Performance Measurements of IEEE 802.11 a, g Laboratory Point-to-Point Links

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Abstract – **The importance of wireless communications has been growing. Performance is a very relevant issue, leading to more reliable and efficient communications. Laboratory measurements are made about several performance aspects of Wi-Fi (IEEE 802.11 a, g) point-to-point links. A contribution is given to performance evaluation of this technology, using available access points from Enterasys Networks (RBTR2). Detailed results are presented and discussed, namely at OSI levels 4 and 7, from TCP, UDP and FTP experiments: TCP throughput, jitter, percentage datagram loss and FTP transfer rate.**

Keywords – **WLAN, Wi-Fi, Point-to-Point Links, Wireless Network Laboratory Performance Measurements.**

I. INTRODUCTION

Wireless communications are increasingly important for their versatility, mobility and favorable prices. It is the case of microwave based technologies, e.g. Wi-Fi. 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]. As the 2.4 GHz band becomes increasingly used and interferences increase, the 5 GHz band has received considerable interest, although absorption increases and ranges are shorter.

Nominal transfer rates up to 11 (802.11b) and 54 Mbps (802.11 a, g) are permitted. CSMA/CA is the medium access control. Wireless communications, wave propagation [2,3] and WLAN practical implementations [4] have been studied. Detailed information is available about the 802.11 architecture, including performance analysis of the effective transfer rate. An optimum factor of 0.42 was presented for 11 Mbps point-to-point links [5]. Wi-Fi (802.11b) performance measurements are available for crowded indoor environments [6]. Performance has been a very important issue, resulting in more reliable and efficient communications. New telematic applications present special sensitivities to performances, when compared to traditional applications. Application characterization and requirements have been discussed for cases such as voice, Hi Fi audio, video on demand, moving images, HDTV images, virtual reality, interactive data, static images, intensive data, supercomputation, electronic mail, and file transfer [7]. E.g. requirements have been quoted as: for video on demand/moving images, 1-10 ms jitter and 1-10 Mbps throughput; for Hi Fi stereo audio, jitter less than 1 ms and 0.1-1 Mbps throughputs.

Several performance measurements have been made for 2.4 GHz Wi-Fi [8], as well as WiMAX and high speed FSO [9,10]. In the present work further Wi-Fi (IEEE 802.11 a,g) results arise, through OSI levels 4 and 7. There is interest in comparing two technologies working in the 5 GHz and 2.4 GHz bands, as at 2.4 GHz interferences have grown up. Performance is evaluated in laboratory measurements of point-to-point links using available equipments.

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

II. EXPERIMENTAL DETAILS

The measurements used Enterasys Networks RBTR2 level 2/3/4 access points [11], equipped with IEEE 802.11 a/b/g radio cards similar to the Agere-Systems model 0118 type, and firmware version 6.08.03, and 100-Base-TX/10-Base-T Allied Telesis AT-8000S/16 level 2 switches [12]. The configuration of the access points was for minimum transmitted power i.e. micro cell, point-to-point, LAN to LAN mode, using the antenna which was built in the card. Interference free communication channels were used in the communications. WEP encryption was not activated. No

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power levels above the minimum were required, as the access points were very close (30 cm).

The laboratory setup is shown in Fig. 2. TCP and UDP experiments at OSI level 4, were as mentioned in [10], permitting network performance results to be recorded. Both TCP and UDP are transport protocols. TCP is connection-oriented. UDP is connectionless, as it sends data without ever establishing a connection. For a TCP connection, TCP throughput was obtained. For a UDP communication with a given bandwidth parameter, UDP throughput, jitter and percentage loss of datagrams were obtained. TCP packets and UDP datagrams of 1470 bytes size were used. A window size of 8 kbytes and a buffer size of the same value were used for TCP and UDP, respectively. One PC, with IP 192.168.0.2 was the Iperf server and the other, with IP 192.168.0.6, was the Iperf client. Jitter, which represents the smooth mean of differences between consecutive transit times, was continuously computed by the server, as specified by RTP in RFC 1889 [13]. This scheme was also used for FTP measurements, where FTP server and client applications were installed in the PCs with IPs 192.168.0.2 and 192.168.0.6, respectively.

The PCs were portable computers running Windows XP. They were configured to maximize the resources allocated to the present work. Also, batch command files were written to enable the TCP, UDP and FTP tests. The results were obtained in batch mode and written as data files to the client PC disk.

