFA, a long-distance communication is possible. Now, WDM (wavelength division multiplexing) network based on optical fiber transmission medium has realized long-distance information transmission. WDM optical network is an efficient transmission network. In WDM optical network, it uses wavelength routing and optical switching technology to provide transparent cross connection function for high-speed optical data stream directly by nodes in optical layer network[4]. In the node of electric layer network, it is mainly used to form high-speed optical data stream and realize cross connection of multiplexed low-speed and medium speed ratio special streams. This is a hybrid system of light and electricity. Because of the advantages of optical and electrical, in such a hybrid system, optical and electrical complement each other, thus avoiding a lot of unnecessary multiplexing and demultiplexing operations for switching services. On the other hand, it also simplifies the network node switching structure. For an optical communication network, how to find the appropriate route is a very important problem for the optical network. In optical network, routing is usually represented by the wavelength of light, so optical network is also called wavelength routing network. In this network, the network structure is composed of single fiber or multi fiber of network node and link node. The node of optical network can cross connect the optical channel of input and output, and has the characteristics of dynamic reconfiguration of optical network[5]. When the customer layer service arrives, WDM optical network needs to assign routing and select wavelength for each service, and establish optical transmission channel for service transmission. Wavelength routing WDM optical network has many advantages, for example, it is more flexible in the group network, its transparency can also enable it to support a variety of customer layer signals. In addition, WDM optical network has less power consumption and more efficient multi port switching capability. Therefore, WDM optical network has more extensive applications. However, due to the use of wavelength as routing in WDM optical network, it also brings some shortcomings. Wavelength routing needs to meet different wavelength constraints when routing and allocating wavelengths[6]. That is to say, if two optical channels use the same physical link at the same time, the two optical channels must use different wavelengths in this physical link, which brings certain restrictions to WDM optical network without wavelength converter. For WDM optical network, wavelength is the most valuable resource, and not all wavelengths can be used, and only a few wavelengths that conform to the physical properties of optical fiber can be used as routing. Therefore, if more wavelengths are involved, WDM optical networks will have more routing opportunities, which is of great significance to improve the performance of WDM optical communication networks.

2. Optical Fiber Communication Network
In WDM optical network, from the network structure, WDM optical network is composed of optical network nodes and single fiber connecting nodes. In the process of information transmission, optical channels of different wavelengths are multiplexed in the same fiber, and then long-distance transmission is carried out. The node of optical network has more powerful functions. If it is an OXC
(optical cross connect) node, OXC can cross connect the input and output optical channels, and has the characteristics of dynamic reconstruction. The WDM optical network is shown in figure 1(a).

For WDM optical network, wavelength is used as the route. Therefore, for the same fiber link, different optical channels must have different wavelengths to avoid interference between optical channels. In the optical network without wavelength converter, the wavelength of an optical channel must be the same everywhere, which is the limiting condition of wavelength continuity. When the communication service arrives, WDM optical network needs to assign route and select wavelength for each service at access point, and establish optical transmission channel for service transmission. This is the routing and wavelength assignment (RWA). Since the demand of optical network services is growing explosively, and the wavelength of available resources in optical network is limited, how to select the appropriate routing and allocate the optimized wavelength for services in the limited network resources will directly affect the overall performance and transmission efficiency of the network.

If OXC has wavelength conversion function in WDM optical network, it will greatly improve the overall performance of WDM optical network and greatly improve the efficiency of information transmission. It is shown in figure 1(b).

![Figure 1. Wavelength routing in WDM optical network.](image)

For example, when two optical channels share a link, if the network node OXC has no wavelength conversion function, then different wavelengths must be used to represent different optical channels. However, for OXC node with wavelength converter, the optical channel does not have to meet the wavelength continuity limit, and different wavelengths are directly converted by OXC.

3. Network Routing Design

In WDM optical networks, there are generally two routing choices.

3.1. Fixed Routing

This is the most direct and simple routing method, in which the network will provide a fixed optical channel for each pair of nodes. The routing work is arranged before the arrival of network services. When the network topology is known, the standard shortest path algorithm is used to allocate fixed optical channels for each pair of nodes. In a fixed routing network, the algorithm used is the traditional Dijkstra algorithm. The advantage of Dijkstra algorithm is that it can find the shortest route. Of course, the so-called shortest is not simply the shortest length. For a WDM optical network, the shortest path is meaningful and contains many aspects. In fact, the shortest path means that the total weight of each link that the route passes through is the smallest. Although the weight is only a simple number in the abstract logical topology, it has many specific meanings in the actual network. For a WDM optical network, when fixed routing is used, the communication between a pair of nodes is always based on the fixed route set in advance. The advantages of this fixed routing method are simple and fast. The disadvantage is that when the traffic changes dynamically, if there is wavelength conflict, it will cause serious traffic congestion, which will affect the overall performance of WDM optical network, as shown in figure 2(a). In addition, in fixed routing, because there is no alternative route, WDM optical network does not have link failure recovery capability in case of unexpected network failure.
3.2. Fixed Route with Backup

