DESIGN AND ANALYSIS OF MEDIUM ACCESS CONTROL PROTOCOLS FOR AD HOC AND COOPERATIVE WIRELESS NETWORKS

This thesis aims at contributing to the incessant evolution of wireless communications. The focus is on the design of medium access control (MAC) protocols for ad hoc and cooperative wireless networks. The dissertation is divided into three fundamental parts.

In the first part, a comprehensive state of the art is presented and a background on the topic is provided. The motivation and objectives of the thesis are presented at the end of this first part.

The second part of the thesis is devoted to the design, analysis and performance evaluation of a new high-performance MAC protocol. It is the Distributed Queuing MAC Protocol for Ad hoc Networks (DQMAN) which constitutes an extension and adaptation of the near-optimum Distributed Queuing with Collision Avoidance (DQCA) to operate over networks without infrastructure. DQMAN introduces a new access paradigm in the context of distributed networks; the integration of a spontaneous, dynamic, soft-binging master-slave clustering mechanism together with a high-performance infrastructure-based MAC protocol. Theoretical analysis and computer-based simulation show that DQMAN outperforms IEEE 802.11.
The main characteristic of the protocol is that it behaves as a random access control protocol when the traffic load is low and it switches smoothly to a reservation protocol as the traffic load grows. In addition, its performance is almost independent of the number of users of a network. Moreover, the random-access based clustering algorithm allows for the coexistence and intercommunication of stations using DQMAN with the ones just based on the legacy standard. This assessment is also presented in this second part of the dissertation.
Indeed, the rationale presented in this second part of the thesis can be extended to any other MAC protocol. A case study of this is presented to conclude the second part wherein the Point Coordination Function (PCF) of the IEEE 802.11 Standard is adapted to be used in ad hoc networks. The new protocol is named Distributed PCF (DPCF). This novel protocol is described and comprehensively analyzed in this part of the thesis.
The third part of the thesis turns the focus to a specific kind of cooperative communications: Cooperative Automatic Retransmission Request (C-ARQ) schemes. The main idea behind C-ARQ is that when a packet is received with errors, a retransmission can be requested not only to the transmitter, but also to any of the users which overheard the original transmission. These users become spontaneous relays an assist the failed transmission by forming a temporary ad hoc network. Although such a scheme may provide cooperative diversity gains, having a number of users in the communication between two users involves a complicated coordination task that has a certain cost, which has been generally neglected in the existing literature. The cost of the MAC layer in C-ARQ schemes is analyzed in this part of the thesis and two novel MAC protocols for C-ARQ are designed, analyzed and comprehensively evaluated. They are the DQCOOP and the Persistent Relay Carrier Sensing Multiple Access (PRCSMA) protocols. The former is based on DQMAN while the second is based on the IEEE 802.11 Standard. A comparison with non-cooperative schemes and the standard performance is included to have actual reference benchmarks of the novel proposals.