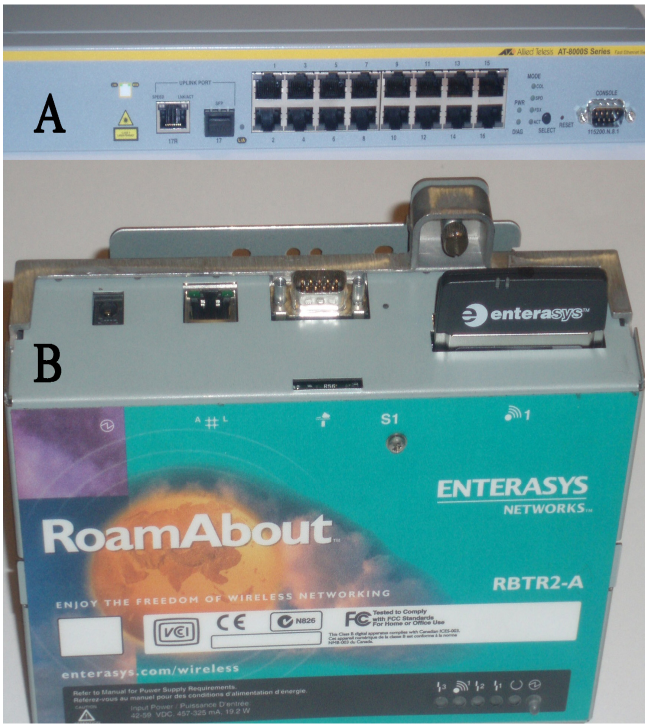

Fig. 1- Switch (A) [12] and Access Point (B) [11].

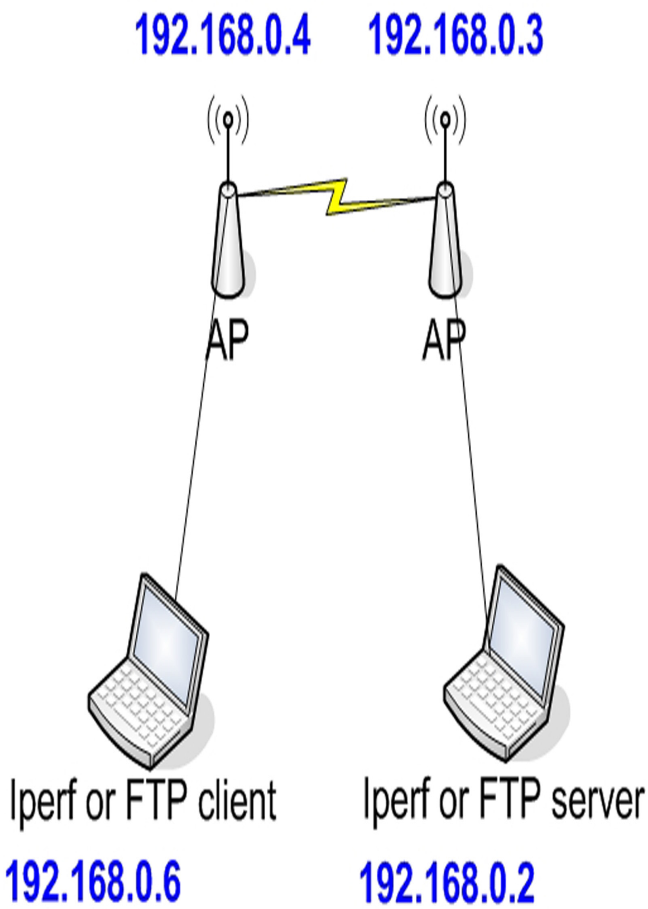

Fig.2- Laboratory setup scheme.

III. Results and Discussion

The access points were configured, for each standard IEEE 802.11 a, g, with typical fixed transfer rates. For every fixed transfer rate, data were obtained for comparison of the laboratory performance of the links, measured namely at OSI levels 4 and 7 using the setup of Fig. 2. For each standard and every nominal fixed transfer rate, an average TCP throughput was determined. This value was used as the bandwidth parameter for every corresponding UDP test, giving average jitter and average percentage datagram loss. The main results are shown in Figs. 3-6.

