CROSS LAYER DESIGN AND ANALYSIS OF WIRELESS NETWORKS WITH EFFECTIVE BANDWIDTH FUNCTION

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ABSTRACT

In this paper we propose a useful framework for a cross layer design and analysis of wireless networks where an AMC (Adaptive Modulation and Coding) scheme is employed. In the framework, we model the joint effect of the packet transmission error rate at the PHY layer and the packet loss probability at the MAC layer by introducing the effective bandwidth function of the packet service process. With the help of the effective bandwidth function, we can characterize the wireless channel, analyze the queueing system, and determine an AMC scheme which satisfies the required packet loss probability by a user and minimizes the average packet transmission error rate. Some numerical examples show the characteristics of wireless networks with an AMC scheme and how to determine an AMC scheme in detail.

INTRODUCTION

The aim of this paper is to propose a useful framework for a cross-layer design of wireless networks where an AMC scheme is employed. For this purpose, we consider a finite size queue at the MAC layer in a wireless network where packet retransmissions for incorrectly received packets are allowed. Due to the packet retransmission all packets are eventually transmitted once stored in the queue at the MAC layer. So, the packet loss probability due to the overflow of the queue at the MAC layer can be considered as the performance at the MAC layer. On the other hand, the performance of the PHY layer can be considered by virtue of the packet error rate due to the AMC scheme employed at the PHY layer. That is, if the packet error rate is high, the transmission efficiency which is defined by the ratio of the number of correctly received packets over the total number of transmitted packets, is low. On the contrary, if the packet error rate is low, the transmission efficiency is high. Therefore, assuming that a user requires a specific level of packet loss probability, it is very important to design an AMC scheme which satisfies the required packet loss probability at the MAC layer and maximizes the transmission efficiency at the PHY layer simultaneously, which is the cross layer design considered in this paper.

MAIN RESULTS

In our framework for the cross layer design, for a given AMC scheme, we model the wireless channel by a finite state Markov chain and compute the packet error rates in the AMC modes. Using the computed packet error rates, we then characterize the service process of the queue at the MAC layer where packet retransmissions are considered. Contrary to [1,2], our framework does not specify the arrival process of packets, and it concentrates on the service process employing AMC, separately from the arrival process. This gives our framework great flexibility and broad applicability. For the purpose, we introduce the notion of the effective bandwidth function of the service process [3]. The effective bandwidth function takes the effect of the AMC scheme both at the MAC layer and at the PHY layer into account, and thus it is a useful device to the cross-layer design or analysis of wireless networks employing an AMC scheme.

In general, it is expected that the queueing performance at the MAC layer is getting better as the effective bandwidth function is increasing. So, for each target (average) packet error rate at the PHY layer we first focus ourselves on the AMC schemes which have average packet error rate below the target packet error rate at the PHY layer, and select a suitable AMC scheme among them which maximizes the effective bandwidth function. We then compute the packet loss probability at the MAC layer for each AMC scheme by using its corresponding effective bandwidth function. Among the set of target packet error rates (and the corresponding AMC schemes) which satisfy the required packet loss probability at the MAC layer by a user, we finally select the minimum target packet error rate and its corresponding AMC scheme for our cross layer design purpose. This is because the AMC scheme corresponding to the minimum target packet error rate maximizes the transmission efficiency at the PHY layer and satisfy the required packet loss probability at the MAC layer simultaneously.

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