Frequency-Domain Multipacket Detection: A High Throughput Technique for SC-FDE Systems

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Abstract - Usually, packets involved in a collision are lost, requiring their retransmission. However, the signal associated to collisions has important information concerning the packets involved. In fact, with proper retransmissions we can efficiently resolve collisions.

In this paper we propose a frequency-domain multipacket detection technique for SC-FDE schemes (Single-Carrier with Frequency-Domain Equalization) that allows an efficient packet separation in the presence of successive collisions.

This technique allows high throughputs, since the total number of transmissions is equal to the number of packets involved in the collision, even when the channel remains fixed for the retransmissions. Since we consider SC-FDE schemes and the complexity is concentrated in the receiver, this technique particularly appealing for the uplink of broadband wireless systems. [1]

I. Introduction

In wireless systems multiple users might try to access a given channel and the objective of MAC protocols (Medium Access Control) is to allow this in an efficient way. When different users are simultaneously accessing a given channel we have a collision, an event that is almost unavoidable in wireless systems. The simplest and more common approach to cope with collisions is to assume that all packets involved are lost. This means that we need to retransmit all packets involved in a collision, which leads to significant reduction in the system throughput. To reduce the chances of multiple collisions a given user transmits in the next available slot with a given probability. With this strategy, if two packets collide we need three time slots to complete the transmission (more if there are multiple collisions).

However, the signal associated to a collision contain information on the packets involved, which can be used to improve the system performance [1]. In fact, if we do not discard collided packets and we use proper retransmissions we can efficiently resolve collisions. To overcome this problem, a TA (Tree Algorithm) was combined with a SIC scheme (Successive Interference Cancelation) [2]. Within this SICTA technique, we do not discard the signal associated to a collision. Instead, if the packets of users A and B collide then, once we receive with success the packet of one of those users we can subtract the corresponding signal from the signal with collision and recover the packet from the other user. With this strategy, if two packets collide we need two time slots to complete the transmission (unless there are multiple collisions). The major problem with this technique is that packet errors might lead to a deadlock problem [3]. Moreover, the required number of transmissions might be high if we have successive collisions.

These techniques have the major limitation that we do not take full advantage of the information in the collision. The ideal situation would be to use the signals associated to multiple collisions to separate the packets involved.

In this paper we propose a frequency-domain multipacket receiver that allows an efficient packet separation in the presence of successive collisions. We consider the use of SC-FDE schemes (Single-Carrier with Frequency-Domain Equalization), generally accepted as one of the best candidates for the uplink of future broadband wireless systems [4], [5]. Our multipacket detector has relatively low complexity, even for severely time-dispersive channels, since it allows an FFT-based implementation (Fast Fourier Transform). To be effective, our technique requires uncorrelated channels for different retransmissions. For systems where this is not possible, we consider a modified version of our technique where the frequency-domain block to be transmitted has different shifts for different retransmissions.

This paper is organized as follows. The system characterization is made in sec. II and our multipacket detection technique is described in sec. III. The MAC scheme is analyzed in sec. IV and a set of performance results is presented in sec. V. Finally, sec. VI is concerned with the conclusions of this paper.

II. System Characterization

In this paper we consider the uplink transmission in wireless systems employing SC-FDE schemes. We have a slotted system and each user transmits a packet during a given time slot (for the sake of simplicity, it is assumed that the packets associated to each user have the same duration and correspond to an FFT block). Whenever more than one user targets a given time slot we have a collision.

It is assumed that different packets arrive simultaneously, i.e., there is some time-advance mechanism able to compen-

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