

A Feasibility Study on Vehicle-to-Infrastructure Communication: WiFi vs. WiMAX

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Abstract—Vehicular Network is becoming increasingly popular in recent years, in which vehicles constitute a wireless mobile network. Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) are two different modes of communication in a vehicular network. Some measurement studies have previously been undertaken to understand the feasibility of using WiFi for V2V and V2I communication. Recently WiMAX is emerging as one of the possible candidates for next generation mobile networks. In this work, we set out to understand the feasibility of using WiMAX for V2I communication as compared to the use of WiFi. Due to the hardware limitation, we focus on a static setting in urban environment. Our initial measurement studies show that while WiMAX can offer a longer communication range than WiFi, its latency can be significantly larger than that of WiFi at a short distance (e.g. less than 100m). In addition, we show the setting of frame size has a strong impact on the performance of WiMAX.

I. INTRODUCTION

Vehicular network is an emerging class of wireless communication paradigm that enables vehicle to communicate with road-site units (V2I) and with other vehicles (V2V). Some prior studies used IEEE 802.11 radio technology to evaluate the feasibility of vehicular network in a real world scenario for both V2I and V2V communication. For example, Ott [?] performed measurements from cars running at high speeds (from 80km/h to 180km/h) on an autobahn in German. Their results showed that the distance between the vehicle is the main factor that affects the connectivity of V2I communication. Wellens et al. [?] measured goodput, frame error rate of a vehicular network under different conditions such as different speed, communication distances, data rates, etc. Their results showed speed is a negligent factor when using WiFi for short distance V2I communication. Jerbi et al. [?] measured the performance of multi-hop communication in a vehicular network using WiFi in three different scenarios: Vehicle-to-Infrastructure, Vehicle-to-Vehicle and Hybrid. Their results again indicated communication range is the major factor that affects V2I communication. Gonzalez et al. [?] measured V2V communication in both light-of-sight (LOS) and non-light-of-sight (NLOS) conditions. They showed that the performance of V2V communication can be significantly degraded in a NLOS environment as compared to a LOS setting.

Prior measurement studies on V2I communication all focused on the use of WiFi since it is free and widely available. Recently, WiMAX is becoming an emerging technology for

next generation wireless network. However, although WiMAX offers better throughput and communication range as compared to WiFi, it is not clear how it performs for V2I communication in theory in a real life environment. In this work, we set out to understand the performance and limitation of WiMAX for V2I communication as compared to the use of WiFi through extensive measurements.

II. MEASUREMENT SETTING

In our experiment, we measure the latency, throughput and packet loss from the vehicle to the base station at the road side in a static setting using WiFi and WiMAX. The testbed is setup in an urban environment. We use Iperf to measure the throughput and packet loss and use ping to measure the latency. In the WiFi experiment, the vehicle is equipped with a laptop with a built-in IEEE 802.11b/g adapter without the use of external antenna. An IEEE 802.11b/g access point (D-Link DL-624s) is set up at the road-side. The access point is configured with the default settings for the beacon interval, transmission power, etc. WEP encryption is disabled in our experiments. All the devices are assigned with static IP address.

In the WiMAX measurement, we use Proxim MP16 3500 for our experiments. The Proxim WiMAX device supports both 3.5 MHz and 7 MHz channel bandwidths. It also supports time division duplex operation and different modulation modes (BPSK-1/2, QPSK-1/2, etc.). We equipped the base station (BS) with a 90 degree external antenna and placed it at the road-side. The vehicle is equipped with a Subscribe Station (SS) to transfer and receive packets to and from the BS. A laptop is connected to the SS and the BS respectively to collect the traces. And the laptop runs on Ubuntu. In our experiments, we only considered two modulation modes (BPSK-1/2 and 64QAM-3/4). The transmission power of BS is set to 28dbm. The uplink and downlink subframe size is configured to 1:1 and frame duration is set to 10ms. We used the default setting of Iperf for the measurements. GPS is used to measure the distance between the vehicle and the road-site unit for both WiFi and WiMAX measurements.

