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Spectrum defragmentation algorithms in elastic optical networks

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A B S T R A C T

Fragmentation in Elastic Optical Networks is an issue caused by isolated, non-aligned, and non-contiguous frequency slots that cannot be used to allocate new connection requests to the network, due to the optical layer restrictions imposed to the Routing and Spectrum Assignment (RSA) algorithms. To deal with this issue, several studies on Spectrum Defragmentation have already been presented. In this work we present an analysis of the different Defragmentation Algorithms in the literature, at the same time we compare the performance of those based on sequential approaches in terms of Blocking Probability, Entropy and Fragmentation Ratio. We also propose a Defragmentation Algorithm based on a Proactive-Reactive approach. Experimental results have shown the conditions under which a Proactive approach can outperform the Reactive ones, and when the Reactive approaches are a better option. Results also showed that our proposed Algorithm is a promissory solution to deal with the Fragmentation problem, because it outperforms the rest of the Sequential Defragmentation Algorithms considered in this study.

1. Introduction

Due to the rising popularity of Internet applications, like Video on Demand (VoD), and Content Delivery Network (CDN), the requirements of current network technologies are rapidly growing, and consequently a more efficient use of the fiber channels is needed. Elastic Optical Networks (EON) [1] can be considered as an alternative solution to this problem, because it can achieve a more efficient use of the spectrum. In fact, this efficiency can be accomplished due to its ability to divide all the available spectrum into little, width-constant spectral slices called Frequency Slots (FS), each corresponding to a certain wavelength [2]. The number of slices assigned to a connection is tailored to its bandwidth requirements, leaving more spectral resources available for future connections.

An essential problem in EON is the selection of the route and spectral resources for a connection request arriving to the network, namely, the Routing and Spectrum Allocation (RSA) [2–4] problem. The EON architecture imposes to the RSA problem three constraints: (1) the wavelength continuity constraint, that is the allocation of a connection in the same wavelength at each link along the route, (2) the spectrum contiguity constraint, that is the allocation of a connection on contiguous FSs on each link along the route, and (3) the spectral conflict constraint, i.e. a connection allocated to a certain spectral resource, cannot overlap with the spectral resources of the other connections. Due to the aforementioned constraints, connections require available, contiguous, and continuous FSs to be allocated in the spectrum. Ina dynamic environment the frequent connections setting-up and tearing-down of a few GHz or even less, can leave isolated FSs, causing the Fragmentation of the Spectrum [5].

Spectrum Fragmentation is referred as the existence of available FSs that are neither aligned, nor contiguous in the spectrum domain, meaning that, they are isolated and can hardly be used to allocate future connections. If the available slot-blocks (one or more contiguous FSs) cannot meet the RSA constraints to allocate a connection request, this connection is rejected, leading to a poor utilization of the spectrum. For this reason, defragmentation is important to reduce the number of rejected connections in the network due to the fragmentation of the available spectrum.

Several Defragmentation Algorithms have already been proposed in the literature. These algorithms can be split into two approaches: *Proactive*, those that takes evasive measures to avoid the fragmentation of the spectrum, in which the defragmentation is invoked without waiting for a new connection request; and *Reactive*, that are triggered when a new connection request arrives and would be blocked if no defragmentation is being made. However, we have not yet found a comparative analysis of the performance of these algorithms, that will allow us to see in which scenarios the performance of one approach could be better than the other.

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