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Joint opportunistic power and rate allocation for wireless ad hoc networks: An adaptive particle swarm optimization approach

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A B S T R A C T

In this paper, the joint opportunistic power and rate allocation (JOPRA) algorithm, which aims at maximizing the sum of source utilities while minimizing power allocation for all links in wireless ad hoc networks, is solved by means of an improved adaptive particle swarm optimization (IAPSO), which can overcome some limitations of the traditional dual and subgradient method. Compared with the original APSO, in our IAPSO, the maximum movement velocity of the particles changes dynamically, a modified replacement procedure with no introduced additional parameters is employed in constraint handling, and the state of the optimization run and the diversity in the population are taken into account in stopping criteria. It is shown that the proposed JOPRA algorithm can fast converge to the optimum and reach larger total data rate and utility while less total power is consumed. The efficiency of our approach is further illustrated via numerical comparison with the original APSO. This work is a beneficial attempt to integrate adaptive evolutionary algorithms with the resource allocation in wireless ad hoc networks.

1. Introduction

Power is often a scarce resource in wireless ad hoc networks. The primary performance objectives of wireless ad hoc networks are power conservation and utility maximization. Power control is to minimize the overall transmitted power given a constant signal-to-interference-and-noise ratio (SINR) requirement for each user. To solve this problem, many pieces of work have been done in the literature, which mainly concentrate on optimizing power and rate allocation with cross layer design (Alawieh et al., 2008; Huang and Letaief, 2007; Jäntti and Kim, 2006; Lee et al., 2007; Papandriopoulos et al., 2008; Qu et al., 2008, 2010). In addition to these results, several distributed cross-layer optimization frameworks were proposed to jointly allocate spectral bands, power and data rate for lifetime or utility maximization in wireless ad hoc networks. These joint data rate and power allocation strategies are based on nonlinear programming and the dual subgradient method. The optimal solutions by means of the dual method depend on the convexity of the investigated optimization problem. However, in wireless ad hoc networks, because of multi-path routing and time-varying channel states, the optimization problem may not be convex. This implies that it cannot be guaranteed to obtain the optimal power scheduling and rate allocation since there might be a duality gap between the problem and its dual. Therefore, it is needed to introduce some new variables and transform a non-convex optimization problem into a convex one (Lin and Shroff, 2006). Obviously, this leads to the increase of computational complexity. It is also difficult to choose the appropriate dual Lagrangian Multipliers (penalty factors) and iteration step sizes, and a numerical solution obtained by the dual approach requires overwhelming computational effort, which increases exponentially as the size of the problem increases.

At the same time, resource allocation in wireless ad hoc networks is also modeled in a non-cooperative game theoretic framework with the objective of maximizing individual utility. In Kučera et al. (2008), a distributed asynchronous power and rate control framework for wireless ad hoc networks was developed by using a game-theoretic approach. Tan et al. (2010) proposed a payment-based power control scheme using game theory where each user announces a set of price coefficients that reflects different compensations paid by other users for the interference they produce. However, the scheme is difficult and can result in much additional overhead to find a new Nash equilibrium for the fast changing network configuration induced by newly emerging network conditions and corresponding variations in service preferences.

Another non-mathematical power control mechanism is to incorporate power control into the IEEE 802.11 Request To Send

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