Abstract

In peer-to-peer networks, several uncoordinated source-destination pairs compete for the same bandwidth. When users transmit simultaneously they create interference to each other. Orthogonalization techniques, such as TDMA, although leading to simple network architecture, can be very suboptimal in terms of achievable rate. In this work, we consider a simple network with two source-destination pairs sharing a Gaussian fading channel. We use as figure of merit for our network the long-term throughput, both in the ergodic and delay limited setting. We derive the optimal power allocation under various degree of knowledge of the actual channel condition at the transmitter. We show that power control improves throughput, especially at low SNR. We conclude the paper with some system design implications of our findings.

Introduction

We consider a network of fading interference channels, where the transmit signals are received superimposed at the receivers, and corrupted by additive white Gaussian noise and multiplicative Raleigh fading. The inputs are subject to a long-term power constraint. The transmitters and the receivers are assumed to know the instantaneous fading coefficients perfectly, that is, we consider coherent communications and to transmit power control. Regarding the channel fading dynamics with respect to the application delay requirements, we consider the following two models.

Ergodic setting: the system has mild delay constraints and hence each codeword can span many fading states. In this case, the objective of the power control is to maximize the Shannon sum-capacity. Outage setting: the system has strict delay constraints and hence each codeword can span only one fading state. In this case the objective of the power control is to maximize the average expected successfully decoded rate, or equivalently, to minimize the outage probability.

We will focus on a network with two non-cooperative source and destination pairs, referred to as 2-user interference channel. The capacity region of 2-user unfaded interference channel is known only for certain sets of channel gain values. However, the sum rate is known for almost all possible channel values. This work leverages on our previous sum-rate results in [13] for the unfaded case and extend them to the case of Rayleigh fading. In the fading case, the knowledge of the channel gains enables the use of power control at the transmitter. The salient feature of power control is to turn-off transmission when the receive SNR is below a certain threshold. In turns, this allows to save power for more benign fading states, and thus improve the sum-rate, especially at low SNR.

The problem of optimal power allocation for multiple-access and broadcast fading channels in the ergodic setting has been determined in [1] and [3], and for the outage, or delay limited case, in [2] and [4]. Extensions to relay and cooperative multiple access channels appeared in [3-10]. Interference channels have the property of combining elements of multi-access and broadcast. We show how the derived power allocation shares elements of both channels.

We conclude by presenting numerical results to show the benefits of power control and comment on the system requirements to implement the proposed power allocation scheme.

References


