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RSCA method with Dividing Frequency Slots Area in Space Division Multiplexing Elastic Optical Networks
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Abstract

This documentary provides a routing, spectrum and core assignment method with the dividing frequency slots area for space division multiplexing elastic optical networks. This effective RSCA method to solve this problem better. The proposed method utilizes the Frequency Slots Area (FSA) concept and first-last fit policy of frequency slots assignment to have less spectrum fragments, lower crosstalk, smaller traffic blocking probability and higher spectrum resource utilization.

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1. Introduction

With the rapid development of Internet technology and the emergence of new applications such as intense social networking, real-time gaming, High Definition audio-video streaming and cloud computing, the demand for network capacity has increased greatly. The capacity of traditional single-mode fiber is close to its physical capacity limit, so the SDM technology that can greatly improve the network capacity has received more and more attention. In SDM technology, MCF is one of the most promising technology. On the other hand, for the sake of flexible and effective use of spectrum resources, EON has been widely accepted as the next generation high-speed network. In the elastic optical network, the spectrum resources are divided into finer frequency slots, which can be more flexible and effective used

by traffic requests. In elastic optical networks, spectrum resources are assigned flexibly according to connections' requirements. This flexibility based on fine-grained resource provisioning can reduce the amount of spectrum resources wasted, compared with traditional rigid spectrum assignments. At the network level, the RSA problem is the most important problem concerning elastic optical networks. There are two continuity constraints for an assigned spectrum in the RSA problem. These constraints require the same and continuous spectrum to be assigned for all links on the selected transmission route if there is no wavelength converter. Because it is necessary to satisfy the spectral constraints of the RSA problem according to traffic demands, which change dynamically, dynamic resource allocation can effectively improve the performance of optical networks.

The advantage of SDM-EONs is that it greatly improves the capacity of the network, allowing for more flexible and efficient use of spectrum resources. However, it brings the RSCA problem with serious crosstalk and high computing complexity. Crosstalk refers to the mutual interference generated by the transmission of signals on the same frequency between adjacent cores. With the increasing number of cores in the fiber, the core-pitch is getting smaller and smaller, and the crosstalk between adjacent cores is becoming more and more serious. At the same time, compared to the traditional EONs, the new core dimension in MCF-EONs makes its computational complexity higher. However, in the RSCA problem, the impact of inter-core crosstalk can be alleviated by properly assigning the core and spectrum resources to requests. Therefore, how to solve the RSCA problem effectively in SDM-EON is a challenge cannot be ignored.

1.1. Terminology

SDM: Space Division multiplexing.

EON: Elastic Optical Network.

RSA: Routing and spectrum assignment problem.

RSCA: Routing, Spectrum and Core Assignment problem.

FSA: Frequency Slots Area.

2. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

3. Overview

In elastic optical network, the traffic requests are constantly changing with time, so it is very important to choose a dynamic solution to the RSCA problem. However, with the continuous establishment and release of the traffic requests, there will be fragments between the frequency slots. In order to improve the utilization of spectrum resources in SDM-EON, it is essential to solve the problem of spectrum fragmentation.

3.1. Elastic Optical Networks

Elastic optical network is different with traditional wavelength-division multiplexing (WDM) network because of the flexible use of spectrum resource. In traditional WDM networks, different traffic requests are assigned with the same fixed spectrum grid. Therefore, if the transmission distance of the request is short and demands less spectrum resource, there will be a lot of spectrum resource wasted in the fixed grid. In elastic optical network, the spectrum resource is allocated to the traffic request by flexible grid. That is to say, the network can choose the modulation format flexibly according to the length of the optical transmission route to save the spectrum resource. For example, when the transmission distance of the traffic is short, the network can choose the modulation formats with high spectrum utilization, such as 16-quadrature amplitude modulation (QAM) and 64-QAM, so that the resource utilization of the network can be improved. On the other hand, if the requested transmission distance of the traffic is long, the network can choose a modulation format with lower spectrum resource utilization, such as quadrature phase-shift keying (QPSK).

3.2. Multi-Core Fiber

Because the transmission capacity of single-mode optical fiber is close to its physical limit, in order to improve the network capacity further, SDM has been widely concerned recently. MCF is one of the most promising transmission technology in SDM system. MCF using single-mode optical fibers is considered to greatly improve the transmission capacity of the network. However, one of the major problems with MCF is the physical impairment of transmitted signals due to crosstalk between cores during transmission. Large crosstalk occurs when the signals are transmitted in the same frequency on adjacent cores. The smaller the distance of the cores, the more serious the crosstalk will be. As shown in Fig.1, since 1 is used in both the adjacent core one and core two, large crosstalk occurs between the core one and core two. Since core one is not adjacent to core three, even if they both use 2, the crosstalk between them is

much lower than the crosstalk between cores one and three. Normally, we can ignore the effects of these low crosstalk.

