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Evaluation of Wi-Fi and LTE Integrated Channel Performance with Different Hardware Implementation for Moving Objects

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Abstract

Combining Wi-Fi and LTE data transmission technologies we can obtain an integrated solution that provides full end-to-end data transmission channel. This article compares goodputs of two LTE routers, which connect multiple WLAN access points (including Wi-Fi access controller) with the remote FTP server. Handover impact on data channel goodput is measured between wireless access points. Experimental data obtained by taking measurements under field conditions using real hardware, which imitates realistic two rank heterogeneous wireless network. The obtained results are very valuable, as they can be used as source data to develop mathematical network models as well as to tune network simulation software. The article also contains a mathematical model, which allows analyzing the impact on the data channel goodput at several competing vehicles which try to gain access to data channel via wireless access points. Experimental data is used in mathematical model. Obtained results supplement previous research and in this case the results show hardware's impact on channel goodput.

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Keywords: Heterogeneous network; Handover; Goodput; Wi-Fi; LTE

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1. Introduction

Two major standardized technologies are currently being considered for Vehicle-to-Everything (V2X) communications in automotive applications: IEEE 802.11p and 3GPP Long Term Evolution (LTE) with Proximity Services (ProSe). However, these technologies have their drawbacks. For example, IEEE 802.11p cannot be used to transfer large amounts of data, such as video, management and security functionalities of the vehicle (e.g., Certificate Revocation List (CRL) distribution) and the transfer of necessary data to roadside units (RSUs) infrastructure and further to control centres. And also this standard solution cannot be used to access the Internet. We could use existing cellular networks (e.g. LTE), but it may be inaccessible due to weak or non-existent coverage in such places like tunnels, underground parking, rural area, mountainous terrain etc., all of which are important places where road safety and other mentioned services must be ensured. Therefore, in order to address these issues, authors offer to use an IEEE 802.11 based infrastructure mainly in places with no broadband mobile network coverage. We also assume that the use of Wi-Fi infrastructure in such problematic areas is economically beneficial. The integrated idea of ubiquitous 5G V2X network presence for vehicles and strict requirements for security mechanisms to prevent unauthorized access to vehicles and related personal data, which are demanding against the network delay, justifies position of authors even more. We can also mention the need in near future to transfer data of sensors placed in the vehicle, as well as transport infrastructure data to 5G networks, which will provide timely supply of data to compute and storage centers[1]. This confirms that previous and upcoming research in directions of both Wi-Fi and LTE technology for moving objects are justified and necessary.

The main goals of the paper are to evaluate performance (goodput) of IEEE 802.11n[2] and LTE integrated channel for two rank heterogeneous wireless networks using different LTE channel access equipment and to evaluate impact of handover (inter-AP) on data channel goodput between wireless access points.

In computer networks, goodput is the application-level throughput (i.e. the number of useful information bits delivered by the network to a certain destination per unit of time). The amount of data considered excludes protocol overhead bits as well as retransmitted data packets. This is related to the amount of time from the first bit of the first packet is being sent (or delivered) until the last bit of the last packet is delivered.

In the Wi-Fi world, handoff, handover and roaming, are all the same, referring to final users moving between different networks with or without supporting IP session continuity. With the same (unchanged) IP address, the IP session continuity can be achieved[3].

To perform the necessary measurements within this study a test-bed were created with further performance evaluation. Experiments were carried out by real equipment in field environment with real road conditions. In first case we used professional LTE router from Cisco and in second case - home type Huawei LTE router.

The results of this work supplement those reported in[4,5,6,7] as in mentioned studies they are missing the review of influence on communication channel performance depending on used LTE access hardware.

The rest of this article is organised as follows. The second chapter is devoted to the system description. The third chapter describes the methodology and scenario of measurements. The fourth chapter is devoted to mathematical models for heterogeneous network. Third and fourth chapters also holds the discussion on obtained results. Finally, we came up with some final conclusions.

2. Description of system

The physical realization (test-bed, see Fig. 1) of communication for the transmission data from the vehicle to the remote server and back is the wireless network. At the first stage the data are transmitted from the mobile object to the nearest access point (AP) according to the IEEE 802.11n standard. Further, from the AP the data are transmitted to the remote server by the channel according to the LTE.

Test-bed consisted of LTE (4G) router (Cisco 819G-4G-G-K9 or Huawei E5186), Wi-Fi access controller (HP MSM720), 3 x Wi-Fi access points (HP MSM460), moving object (vehicle) equipped with powerful laptop (i5-3360M 2.8 GHz CPU, 4 GB RAM, Wireless LAN adapter Intel Centrino Advanced-N 6205) and remote FTP server (E5335 2 GHz CPU, 4 GB RAM). Remote server and laptop were equipped with IxChariot software.