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Applicability of adaptive Clear Channel Assessment mode-1 range in Intelligent Transportation Systems devices

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Abstract

Quality of Service (QoS) performance of Vehicular Ad-hoc NETworks (VANETs) in Intelligent Transportation Systems (ITS) can be improved by varying the Clear Channel Assessment (CCA) mode-1 power. The CCA mode-1 threshold power is the minimum amount of energy required to declare the channel state busy by the physical layer. This paper identifies the applicability of adaptive CCA power in ITS devices by analyzing the impact of different CCA powers on the QoS of a VANET. QoS performance metrics such as packet delivery fraction, mean delay per packet, mean delay per hop and mean jitter are evaluated using the NS-3.26 simulator.

Keywords: ITS, VANET, WAVE, IEEE 802.11p

1. Introduction

At the rate at which technology has been advancing in the recent years, the time is not far when the current transportation system infrastructure will be replaced by Intelligent Transportation Systems (ITS) [1, 2, 3]. In ITS vehicles can communicate with each other by exchanging messages. Sharing information with each other helps in generating emergency alerts and managing traffic. The Wireless Access in Vehicular Environments (WAVE) radio communication standard is defined to provide interoperable transportation services [4]. In addition, Dedicated Short Range Communication (DSRC) is a common term for ITS related technologies. The United States Department of Transportation (USDOT) uses the terminology DSRC for WAVE related technologies [5]. WAVE includes all services that are recognized by the United States National ITS. WAVE uses a 5.9 GHz frequency spectrum (5.850 GHz to 5.925 GHz band) [4]. WAVE recommends Enhanced Distributed Channel Access (EDCA) for the Media Access Control (MAC) layer. There are two types of physical connections in ITS: vehicle to vehicle (V2V) and vehicle to infrastructure (V2I). In ITS, vehicles use the On-Board Unit (OBU) for V2V and V2I communication. The device that encapsulates the OBU is known as the On-Board Equipment (OBE). For V2I communication some stationary units are also deployed near roads which are called Road Side Units (RSUs). RSU enhances the coverage of networks on roads and it may also provide internet connectivity to the OBU. The device that encapsulates RSU is known as Road Side Equipment (RSE).

Interference is a well known problem in Vehicular Ad-hoc NETworks (VANETs) and it impacts Quality of Service (QoS) performance. By varying the Clear Channel Assessment (CCA) range, interference can be controlled in VANETs; further, the CCA range can be controlled by varying the CCA power. There are three CCA modes in the literature: mode-1, mode-2 and mode-3. This study analyzes the QoS performance of VANETs for different Transmission Ranges (TRs) and CCA mode-1 ranges, which will pave the way for confirming the use of adaptive CCA algorithms in ITS devices. Furthermore, the term ‘CCA mode-1’ is reffered to as ‘CCA’ throughout this paper. Network Simulator-3 (NS-3.26) is used to analyze the QoS performance [6]. The remainder of this paper is organized as follows: Sec. 2 illustrates related work, Sec. 3 discusses the methodology, Sec. 4 lists the simulation details, and Sec. 5 discusses the results. Finally, Sec. 6 concludes the paper with the findings of this study.

2. Related Work and Motivation

Ramachandran and Roy in [7] conducted a review on CCA components in wideband wireless area networks. The detailed review in [7] helped to understand the working of CCA components in wireless devices. Sha et al. in [8] identified the false wakeup problem in Wireless Sensor Networks (WSNs), which causes energy loss due to undesirable increase in duty cycles. Sha et al. performed an empirical study and found that the “*CCA wakeup threshold*” is an important parameter to control false wakeups, and they proposed the Adaptive Energy Detection Protocol (AEDP) [8]. While working with the AEDP, Sha et al. confirmed that tuning CCA threshold is difficult and ineffective for links with low signal strength. Subsequently, they suggested the use of CCA polling duration and acknowledgement delay. The empirical study in [8] using different CCA ranges proves that the adaptive energy detection

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