III. MEASUREMENT RESULTS

To compare the performance of WiFi and WiMAX, we first conducted a baseline experiment in our lab where the BS

TABLE I
COMPARISON THROUGHPUT WiFi AND WiMAX IN LABORATORY

Content	Throughput (Kb)
IEEE 802.11g	22400
IEEE 802.16d BPSK-1/2	462.6
IEEE 802.16d QPSK-1/2	890.6
IEEE 802.16d 16QAM-1/2	1850
IEEE 802.16d 64QAM-3/4	4130

TABLE II
COMPARISON THROUGHPUT OF WiMAX IN VARY FRAME DURATION

Frame duration	Simulation results (Kb)	Measurement results (Kb)
5ms	4311	3240
10ms	5237	4679
20ms	5659	5424

(or AP) and the client are close by. As shown in Table I, the throughput of WiFi is significantly larger than WiMAX because it uses a 20MHz channel bandwidth while WiMAX channel bandwidth is set to 3.5MHz in our experiment. However, although WiFi can offer a higher throughput when the distance is short, the throughput quickly drops to zero and the connectivity is lost at the distance of 200m, as shown in Figure I. On the other hand, we are still able to transmit data at the distance of around 1Km for WiMAX with a throughput of up to 1Mbps (using 64QAM modulation).

Frame duration is a key parameter that could affect the throughput and latency of WiMAX. WiMAX uses Time Division Duplex (TDD). A TDD frame consists of multiple OFDM (Orthogonal Frequency Division Multiplexing) symbols. There are some overhead in the MAC layer for each TDD frame such as preamble, padding, broadcasting message (e.g., DL-MAP and UL-MAP), etc. These MAC layer overhead generally occupies about 10 OFDM symbols for each TDD frame. Therefore, there will be more MAC layer overhead for a smaller frame size (Theoretically, the number of available downlink OFDM symbols is 5200 for a frame size of 5ms, 6300 for a 10ms frame and 6850 for a 20ms frame.). As a result, we observed that the throughput of WiMAX increases as we set the frame size to a higher value on the base station. In addition, the frame size can affect the RTT significantly. In WiMAX, if a MAC SDU is too late to be sent in a downlink subframe, it will be scheduled to send in the next downlink subframe. For a ping measurement in WiMAX, it will take at least two frames to measure the RTT (one frame for the channel bandwidth allocation and one frame for the request/reply data packets). Therefore, the measured RTT is increased as we increase the frame duration. Due to the above reason, we found the RTT of WiMAX is significantly larger than that of WiFi when the communication distance is short, as shown in Figure 2. We also observed that the measured throughput of WiMAX is significantly lower than its theoretical estimate from simulation, as shown in Table II.

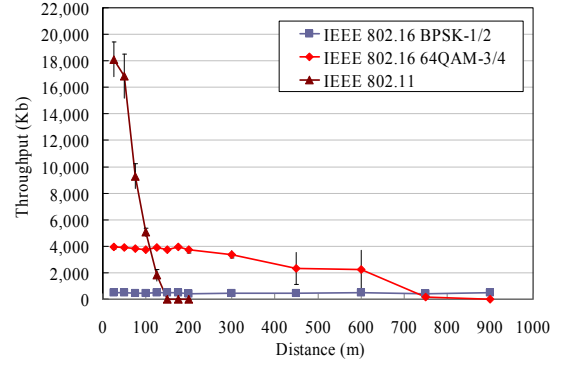


Fig. 1. Comparison throughput between WiFi and WiMAX

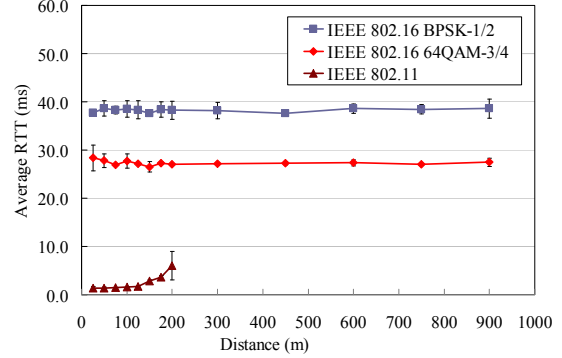


Fig. 2. Comparison delay between WiFi and WiMAX

Our hypothesis is that our WiMAX hardware might implement a different fragmentation mechanism as compared to theory.

IV. CONCLUSION

In this work, we set out to understand the feasibility of using WiMAX for V2I communication as compared to the use of WiFi. Our initial measurement studies show that one might be able to get more throughput and a shorter latency from WiFi at a short distance (e.g. less than 100m), assuming there are too many interfering sources in the area that also use the 2.4GHz band. In addition, we show that frame duration can have a critical effect on the performance of WiMAX. For applications that require small delay, a smaller frame size may be preferred. On the other hand, for applications like file downloading, one might want to use a larger frame size to have a better throughput.

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