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Routing and Spectrum Allocation in Elastic Optical Networks based on Multi-Objective Genetic Algorithm

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1 Summary

EON (Elastic Optical Networks) is an Optical Transport Network where all the equipment can handle optical channels of variable bandwidth and all the switching elements can withstand different granularities in the spectrum of channels [1].

The Routing and Spectrum Allocation (RSA) [2] problem is the principal optimization problem in EON where the challenge is to calculate path and spectrum to connect source and destination nodes. RSA can be approached with exact or heuristic methods. For the exact methods like Integer Linear Programing [3] the greatest difficulty arises, as the large number of conditions that poses the problem. This introduces greater computational complexity when it is calculated the optimal solution of large networks. For other hand, heuristic methods are promising to calculate sub-optimal solutions but in lower cost computational being attractive to complex problems.

The RSA problem can be solved in a multi-objective optimization context, given there are several objective functions in conflict. In this work, we consider a weighted sum of all objective functions with equal weight. In this context, the main contribution of this work is to apply a Multi-objective Genetic Algorithm (MOGA) [4] for the RSA problem considering a set of unicast request with k-shortest path routing and first-fit spectrum allocation algorithm. At the same time, a ILP model was designed to find optimal solutions for small networks, this helps to measure the quality of the proposal MOGA and analize the feasibility finding good solutions in larger networks. ILP and MOGA optimize a objective funtion formed by summation of the maximum spectrum used, the maximum distance, and the total resource assigned in term of bandwidth and distance; subject to the optical layer constraints: continuity, contiguity and non-overlapping spectrum. In the objective function all components are normalized and summed with the same weight.

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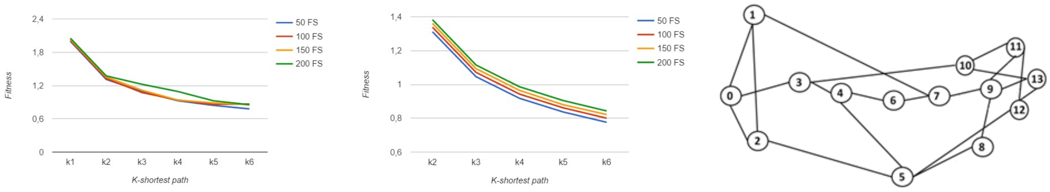

(a) ILP (b) MOGA (c) NSF-14 nodes topology

Figure 1: Experimental results.

2 Implementation and Results

To the MOGA development, the crossover operator of 2 points was used, also multigen mutation operator in which each single gene has a mutation probability. The initial population was generated randomly with 100 individuals using 4 minutes as a stop criterion. As selection operator deterministic tournament was used.

All tests were developed with a computer with these characteristics: processor intel core i7 of 2.4Ghz, 8 Gb of RAM, operating system Windows 8, java 8 and Cplex 12.6 for ILP. The experiment was performed with the NSF-14 nodes topology (Figures 1(c)), the traffic type was uniform all-to-all, i.e. $14 \times 13 = 182$ unicast requests. There was considered four load traffic scenarios: 50, 100, 150 and 200 frequence slots (FS).

Figures 1(a) and 1(b) expose experimental results for differents number of k and load traffics. It can be observed that in both optimizers, as the number of available routes to choose (k) increases, better results are obtained, that is, lower cost. The lowest value obtained by the MOGA does not exceed the lowest value obtained by the ILP, but the computation time limit for the ILP was 4 hours per scenario, while the MOGA had a computing average of 50 minutes with a result quite close to the optimum.

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