On the Uplink Performance of 802.11a and 802.11b in Vehicular Environments

Syed Faraz Hasan, Nazmul H. Siddique and Shyam Chakraborty

***Abstract* – Opportunistic short interval connection to an AP for getting internet services while moving at vehicular speed has attracted attention of many researchers. In this paper, we evaluate performance of all data rates of IEEE 802.11a at three different vehicular speeds in terms of packet loss, end-end delay and amount of information sent on the uplink. We also evaluate 802.11b in terms of same performance matrices under similar set up. Main purpose of these calculations is to judge what benefits, if any, we can have from using 802.11b in vehicular set up when 802.11p WAVE is being developed on 802.11a standard. WAVE allows communication between vehicles and between vehicles and roadside infrastructure.**

***Keywords* – 3GPP Applications, IEEE 802.11, Infrastructure WLAN, NS-2, Vehicular Context, WAVE.**

I. INTRODUCTION

Wireless LANs have become popular in providing broad band connectivity with restricted mobility to users for some time. WLANs operate in two different modes: Infrastructure and Ad hoc. In infrastructure mode, mobile nodes form a Basic Service Set (BSS) by associating with a central element called Access Point (AP). All communications between nodes within a BSS are via AP over its coverage area, commonly known as footprint. Infrastructure mode WLAN APs can be connected to an external network, such as internet, to provide broadband connectivity. While WLANs offer restricted mobility, they are recently being studied for providing broadband services over larger geographical areas. Recent project on Intelligent Transportation Systems (ITS) focuses on providing communication between vehicles and between vehicles and infrastructure primarily for public safety. Short spanned interaction of vehicle with an AP might facilitate downloading traffic updates and more interestingly for providing internet services.

Evaluating 802.11a in vehicular environments is important because 802.11p WAVE (Wireless Access for Vehicular Environments) is being proposed as a modified version of 802.11a [1].

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An interesting question in this regard would be, "If 802.11p is being standardized based on 802.11a, what is the advantage of studying 802.11b for vehicular environments?" We, therefore, simulate 802.11a and 802.11b under similar vehicular set up to see what performance gains are available in using the former instead of the later.

Rest of the paper is organized as follows. Section II describes Related Work; Simulation Set up is explained in section III. Section IV is on Observation, section V on Conclusion and References are given at the end.

II. RELATED WORK

Some works have evaluated the performances of IEEE 802.11a and 802.11b in different vehicular environments; however, hardly any work on evaluating these two under similar vehicular set up is known to authors. This paper gives a performance evaluation of 802.11a and 802.11b under similar set up in terms of end-end delays, amount of data sent on uplink and packet loss at three different vehicular speeds. Consideration of real time traffic patterns is vital for evaluating 802.11 performances in vehicular context. Speed selection for experiments and simulations must consider, for instance, dense, normal and highway traffics. Measurements conducted for 802.11 APs in [3], suggest that speed variations of vehicles do not affect throughput while exact opposite is supported by [2] and [4]. Performance of 802.11a in vehicular context is evaluated in [2] for UDP traffic. Since most of the traffic in a typical internet session is dominated by TCP, our evaluation is based on TCP traffic. The results show that considerable amount of data can be sent on the uplink using an 802.11 AP; however, even better results may be obtained by using AP diversity [5]. Another important factor affecting the performance of 802.11 in vehicular environments is the connection time. Performance evaluations for 802.11g under vehicular set up show productive connectivity for around 1000m at 120km/hr which corresponds to a connection time of around 30 seconds [6]. Eriksson et al in [7] have conducted real-time experiments; their results show that average connection time is not more than 10 seconds. This apparent contradiction might be because of the fact that car used in experiments in [6] essentially encounters one AP only.