4. RSCA

The RSA problem is the most important part of the elastic optical network. In the same way, RSCA is the most important part of EDM-EON. In the traditional WDM network, wavelength channel is the basic unit of resource allocation. Nevertheless, in the elastic optical network basic unit of resource allocation is the frequency slot. The RSA problem in EON is equivalent to the Routing and Wavelength Assignment (RWA) problem in the traditional WDM network. However, due to the flexible resource allocation method of elastic optical network and the application of SDM technology, the RSCA problem in SDM-EON becomes more complex and challenging.

In the traditional WDM network, there is a wavelength continuity constraint, that is, the network must select the same wavelength channel for each link in the transmission route. In elastic optical network, there is a similar continuity constraint for frequency slot. In addition, there is a spectrum contiguity constraint. Spectrum contiguity constraint ensures that the assigned frequency slots have to be consecutive in the spectrum resources of the fiber. Spectrum continuity constraint refers to the frequency slots used by each link on the selected routing path have to be same. According to the transmission distance of traffic requests, the elastic optical network selects different modulation formats to utilize spectrum resources effectively, and determines the number of consecutive frequency slots needed for transmission.

In elastic optical network, the traffic requests are constantly changing with time, so it is very important to choose a dynamic solution to the RSCA problem. However, with the continuous establishment and release of the traffic requests, there will be fragments between the frequency slots. In order to improve the utilization of spectrum resources in SDM-EON, it is essential to solve the problem of spectrum fragmentation.

5. The proposed spectrum and core assignment method

Through routing algorithm and wavelength assignment algorithm, we calculate the K feasible routing of a specific business wavelength. K feasible routing pathes are arranged according to preset priority, among them, the ith routing is recorded as Ri , i=1,2,3 We choose the first reachable optical path and calculate the output power and OSNR value of the first path, and do the following operations

In this draft, we use a k-shortest path algorithm based on Yen's ranking loopless paths algorithm to solve the routing problem .When a traffic request arrives, we use the routing algorithm to calculate k-shortest end-to-end routing paths for it. Then we select the path in order and process the spectrum and core assignment method. If no one path can meet the two constraints, the traffic request will be blocked. In SDM-EONs, it is more difficult to provision huger demands with satisfying continuity constraints due to fragmentation issue . To deal with it, we propose that the spectrum resource of the 7-core MCFs can be divided into several Frequency Slots Areas. This division reduces the blocking probability. Fig. 1 shows the flowchart of the proposed method.

The 7-core MCF can be divided into several different areas according to the number of slots required for traffic requests. In the example, the number of slots required for traffic requests is three, four and five respectively. The first half of the core one, core two and the second half of them are divided into Frequency Slots Area of three (FSA-3) and Frequency Slots Area of five (FSA-5), respectively. The first half of the core five, core six is FSA-5, and the second half is divided into FSA-3.Then we divide the first half and second half of core three and core four into two different Frequency Slots Areas of four (FSA-4). In the last, the remaining entire core seven can be utilized by all the traffic with different frequency slots demand as a common area. When the traffic request needs three frequency slots, only the available frequency slots in FSA-3 and common area will be utilized. In our proposed method, we use first-last fit policy to find the available frequency slots. In other words, when the first three-slot traffic request arrives, we use first fit policy to search for the three available and consecutive frequency slots in FSA-3 and common area. This means that we will first search FSA-3 of core one and core two, then search FSA-3 of core four and core five until there is no available frequency slots and we will search the common area. When the second three-slot traffic request arrives, the last fit policy is applied to find required slots in FSA-3 and common area. That is to say, we take turns using the first fit policy and the last fit policy in FSA and common area for the traffic requests that demand the same number of slots. Because of the first-last fit policy, we can make the distribution of traffic requests with same number of frequency slots more balanced, while bringing fewer fragments. As a result of the use of such frequency slots area concept and special core selected policy, in dealing with a large number of traffic requests with the same frequency slots number demanded the crosstalk will be smaller.

6. Formal Syntax

The following syntax specification uses the augmented Backus-Naur Form (BNF) as described in RFC-2234 [RFC2234].

7. Security Considerations

This kind of information includes network topology, link state and current utilization, as well as the capabilities of switches and routers within the network, which is owing to that the information should be protected from disclosure to unintended recipients. In addition, the intentional modification of this information can significantly affect network operations, particularly due to the large capacity of the optical infrastructure has been controlled.

8. IANA Considerations

This informational document does not make any requests for IANA action.

9. Conclusions

This document discussed a routing, spectrum and core assignment method with dividing frequency slots area in SDM-EONs with 7-core MFC. The simulation results suggest that the proposed method is effective in reducing the path blocking probability and enhancing the spectrum resource utilization.

10. References

10.1. Normative References

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