Chapter 1

Nature-Inspired-Based Modified Multi-Objective BB-BC Algorithm to Find Near-OGRs for Optical WDM Systems and Its Performance Comparison

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ABSTRACT

Multi-objective nature-inspired-based approaches are powerful optimizing algorithms to solve the multiple objectives in NP-complete engineering design problems. This chapter proposes a nature-inspired-based modified multi-objective big bang-big crunch (M-MOBB-BC) optimization algorithm to find the Optimal Golomb rulers (OGRs) in a reasonable timeframe. The OGRs have their important application as channel-allocation algorithm that allow suppression of the four-wave mixing crosstalk in optical wavelength division multiplexing systems. The presented simulation results conclude that the proposed hybrid algorithm is superior to the existing conventional classical algorithms, namely extended quadratic congruence and search algorithm and nature-inspired-based algorithms, namely genetic algorithms, biogeography-based optimization, and simple BB-BC optimization algorithm to find near-OGRs in terms of ruler length, total occupied optical channel bandwidth, bandwidth expansion factor, computation time, computational complexity, and non-parametric statistical tests.

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1. INTRODUCTION

Finding optimal solutions for engineering and industrial design problems having multiple objectives (multi–objective) are computationally very time consuming and tough due to their high degree of complexities, dimensionality, nonlinearities, and inhomogeneity. In order to solve the multi–objective problems in a reasonable time, several nature–inspired based multi–objective optimization algorithms (MOAs) are being proposed (Abbass and Sarker, 2002; Deb, 1999; Deb, 2001; Yang, 2011; Yang et al., 2014). Nature–inspired based MOAs can have several distinct solutions instead of single optimal solution which often conflict with each other and makes it difficult to use any single design option without compromise. The compromise solution is optimal in the wider sense since there is no other better solution present in the search space while taking into consideration all other objectives. Pareto optimal is the best compromise solutions from several different solutions that cannot be dominated as no objective can be better without making some other objective worse. The set of all Pareto optimal solution is designated as Pareto front (Koziel and Yang, 2011; Yang, 2011; Yang et al., 2014). Pareto–optimality is estimated in MOAs to provide flexibility for the design engineer. The aim of MOAs is to search for either the Pareto optimal solutions or the solutions near to Pareto front.

This chapter proposes the application of a nature–inspired based modified multi–objective Big bang–Big crunch (M–MOBB–BC) algorithm to solve an NP–complete optimal Golomb ruler (OGR) sequence problem (Babcock, 1953; Bloom and Golomb, 1977; Colannino, 2003; Distributed.net, 2017; Meyer and Papakonstantinou, 2009; Memarsadegh, 2013; Robinson, 1979; Shearer, 1990; Shearer, 1998) in optical wavelength division multiplexing (WDM) systems. The OGRs can be used as unequally spaced channel–allocation algorithm in optical WDM systems to suppress one of the nonlinear optical effects.

Among the numerous different fiber nonlinear optical effects proposed by researchers Aggarwal (2001), Babcock (1953), Chraplyvy (1990), Forghieri et al. (1994), Kwong and Yang (1997), Saaid (2010), and Thing et al. (2004), the crosstalk due to four–wave mixing (FWM) signal is the major dominant noise effect in optical WDM systems. The performance of the system can be improved if FWM crosstalk signal generation at the channel frequencies is avoided. The efficiency of FWM signal depends on the fiber dispersion and channel–allocation. If the frequency separation of any two channels in an optical WDM system is different from that of any other pair of channels, no FWM crosstalk signals will be generated at any of the channel frequencies (Aggarwal; 2001; Babcock, 1953; Chraplyvy, 1990; Forghieri et al., 1994; Kwong and Yang, 1997; Saaid, 2010; Thing et al., 2004).

To suppress the FWM crosstalk in optical WDM systems, numerous unequally spaced channel–allocation algorithms have been formulated by the many researchers (Atkinson et al., 1986; Forghieri et al., 1995; Hwang and Tonguz, 1998; Kwong and Yang, 1997; Randhawa et al. 2009; Sardesai, 1999; Tonguz and Hwang, 1998) that have the drawback of increased bandwidth requirement when compared with equally spaced channel–allocation. This chapter proposes an unequally spaced bandwidth efficient channel–allocation algorithm by taking into consideration the concept of near–OGRs (Babcock, 1953; Bloom and Golomb, 1977; Shearer, 1990; Thing et al., 2003) to suppress FWM crosstalk in optical WDM systems.

In order to tackle Golomb ruler problem, numerous algorithms have been presented by Galinier et al. (2001), Leitao (2004), Rankin (1993), Robinson (1979), and Shearer (1990). The successful realization of nature–inspired based optimization algorithms such as Tabu search (TS) (Cotta et al., 2006), Memetic approach (MA) (Cotta et al., 2006), Genetic algorithms (GAs) (Ayari et al., 2010; Bansal, 2014; Robinson, 2000; Soliday et al., 1995) and its hybridizations with TS (HGA) (Ayari et al., 2010),

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