Laboratory Performance Measurements of WiMAX and Wi-Fi Point-to-Point Links

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Abstract. *Wireless communications using microwaves are increasingly important. Performance is a very relevant issue, resulting in more reliable and efficient communications. Laboratory measurements are made about several performance aspects of WiMAX (IEEE 802.16d) and Wi-Fi (IEEE 802.11a, b, g) point-to-point links. An initial evaluation and comparison of these technologies is made, using Alvarion equipments and access points from Enterasys Networks. Through OSI levels 1, 3 and 4, detailed results are presented and discussed, namely: SNR, latency and ICMP packet loss. It is concluded that WiMAX, which is an important emerging and rapidly expanding wireless wide band technology, shows the best performance.*

Keywords: WLAN, Wi-MAX, Wi-Fi, Point-to-Point Links, Wireless Network Laboratory Performance Measurements

1. Introduction

Wireless communications are increasingly important for their versatility, mobility and favourable prices. It is the case of microwave based technologies, e.g. WiMAX and Wi-Fi.

WiMAX permits medium and long distance wireless links, for both point-to-point and point-to-multipoint configurations. It corresponds mainly to the IEEE 802.16 standard and its evolution [1]. There is a fixed version of WiMAX based on IEEE 802.16d or 802.16-2004, allowing for data rates up to 75 Mbps. WiMAX has become interesting for enabling alternatives to traditional telecommunication infrastructures such as phone and coax TV cabling, through technologies such as VoIP and IPTV, while maintaining the capacity for Internet services. IEEE 802.16e/g has provided for mobility, permitting the use of cellular-like phones moving at considerable speeds. WiMAX has, efficiently, enabled to extend medium and long range backbones. Frequency bands of 5.4 and 5.7 GHz are used. Analysis and performance evaluation of IEEE 802.16 has been made [2]. WiMAX performance has been studied [3].

The importance and utilization of Wi-Fi have been growing for complementing traditional wired networks. Wi-Fi has been used both in ad hoc mode and infrastructure mode. In this case an access point, AP, is used to permit communications of Wi-Fi devices with a wired based LAN through a switch/router. In this way a WLAN, based on the AP, is formed. Wi-Fi has reached the personal home, forming a WPAN, allowing personal devices to communicate. Point-to-point and point-to-multipoint configurations are used both indoors and outdoors, requiring specific directional and omnidirectional antennas. Wi-Fi uses microwaves in the 2.4 and 5 GHz frequency bands and IEEE 802.11a, 802.11b and 802.11g standards [1]. Nominal transfer rates up to 11 (802.11b) and 54 Mbps (802.11 a, g) are permitted. CSMA/CA is the medium access control. Wi-Fi performance is available in indoor environments [4].

Performance has been a very important issue, resulting in more reliable and efficient communications. Several measurements have been made for 2.4 GHz Wi-Fi [5], as well as WiMAX and high speed FSO [6,7]. In the present work further results arise, through OSI levels 1, 3 and 4. WiMAX and Wi-Fi (IEEE 802.11 a,b,g) are evaluated and compared for performance in laboratory measurements of point-to-point links.

The rest of the paper is structured as follows: Chapter 2 presents the experimental details i.e. the measurement setup and procedure. Results and discussion are presented in Chapter 3. Conclusions are drawn in Chapter 4.

2. Subject and Methods

WiMAX measurements were performed using the Alvarion BreezeNET B100 model, operating in the 5.4 GHz band. This equipment supports, namely: IEEE 802.3 CSMA/CD; OFDM; BPSK, QPSK, 16-QAM, and 64-QAM modulations; 21 dBi antennas; high RF saturation, with high performance; NLOS; 802.1Q; QoS; a maximum transfer rate of 108 Mbps (turbo mode) [8]. Modulation was set to 8, 64-QAM-3/4, with signal to noise ratios above 23dB. In the tests, 54 Mbps (normal mode) and vertical polarization were used. There were interference free conditions.

