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New optimization model for routing and spectrum assignment with nodes insecurity

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ABSTRACT

By adopting the orthogonal frequency division multiplexing technology, elastic optical networks can provide the flexible and variable bandwidth allocation to each connection request and get higher spectrum utilization. The routing and spectrum assignment problem in elastic optical network is a well-known NP-hard problem. In addition, information security has received worldwide attention. We combine these two problems to investigate the routing and spectrum assignment problem with the guaranteed security in elastic optical network, and establish a new optimization model to minimize the maximum index of the used frequency slots, which is used to determine an optimal routing and spectrum assignment schemes. To solve the model effectively, a hybrid genetic algorithm framework integrating a heuristic algorithm into a genetic algorithm is proposed. The heuristic algorithm is first used to sort the connection requests and then the genetic algorithm is designed to look for an optimal routing and spectrum assignment scheme. In the genetic algorithm, tailor-made crossover, mutation and local search operators are designed. Moreover, simulation experiments are conducted with three heuristic strategies, and the experimental results indicate that the effectiveness of the proposed model and algorithm framework.

1. Introduction

Traditional wavelength division multiplexing networks can only provide the coarse granularity of a single wavelength and cannot suit for different bandwidth connection requirements adaptively, especially in the case of the requested bandwidth being only fractional bandwidth of a wavelength. The continuous growth of various applications, such as internet protocol television, video on demand, cloud computing, requires an efficient networking infrastructure [1]. The recent elastic optical networks can provide the flexible and variable bandwidth allocation to each connection request and get higher spectrum utilization by using the technology of orthogonal frequency division multiplexing [2]. Orthogonal frequency division multiplexing is a multi-carrier modulation technology. It can distribute the high-speed data stream into several orthogonal low-speed subcarriers [3]. The adjacent subcarriers have the spectrum overlapping of a subcarrier bandwidth. This subcarrier is referred to the frequency slot(FS). The elastic optical network can allocate several consecutive frequency slots to each connection request according to the required bandwidth by using orthogonal frequency division multiplexing as a spectrum-efficient modulation technology. Adjacent spectrum bandwidths assigned to two connection requests in the same link should be separated by the guaranteed frequency slots (GFs). Similar to the routing and wavelength assignment (RWA) problem in wavelength division multiplexing networks [4], routing and spectrum assignment(RSA) problem exists in elastic optical network [5]. In order to establish a light-path for the connection request in elastic optical network, three constraints should be satisfied as follows: (1) Spectrum consistency means that the start frequency slot index on different links of a path must be identical; (2) Spectrum continuity means that we must assign consecutive frequency slots to a specific connection request. That is to say, a large connection request can not be divided into several smaller connection requests; (3) A frequency slot on a link should be assigned to one connection request at the most. Generally speaking, the objective of static routing and spectrum assignment is to minimize the maximum index of the used frequency slots with unlimited resource, and to minimize the ratio of blocking with limited resource. Certainly, there are some other optimization objectives, such as energy consumption, cost, etc.

In recent years, more and more researches focus on routing and spectrum assignment problem. Christod, et al. [3] formulated routing and spectrum assignment problem as an integer linear programming (ILP) problem. In addition, they presented a decomposition method

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