A Study on Relay Selection and Routing for Cooperative and Cognitive Radio Ad Hoc Networks

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SUMMARY OF Ph.D. DISSERTATION

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Title

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Abstract

With the development of wireless technologies, autonomously distributed wireless ad hoc networks have attracted much research interest. In such networks, infrastructures such as base stations and wired connections are not necessary, and mobile terminals can directly exchange information to each other by relaying data packets. However, data are transmitted by the multihop relaying, and the wireless channel condition and topology changing significantly affect the performance. Therefore, it is important to appropriately select the relay and route. Another characteristic of wireless ad hoc networks is the abundant spatial diversity provided by the dynamic topology and broadcast nature of wireless channels. Cooperative transmission has attracted much research interest due to its ability to efficiently exploit the spatial diversity to improve the performance degradation caused by the node mobility and multipath fading. The basic operation of cooperative transmission is that the relay retransmits the overheard data to the destination in the second time slot when the destination cannot decode the received data in the first time slot. On the other hand, cognitive radio (CR) has been recognized as a promising technology to solve the scarcity problem of the limited radio spectrum resource. In CR, cognitive users (CUs) can use the spectrum belonging to primary users (PUs) when PUs do not use it. Additionally, PUs and CUs can use the spectrum belonging to PUs concurrently if the transmission power of the cognitive source is lower than a certain threshold such that the quality-of-service requirement of the primary transmission is satisfied. However, although the relay selection and routing in cooperative and cognitive radio ad hoc networks are important research issue, they are not thoroughly studied.

In this thesis, when cooperative transmission is combined with CR in wireless ad hoc networks, the relay selection and routing issues are studied, and schemes that improve the end-to-end reliability and transmission power are proposed.

In Chapter 1, principles, research issues, and conventional schemes of wireless ad hoc networks, cooperative transmission, and CR are generally introduced. In addition, the background, purpose, and position of this dissertation are described.

In Chapter 2, we propose a cooperative transmission scheme that semi-distributedly selects the relay with the lowest theoretical bit error rate (BER)

in IEEE 802.11 based wireless ad hoc networks. In the proposed scheme, each relay candidate can adaptively switch its relaying protocol between amplify-and-forward (AF), decode-and-forward (DF), and no relaying (direct transmission) according to channel conditions of the source-to-relay, relay-to-destination, and source-to-destination links. It is shown that the proposed scheme improves BER compared to AF, DF, and no relaying.

In Chapter 3, for cooperative wireless ad hoc networks, we propose a medium access control protocol with distributed relay selection using group-based probabilistic contention and re-participation. Low outage probability, short contention period, and less number of acknowledgement packets can be achieved by defining the contention and re-participation probabilities of each relay candidate based on its outage probability. Simulation results validate the effectiveness of the proposed scheme.

In Chapter 4, distributed ad hoc cooperative routing (DAHCR) schemes are proposed when cooperative transmission is performed in cluster-based multihop networks. In each hop, the relay and receiver are probabilistically selected based on the required sender transmission power. Simulation results show that DAHCR schemes reduce the required transmission power compared to the conventional distributed ad hoc routing (DAHR). However, compared to DAHR, the complexity is increased by DAHCR schemes.

In Chapter 5, we propose a primary traffic based routing algorithm with cooperative transmission (PTBR-CT) in cognitive radio ad hoc networks where the underlay access strategy is used. When the primary source transmits data in two successive time slots, CUs perform preliminary farthest relay selection based cooperative transmissions to enlarge hop transmission distances to reduce the number of cognitive relays on the route. Simulation results show that PTBMR-CT improves the average end-to-end reliability, throughput, required transmission power, and transmission latency compared to the conventional primary traffic based farthest neighbor routing.

Chapter 6 concludes this dissertation.