Wi-Fi experiments of two types were carried out: EXP1 and EXP2. EXP1 used Enterasys RBTR2 level 2/3/4 access points (AP1) with firmware version 6.08.03 [9], and 100-Base-TX/10-Base-T Allied Telesis AT-8000S/16 level 2 switches [10]. The configuration was for minimum transmitted power, micro cell, point-to-point, LAN to LAN mode, using the radio card antenna. EXP2 used Enterasys RBT-4102 level 2/3/4 access points (AP2) with firmware version 1.1.51 [9], and the same type of level 2 switch. The configuration was similar to EXP1. In both EXP1 and EXP2 interference free communication channels were used. WEP encryption was not activated. No power levels above the minimum were required as the APs were very close (30 cm).

WiMAX and Wi-Fi laboratory tests were made in point-to-point mode, using the setup scheme shown in Fig. 1, where RB and BU represent remote bridge and base unit, respectively. The RB-BU distance was 100 m. For 7-echo UDP traffic injection (OSI level 4) the WAN Killer software was available [11]. Packet size was set to the default of 1500 bytes. The traffic injector was the PC with IP 192.168.0.1, having the PC with IP 192.168.0.5 as destination. Latency was measured as the round trip time of ICMP packets (OSI level 3) involving the PCs having IPs 192.168.0.2 and 192.168.0.6. Percentage packet loss was also measured for different ICMP packet sizes (32 and 2048 bytes) through the same two PCs.

3. Results and Discussion

The main WiMAX results are shown in Fig. 2. A polynomial fit was made to percentage packet loss for 32 byte ICMP packets. The data indicates that, for traffic peaks up to 70 % of the maximum nominal transfer rate (54 Mbps), communications quality is possible as recorded in Table1, as the values of latency and percentage packet loss are within acceptable limits (less than 10 ms and 2%, respectively). For Wi-Fi experiments both AP1 and AP2 were configured, for every standard, with typical fixed transfer rates. For every experiment and fixed transfer rate, measurements were made, with percentages of injected traffic varying from 0% to maximum values. At OSI level 1, typical SNR values are shown in Fig. 1. The best noise levels N were for 802.11a. Measurements through OSI levels 3 and 4 permitted determination, for every standard and fixed transfer rate, of the maximum percentage of network utilization under quality conditions. Some sensitivity to AP type was observed. Table 1 shows the average values obtained from EXP1 and EXP2. It was found that, for every

standard, the maximum percentage of network utilization under quality conditions decreases with increasing fixed transfer rate. Some results obtained for 802.11g, at a 54 Mbps are illustrated through Fig. 2. Table 1 shows that WiMAX has the best performance (70%). It is followed by Wi-Fi: 802.11g and 802.11a at 54 Mbps, having 40% each.

Table 1. WiMAX /Wi-Fi average maximum percentages of network utilization under quality conditions versus IEEE802.16d/IEEE 802.11 a, b, g standards and fixed transfer rate (Mbps).

IEEE standard/ Fixed transfer rate	5.5 (Mbps)	11 (Mbps)	12 (Mbps)	36 (Mbps)	54 (Mbps)
802.16d					70%
802.11b	70%	45%			
802.11g			60%	50%	40%
802.11a			65%	55%	40%

