A New Defragmentation Algorithm For Dynamic Optical Networks

Marta Buffa[1*], Annalisa Morea[1], Federica Poli[2], Andrea Paparella[1]

1 Nokia Italy, Vimercate (MB), Italy
2 Department of Engineering and Architecture, University of Parma, Parma, Italy
**marta.buffa@nokia.com*

Three different strategies are proposed to mitigate the fragmentation issue and minimize the amount of occupied resources in dynamic optical networks. Strategies with rerouting accommodate up to 7% further traffic with respect to recoloring strategies.
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1. Introduction

The recent analysis of traffic has shown a shift from homogeneous and static to more heterogeneous and dynamic, because of 5G applications [1]. This is encouraging the evolution towards automatically reconfigurable networks, and the need of network architectures more and more controlled and reconfigured remotely by the exchange of messages and protocols. In these networks, traffic arrives randomly and optical connections are established and torn-down at any moment, scattering free resources on the spectrum comb. This effect is known as spectral fragmentation [2], which effect is the degradation of the overall efficient resource utilization and the network performance, yielding higher blocking probability (incapacity to set-up connections even with free resources).
In this work we proposed a reconfiguration process for reducing optical fragmentation and allowing the set-up of a higher amount of traffic.

2. Defragmentation strategies

The spectrum defragmentation technique we adopted is reactive, i.e. it performs after the achievement of a certain network condition. The spectrum rearrangement could be obtained either by changing the wavelength of a connection (recoloring, RC), or the path and possibly the wavelength of a connection (rerouting, RR). For rearranging the spectrum with the RC strategy, we implemented the Conflict Graph (CG). The CG determines the conflict degree of optical connections by counting the number of links shared between the other connections present in the network. Connections with higher conflict degree are recolored at first. The RC-CG strategy compacts the spectrum with simple changes of the connection information stored in the network database for maintenance purposes: path devices remain unchanged, while occupied wavelengths are modified. Differently, the RR strategy requires more database updates (path and wavelengths). After rerouting, the order for allocating the spectrum to the connections could be random or follow the CG: this latter case is named RR-CG. When defragmentation runs, all active connections are impacted, and some active connections may be disrupted for a limited time period. Through the proposed algorithm, we minimize the number of disrupted services and their disruption time. To achieve these goals, we implemented a further graph, named Dependency Graph [3], which measures the conflicts, in terms of spectral occupation among connections before and after the reconfiguration. Connections with highest dependency values are the ones that block the reconfiguration of the largest number of connections, so the ones that have the highest chance to be disconnected for allowing reconfiguration of other connections at the same time.
To assess the advantages of spectrum defragmentation and estimate the proposed strategies, we investigated their performance over a network of 13 contentionless nodes and 33 bidirectional links, each with up to 44 wavelengths. After the creation of sequences of 2000 events with an event generator, we measured the network performance in terms of overall network fragmentation, average free resources, average paths length and blocking probability. Then, we defragmented the network and we recomputed the network performance. Simulations are done by varying the traffic load ρ of the network, defined as the ratio between the mean connection arrival time and its duration. Our analysis was obtained by averaging 12 sequences of events for each ρ and we noticed that: the use of the RC-CG gives the best compactness of the spectrum; conversely, due to the rerouting capability, RR and RR-CG reduce the path length associated to the connection and the amount of occupied spectrum. From a network operator point of view, defragmentation is desirable only if it is possible to add more traffic with the deployed resources. To assess the advantages of the proposed strategies, we measured the possibility of adding further services in the network as a function of ρ. Results demonstrated that RR and RR-CG accommodate more extra traffic with respect to RC-CG.

3. Conclusion

As a conclusion, defragmentation is a complex network reconfiguration that could interrupt traffic connections and its application would be advantageous if optical connection rerouting is performed, even if this implies more database management.

References

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