Doctoral Thesis

Receiver Design for Highly Mobile Wireless Regional Area Network

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Abstract

With the spread of the Internet of Things (IoT) and intelligent transportation system (ITS), wireless communication system with larger capacity and more efficient spectrum utilization is required. Due to the excellent propagation properties of TV white spaces (TVWS) communication system, the TVWS-based wireless regional area network (WRAN) communication is one of the promising technologies for wide-coverage and large-capacity network. IEEE 802.22 was standardized as a fixed point-to-multipoint WRAN communication system operating in TVWS. To cope with various application scenarios for IoT and ITS in mobile communication scenarios, the transmission performance should be enhanced, and new receiving schemes need to be designed for accommodating mobile users. Also, an evaluation platform for design and development of such new receivers is required. This thesis aims to design a reliable receiver applicable to IEEE 802.22-based mobile WRAN communication system and establish a flexible testbed for practical evaluation of the universal system including receivers with imitating radio propagation channel in a multipath fading environment.

A reliable receiver is crucial for the WRAN communication system to achieve sufficient transmission performance in highly mobile and fading propagation environments. Therefore, as the first topic of this thesis, a reliable receiver design for IEEE 802.22-based mobile WRAN communication system adhering to the standardized physical layer (PHY) parameters is proposed and analyzed. Due to the scattered pilot design for fixed communication in the existing IEEE 802.22-based communication system, its frame structure hinders transmission performance in a highly mobile and long-delay multipath fading environment. The performance of the proposed scheme is evaluated by computer simulation. As a simulation result, the feasibility of the IEEE 802.22-based highly mobile wide area communication system in a long-delay multipath fading environment is demonstrated.

Then, this thesis discusses an experimental platform for IEEE 802.22-based highly mobile wide area communication system. Computer simulation is considered an efficient tool for the PHY performance evaluation during the communication system development. However, the effect of hardware impairment on transmission performance is hardly taken into account by only computer simulation, and further experiment-based PHY performance evaluation is required. This thesis focuses on the development of software

defined radio (SDR)-based experimental platform. The recent advent SDR technology is an appealing choice to establish an experimental platform for PHY performance evaluation of the IEEE 802.22-based highly mobile wide area communication system due to its flexibility and reliability. In this thesis, an SDR-based experimental platform is developed. As a validation, the PHY performance by applying the developed SDR-based experimental platform is compared with computer simulation. As a measurement result, the feasibility of the IEEE 802.22-based highly mobile wide area communication system is further demonstrated.

In the development of a reliable IEEE 802.22-based highly mobile wide area communication system transceiver for various propagation scenarios, a general and statistical channel model to simulate multipath fading propagation characteristics in a real environment is necessary for evaluating total performance and robustness of the designed wireless communication system. In this thesis, a novel channel modeling algorithm and channel reproduction framework are proposed. For the validation of the proposed algorithm, the essential factors of channel modeling are extracted from the experimentally measured data by applying the SDR-based experimental platform. The multipath fading characteristics measured in the experiment are modeled and reproduced by the proposed modeling algorithm and reproduction framework with a high fitness of statistical characteristics.

The chapters of this thesis are organized as follows. Chapter 1 outlines the background of vehicular networks and the overview of this thesis. In Chapter 2, wireless technologies for vehicular communication systems and TVWS systems are discussed. The robust receiver scheme for IEEE 802.22-based highly mobile wide area communication system is proposed in Chapter 3. An SDR-based experimental platform for IEEE 802.22-based highly mobile wide area communication system is presented in Chapter 4. Chapter 5 proposes a channel measuring and modeling prototype for WRAN communication system. Finally, Chapter 6 concludes this thesis.