A Mobility-Based Routing Protocol for CR Enabled Mobile Ad Hoc Networks

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ABSTRACT

With the fast development of hardware and chipset functionality and capability, smart devices equipped with advanced technologies, such as Cognitive Radio (CR) will offer promising opportunities for mobile network. The authors in this work design a mobility based routing protocol (CRMBR) which operates in CR enabled Mobile Ad hoc Networks (MANETs). The adopted cross layer structure transfers the cognitive sensing data, such as channel quality and available bandwidth, from Physical layer up to MAC/Network layers periodically. Network layer uses such information for executing route selection algorithm while MAC layer runs the sub-channel scheduling algorithm based on CR data before each transmission. CRMBR further employs an advanced acknowledgment scheme in MAC layer for sub-channel selection to reduce the control overhead while forwarding data in MANETs. The performance of CRMBR is investigated via simulations on OpNET platform and the results confirm its favorable operation within CR MANET environments compared to two classic routing protocols in Ad hot networks: AODV and DSR.

Keywords: Cognitive Radio, Cross Layer, MAC Layer, Mobility, Multi-Channel, Routing

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1. INTRODUCTION

In recent years, research into the Internet of Things (IoT) has developed significantly. No longer limited to the application concept phase, IoT now encompasses access networks (such as sensor, RFID, and mobile devices), the backbone network structure (such as cloud computing, ubiquitous computing), as well as middleware techniques, embedded system control, IoT protocols, IoT signal processing, and IoT security and authentication. In all of these new domains the target is the same, which is to establish a healthy, robust and secure network for device-to-device communication. Meanwhile Cognitive Radio (CR) (Mitola & Maguire, 1999) has been identified as one of the promising techniques that is being adopted within wireless research to improve the utilization of scarce spectrum resources. Along with the fast evolution of hardware, it can be foreseen that in the near future every device could be CR enabled. Nowadays, more and more IoT application scenarios are being studied, not only within restricted geographical areas, such as e-home or e-office, but also with regard to certain communication situations, such as vehicle-to-vehicle, emergency, disaster rescue, etc. Ad hoc networks, with their independence from pre-defined network infrastructure, are recognized as a popular approach for IoT. As long as the nodes in the ad hoc network are equipped with the self-organized conversation capability, a sufficient device-to-device communication network can be auto deployed anywhere on demand.

Considerable research relating to CR networks has been carried out on the physical layer, such as in the studies (Zeng & Liang, 2007; Ghasemi & Sousa, 2007) and the MAC layer in work (Kim & Shin, 2008; Jia, Zhang, & Shen, 2008), such that CR performance is improving. However, another key issue in CR ad hoc networks regarding device-to-device communication, which cannot be avoided, is how to forward the data from the source to the destination efficiently. AODV (Ad hoc On Demand Distance Vector) (Perkins & Royer, 1999) and DSR (Dynamic Source Routing) (Johnson, Maltz, & Broch, 2001) are regarded as the most widely deployed routing protocols in ad hoc networks. A few works have now started to consider new routing protocols for use in CR ad hoc networks. Work (Ju & Eveans, 2009; Kyasanur & Vaidya, 2006) defined a SARP (Spectrum-Aware Routing Protocol) which assumes the mobile devices possess multi-RF interfaces. One geographically based routing protocol for CR ad hoc networks is proposed by the authors (Chowdhury & Felice, 2008). Considering the device cost, more than one RF interface is not a cost effective choice and even with an embedded GPS chipset, obtaining precise and up-to-date location information is still hard to achieve. Therefore in this paper, we propose a novel cross layer routing protocol in CR mobile Ad Hoc Networks (CR MANET) for IoT. With perfect knowledge of frequency usage data from the Physical layer, the Network layer works efficiently together with the MAC layer to provide suitable path selection and multi-channel allocation for data forwarding and transmission.

Unlike the majority of CR work, which focuses on the physical layer or MAC layer, considering the accuracy of sensing or the balance between sending time and transmission time, our work makes use of CR sensing information for route selection in the CR MANET. With knowledge of frequency usage data from the Physical layer, the Network layer works efficiently together with MAC layer to provide suitable path selection and multi-channel allocation for data forwarding and transmission. Furthermore, the cross layer design ensures that the routing protocol adapts well to the real-time radio environment throughout the transmission session. Due to the continuing information sharing activities among three layers in the CR MANET, this real-time adaptive cross layer routing protocol can react to changing network conditions in order to maintain an improved end user experience.

The rest of the paper is organized as follows: Section II introduces some related work. Section III gives the overall cross layer design
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