Cross-Layered OFDMA-Based MAC and Routing Protocol for Multihop Adhoc Networks

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Abstract. In this paper, a dynamic Sub-channel Assignment Algorithm (DSA) based on orthogonal frequency division multiple access (OFDMA) technology operating in the time division duplexing (TDD) and a new routing protocol are proposed. The proposed of dynamic Sub-channel Assignment Algorithm solves several drawbacks of existing radio resource allocation techniques in OFDM system used in ad-hoc and multi-hop networks, such as the hidden and exposed node problem, mobility, co-channels interference in frequency (CCI). An interference avoidance mechanism allows the system to reduce CCI and to operate with full frequency re-use. The proposed routing protocol is jointed with the MAC protocol based the algorithm to ensure the mobility and multi-hop, thus the quality of service in ad-hoc and multi-hop networks is significantly improved.

Keywords: OFDMA, MAC protocol, routing protocol, ad-hoc networks, multi-hop networks.

1 Introduction

A major challenge in wireless networks for multi hop communications is the co-channel interference (CCI). This interference is introduced when two different radio stations simultaneously use the same frequency. It is mainly caused by the spectrum allocated for the system being reused multiple times in TDMA network. CCI is one of the major limitations in cellular and Personal Communication Services wireless telephone networks since it significantly decreases the carrier-to-interference ratio. In addition, it makes the diminished system capacity, more frequent handoffs, and dropped calls. IEEE 802.11 Distributed Coordination function operation is based on conventional carrier mechanism (CSMA/CA) in order to prevent channel collisions, CCI and provide the communication between multiple pairs of independent mobile nodes without access points or base stations such as mobile adhoc networks [1-2].
Recently, orthogonal frequency division multiplexing (OFDM) has been intensively investigated for wireless data transmission in broadband cellular and ad-hoc networks. The multiple access technique for these networks is OFDMA [3]. The concept of this technique is to assign different users to different sub-channels in order to avoid interferences.

The paper is organized as follows: In section 2, we briefly review sub-channels allocation methods. Section 3 describes the proposed DSA algorithm. In section 4, the proposed routing protocol is presented. Simulation schemes, numerical results, are discussed in section 5. Finally, conclusions are drawn in session 6.

2 Review of Sub-channels Allocation Methods

2.1 OFDM-FDMA Fix Allocation

The fixed allocation method of OFDM-FDMA for multiuser communications was proposed [8]. In such method, different users will be fixedly assigned to different sub-channels. Therefore, this method has not any anti-interference mechanism.

2.2 OFDM-FDMA Random Allocation

The OFDM-FDMA random allocation method is based on the idle and busy of sub-channels allowing users to accounts different sub-channels [9]. However, it does not have any attention to the network interference. Once a sub-channel is selected, a user starts transmitting using the selected sub-channel. During a transmission process, if a sub-channel does not meet the required QoS, it will be released and assigned to new user. Although the method is simple and it offers an adaptive mechanism, it does not provide CCI avoidance.

3 Proposed DSA Algorithm

Co-channel interference (CCI) is crosstalk from more than one different radio transmitter using the same frequency in wireless networks. Reducing CCI is very important since it makes the poor throughput performance. To avoid CCI and collisions, we propose a novel channel allocation algorithm called DSA which supports simultaneous transmissions in Vehicle Ad Hoc Network among nodes. In this section, the problem of CCI in OFDMA/TDD in wireless networks is discussed in detail. Then, we present the proposed Dynamic Subchannel Assignment (DSA) algorithm.

3.1 CCI in OFDMA/TDD System

To illustrate the problem of CCI, a simple scenario consisting of two base stations (BSs) and four mobile stations (MSs) is depicted in Fig. 1. Let us assume an example of exchanging data among BSs and MSs as following. The mobile station MS_{1_{Rx}}, MS_{2_{Rx}} and MS_{3_{Rx}} receive data from base station BS_{1_{Tx}}, while at the same