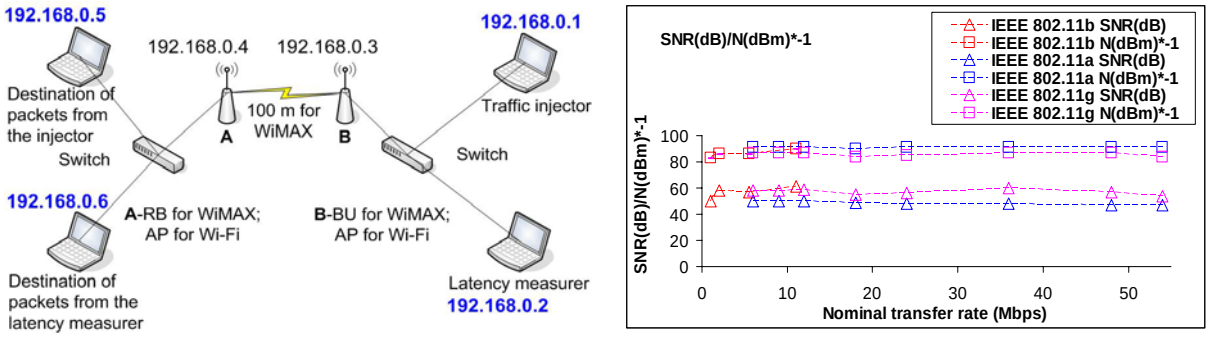

Fig. 1. WiMAX and Wi-Fi laboratory setup scheme, and Wi-Fi typical SNR (dB) and N (dBm).

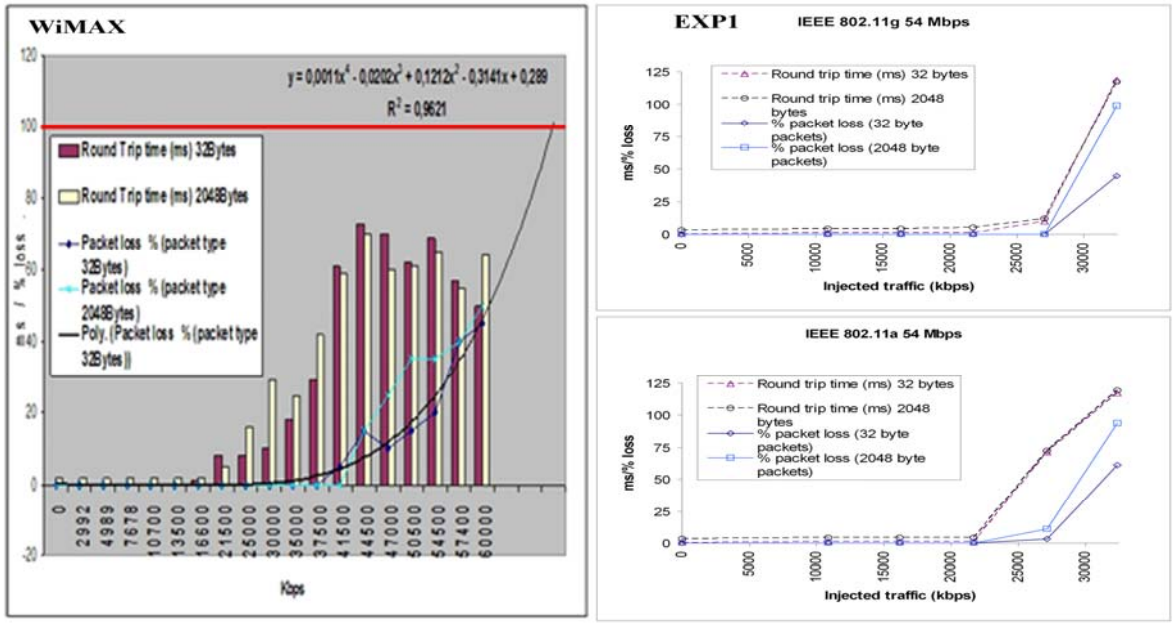

Fig. 2. Synthesis of results showing latency (ms) and ICMP percentage packet loss for WiMAX [6] and Wi-Fi (802.11g and 802.11a at 54 Mbps) experiment 1 (EXP1).

4. Conclusions

In the present work some systematic performance measurements were made using available equipments: both WiMAX (802.16d) and Wi-Fi (IEEE 802.11a, b, g) in point-to-point links. Through OSI levels 3 and 4, the measurements permitted to find maximum percentages of network utilization under conditions of communications quality. WiMAX was found to have the best performance. Further tests are required and planned mainly at OSI levels 4 and 7, using both normal and turbo mode. For Wi-Fi, the maximum percentage of network utilization under quality conditions was found to decrease with increasing fixed transfer rate. Additional measurements either started or are planned using several equipments, both in laboratory and outdoors involving, mainly, medium range links.

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