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An Evolutionary Game Perspective to ALOHA with power control

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Abstract: We study a large population of communicating terminals using an ALOHA protocol with two possible levels of transmission power. We pose the problem of how to choose between these power levels. We study two non-cooperative optimization concepts: the Nash equilibrium and the Evolutionary Stable Strategy. The latter was introduced in mathematical biology in the context of Evolutionary Games, which allows to describe and to predict properties of large populations whose evolution depends on many local interactions, each involving a finite number of individuals. We compare the performances of these non-cooperative notions with the global cooperative solution. The payoffs that we consider are functions of the throughputs and of the cost for the power levels. We study in particular the impact of the pricing for the use of the power levels on the system performance.
Key words: ALOHA, Evolutionary Games, Evolutionary Stable Strategies

1. INTRODUCTION

Interest has been growing in recent years in studying competition aspects of networking in general, access to a common medium in particular, within the frame of non-cooperative game theory, see e.g. the survey paper [1]. In this paper we focus on the ALOHA access scheme [2].

Several previous papers have already studied ALOHA or slotted ALOHA in a non-cooperative context. The papers [3–7] have studied ALOHA for a non-cooperative choice of transmission probabilities. Several papers study slotted ALOHA with power diversities in the context of the cooperative formulation [8–10]. In [11] the authors have studied the performance of slotted ALOHA in a non-cooperative context, modeled as a game, in which both retransmission probabilities as well as power levels are controlled. A Markov chain formulation has been obtained, whose numerical solutions enable to study the system performance. In the current paper, in contrast, we propose an alternative simpler modeling approach which allows us to obtain explicit analytical expressions for the performance measures. This allows us then to compute analytically the solutions for various non-cooperative optimization criteria.