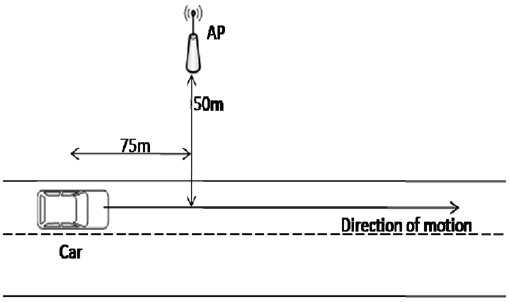

Figure 1: Simulation Set up

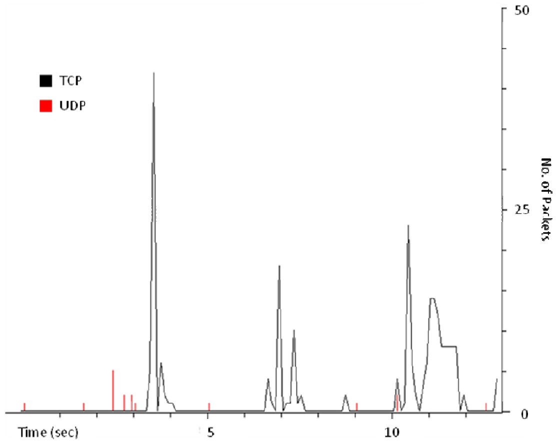

Figure 2: TCP and UDP traffics in a typical internet session

On the other hand in [7], car traverses along a populated city encountering several APs and hence initiating handovers periodically.

Mobile-AP separation is also a significant factor affecting the overall system throughput. Works on impact of mobile-AP separation on throughput are done in [3], [4] and [6] under 802.11b/g set up. We evaluate the same for 802.11a networks later in section IV.

III. SIMULATION SET UP

A typical simulation set up for performance evaluation of 802.11 networks at vehicular speeds involves a car moving by different APs located across an area, simulated in NS-2 [8]. As a car approaches an AP, it connects to it and uses its resources until it gets out of range within certain time duration. It then waits for encountering another AP to restart its session. Our set up comprises of a car moving towards an AP at three vehicular speeds 30, 60 and 90km/hr. As stated earlier, these speeds represent all possible traffic scenarios; dense traffic speeds are normally 30km/hr, normal urban speeds are 60km/hr and highway speeds are represented by 90km/hr. Antennas placed on car and AP correspond to Cisco 1240 series threshold values. Each simulation runs for 10 seconds, a practical connection time in urban environment, allowing the car to send TCP packets on the uplink. RTS/CTS handshakes are disabled to evaluate only the actual amount of data sent. Similar evaluations are carried out by configuring the set up with 802.11b parameters.

Our simulation set up, shown in Figure 1, can be visualized as an AP placed on the top of a building offering some coverage on the adjacent road 50m away. As mentioned in section II, we focus on time interval in which the car remains connected to the AP, or in other words, on the time period for which the car remains within the footprint of an AP, known as "production time" [4]. Since we want to evaluate connection benefits with in this time only, we ensure that the car is in the AP footprint at the beginning of simulation. To achieve this, horizontal mobile – AP separation is kept 75m, as shown in Figure 1.

The idea of evaluating TCP traffic is consistent with the fact that most of packet exchange during an internet session is dominated by TCP transfers. While browsing three different websites http://www.ulster.ac.uk, http://isrc.ulster.ac.uk and http://scis.ulster.ac.uk live traffic was sniffed using Wireshark. It is clear from Figure 2 that number of TCP packets exchanged in this internet session is much higher than UDP.

IV. OBSERVATIONS

A. Performance evaluation of 802.11 data rates

Although 802.11 WLANs are originally meant for providing data services, studies have shown that they can support voice and video communications as well [9]. Evaluating the provision of such convergent services using 802.11 requires consideration of more parameters than just information sending capacity. For example, real-time communications are delay sensitive applications. Evaluation of end-end delay, therefore, becomes a parameter of interest in 802.11 WLANs. Applications belonging to 3GPP QoS Background class might tolerate end-end delays but can not tolerate large packet loss [10]. We, therefore, calculate the values of end-end delay and packet loss along with amount of data sent for 802.11 in vehicular context to account for all 3GPP QoS classes. From results shown in Tables 1 to 3 for 802.11a, we find that at all speeds, end-end delay decreased with increasing data rates. This trend suggests that higher data rates of 802.11a have a better tendency to support real-time and semi-real-time applications. On the other hand, amount of data sent on the uplink, increase with increasing data rates. However, performance difference between 48 and 54Mbps rates is quite small, rendering them to be considered as performing equally. Tables 1-3 suggest that speed variation does not significantly change amount of data sent on the uplink. This is an apparent contradiction to findings of [2] and [4]. We argue that speed variations