Abstract

The future wireless communication systems are anticipated to be able to fulfill requirements of higher data rate, larger coverage, low power consumption, generic architecture, high scalability and re-configurability. This dissertation mainly focuses on three issues related to the mentioned requirements: rate adaptation, coverage extension and low power consumption.

As wireless communication has been integral part in our daily lives, a multitude of mobile applications, multimedia, data access and sharing, streaming video and many other services have been emerging day by day. As a result, demands for higher data rate, larger capacity and broader radio coverage to deliver mobile services to as large area as possible have been constantly increasing. To meet those demands, inevitable challenging task is to cope with wireless mobile channel. In particular, propagation channels in most metropolitan areas such as city centers where there are densely scattering large obstacles are dynamic in nature and do not have line of sight paths between local base stations and end users. Thus, means to adapt with dynamic behavior of channels, mitigate propagation loss and shadowed fading effect, and reduce dynamic range of received signal power at end users are essential.

Key solutions to cope with wireless mobile channels are: controlling transmission rate with channel; compensating pathloss by using power control and signal repeaters (relays); diversity techniques to mitigate fast fluctuation of channel; avoiding shadowed channel path by providing diverse paths. Transmission rate can be controlled by means of adaptive modulation and coding (AMC) to adapt with instantaneous channel

condition. Multihop cooperative relays can mitigate pathloss as well as shadowing while reducing dynamic range of channel fluctuation given the relays are able to cooperate with each other to exploit spatial diversity. Automatic repeat request (ARQ) can add reliability to the rate adapted relay cooperated links.

With regard to data rate adaptation and link reliability, this study investigated control delays in AMC and HARQ in asymmetric time division duplex (TDD). Owing to variation in wireless mobile channels, AMC may select inappropriate modulation and coding scheme (MCS) at some instants. Such erroneous selection results in packet errors. The analysis in this study formulates a theoretical expression to calculate erroneous MCS selection probability for different TDD time slot allocations. Next, throughput degradation and corresponding delay in HARQ are evaluated in relation with the calculated probability. Regarding the issues related to coverage extension and diversity gain, this study focuses on a relay selection based cooperation strategy called selective cooperative ARQ. A novel cooperative ARQ protocol is proposed for multihop relay system to enhance selection diversity gain in retransmission process of ARQ.

Specifically, the topics in this dissertation are contributed by the following two main research studies.

- Evaluation of asymmetric TDD systems with AMC and HARQ
- Cooperative relay communication: cooperative ARQ protocols for multihop relay systems

Chapter 1 gives a general introduction of the thesis. Firstly, recent remarkable evolution of wireless communications and major requirements for future systems are discussed. A comprehensive description of wireless mobile channel is also described. Moreover, highlighting the key technologies for future systems, motivation of the study is laid out. Finally, overviews and scopes of each chapter are summarized, followed by position and contributions of the studies.

Chapter 2 introduces fundamentals of the key technologies used in the topics in this dissertation. Firstly, it describes data rate adaptation using multilevel modulations and variable coding. Secondly, it gives the principle of multicarrier transmission for future wireless systems in downlink. Thirdly, a brief description on asymmetric TDD system is introduced. Finally, relay cooperation strategies and topologies are discussed highlighting achievable diversity order and bandwidth efficiencies.

Chapter 3 evaluates asymmetric TDD systems by taking control delays in AMC and HARQ into account. Flexibility in assigning different bandwidth in TDD systems enables flexible traffic control in uplink and downlink according to the demands. AMC further enhances instantaneous rate adaption for each user on the assigned traffic volume or bandwidth. However, in asymmetric TDD systems with a significant larger traffic in downlink than that in uplink, performance of AMC may degrade owing to erroneous selection of modulation and channel coding rate as a result of channel fluctuation during downlink slots. To investigate this, MCS selection error probability in asymmetric TDD systems is evaluated by both theoretical calculation and computer simulations. Based on computed selection error probability, the corresponding performance degradation in terms of throughput and average delay to successfully receive packet is evaluated.

In Chapter 4, a novel selective cooperative ARQ scheme is proposed for a multihop relay system. The proposed relay system employs a distributed relay selection scheme that enables cooperating relays to independently decide whether to transmit or not based on their channel conditions and self-error checking results. The proposed system can overcome influence of source-relay channel and achieve higher diversity gain in subsequent transmissions. Theoretical expressions for packet error rate performance of the proposed system are also derived. Performance evaluations are carried out extensively by means of theoretical approach and simulations.

Finally, Chapter 5 draws overall conclusions for the main topics presented in this dissertation.