For WDM optical network, fixed routing has too many limitations, which can not fully meet the requirements of WDM optical network for routing. Therefore, people have improved the fixed routing method and added several spare routes to the fixed routing. Its specific method is as follows: for the services of any pair of nodes in the network, several available alternate routes are provided in advance and arranged in a certain priority order. The first route is the primary route, and the rest is the standby route. When multiple services in the same direction arrive at the same time, routes can be assigned to different services from front to back. When the primary route of the service is blocked, the secondary route can be selected for communication. The advantage of this method is simple, on the other hand, it also has a certain link failure recovery ability. Therefore, compared with the old fixed routing method, the service transmission ability of the network is greatly improved and the blocking rate of the network is greatly reduced. It is shown in figure 2(b).

![Network routing](image)

Figure 2. Network routing.

4. Policy Routing Design

In WDM optical network, network operators should consider two aspects. On the one hand, how to minimize the maintenance cost of network operation; on the other hand, how to make more profits with network operation. Network planning and management personnel will design and complete the plan in advance. For the operation of WDM optical network, the service rule of network service is: first come, first served. Although the arrival of data traffic is completely random, the average arrival rate is certain. The queuing system of the network is in steady state. Traffic leaving the network system is also completely random. The above conditions are Poisson conditions of network system.

For WDM optical network, the network traffic is generally discussed according to Poisson condition. In optical network system, considering that the number of traffic arriving per unit time is a random variable obeying Poisson distribution. Therefore, the function of Poisson distribution is

\[ p(x) = \frac{\lambda^x}{x!} e^{-\lambda} \]  

(1)

Where, parameter \( x \) is the number of traffic arriving in unit time, \( \lambda \) is the average arrival rate of traffic.

In order to improve the routing ability of WDM optical network, it is necessary to design a good routing scheme. Therefore, the following basic routing strategies are proposed:

1. In WDM optical networks, a connection channel will be requested after the service arrives. If the request is rejected due to insufficient channels, the service request will be discarded immediately, that is, there is no need to wait for queuing.

2. In WDM optical networks, traffic is not necessarily a complete whole, but also a part of it. In general, it can segment the traffic according to the actual network routing. For example, the service can be divided into two parts. The first part of the division should try to use a complete wavelength bandwidth. In the second part of the partition, the IP logical link with residual bandwidth should be used as much as possible.

For WDM optical network, since the optical buffer technology has not been fully implemented, therefore, considering that after the arrival of network services, if an optical channel cannot be
established, it has to be discarded to prevent the network from blocking, which is also a preventive measure. For this new routing strategy, experiments are carried out. The result is shown in figure 3.

**Figure 3.** The relation of policy routing (PR) with Dijkstra routing.

Figure 3 shows the relationship between service arrival rate and network blocking rate. From figure 3, we can see that compared with the traditional algorithm, the new policy routing algorithm has certain advantages. In addition, it is found from figure 3 that the blocking rate of network system increases with the increase of service arrival rate in the network. This phenomenon is easy to think of, because when the network traffic is increasing, the load on the network will be heavier and heavier. Therefore, the blocking rate of the network will increase with the increase of the service.

For the algorithm with the fixed routing with backup (FRB), the new algorithm policy routing (PR) also has obvious advantages. The experimental results are shown in figure 4.

**Figure 4.** The relation of policy routing (PR) with fixed routing with backup (FRB).

From figure 4, it can be clearly seen that with the increase of network service arrival rate, the network system blocking rate under these two algorithms also increases. But the system blocking rate of the new policy routing algorithm PR is lower, which means that the algorithm PR is better than the algorithm FRB. However, with the increase of service arrival rate, the difference between the two algorithms becomes smaller and smaller, which shows that the blocking factor of network is mainly caused by the depletion of potential bandwidth resources under the condition of large traffic load.

5. Conclusion

In the information age, with the rapid development of Internet, new requirements are put forward for the structure and function of optical network. Wavelength division multiplexing technology is to transmit multiple wavelength optical signals in one optical fiber at the same time. In WDM networks, multiple wavelengths can be transmitted simultaneously with one fiber. Because in WDM optical network, wavelength as one of the most valuable resources, is needed to make full use of. For this
purpose, each band can be divided into a number of independent optical fiber channels. The main advantage of WDM is that it can make full use of the huge bandwidth resources of optical fiber and transmit a variety of different types of signals at the same time. Each wavelength used is independent of each other, so it can transmit signals with completely different services. In this paper, the routing technology in WDM network is studied, and a new strategy routing method is proposed. The experimental results show that the new method is better than the old routing method.

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