In Fig. 3, polynomial fits were made to the TCP throughput data, where R^2 is the coefficient of determination. It is seen that the best TCP throughputs are for 802.11a. The average values are 12.92 and 12.60 Mbps for 802.11a and 802.11g, respectively. In Figs. 4 and 5, the data points representing jitter and percentage datagram loss were joined by smoothed lines. In Fig. 4, the jitter data are on average lower for IEEE 802.11g (1.8 ms) than for 802.11a (2.1 ms). Fig. 5 shows that, generally, the percentage datagram loss data (1.2 % on average) agree reasonably well for both standards.

At OSI level 7 we measured FTP transfer rates versus nominal transfer rates configured in the access points for the IEEE 802.11a, g standards. Every measurement was the average for a single FTP transfer, using a binary file size of 100 Mbytes. The results thus obtained are represented in Fig. 6. Polynomial fits to data were made for the implementation of each standard. It was found that the best FTP performance was for 802.11a.

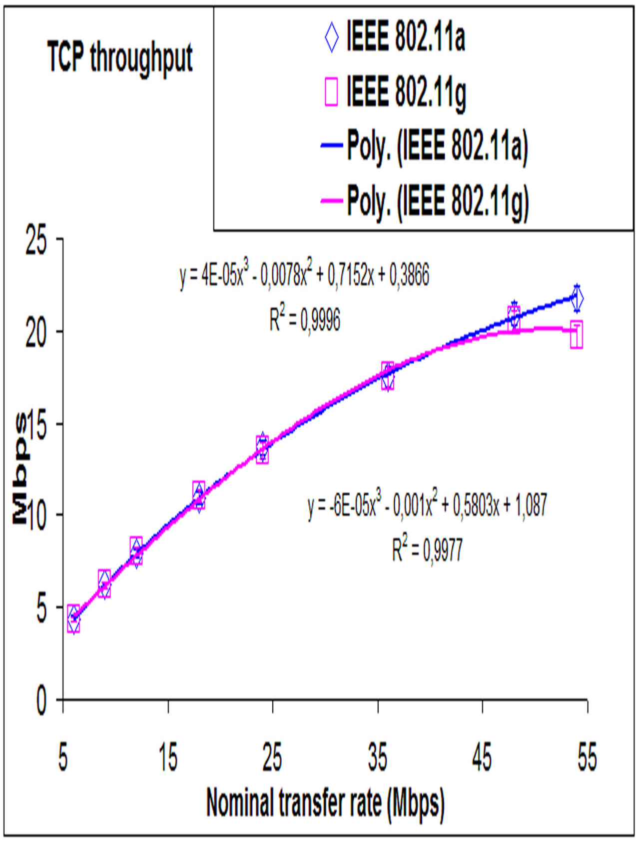

Fig.3- TCP throughput versus technology and nominal transfer rate.

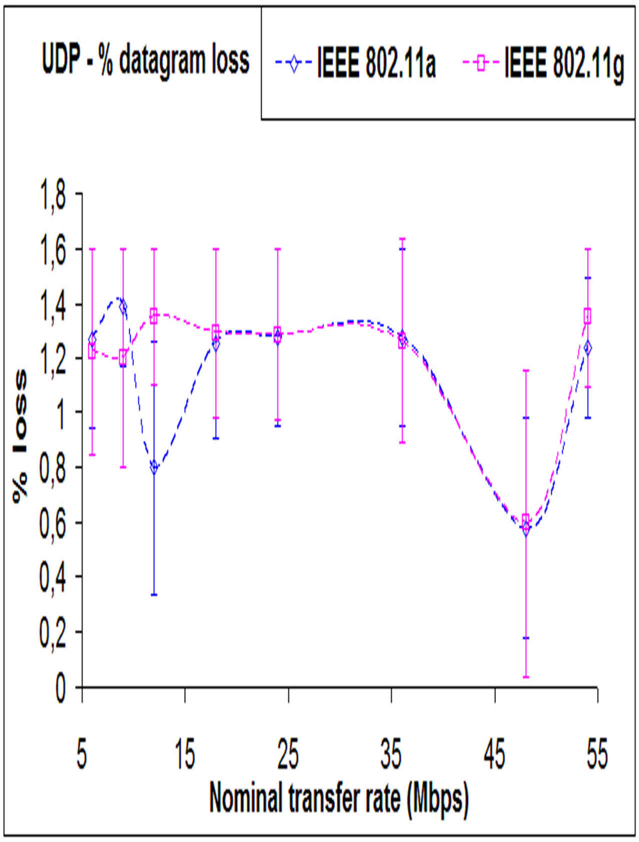

Fig.5- UDP – percentage datagram loss results versus technology and nominal transfer rate

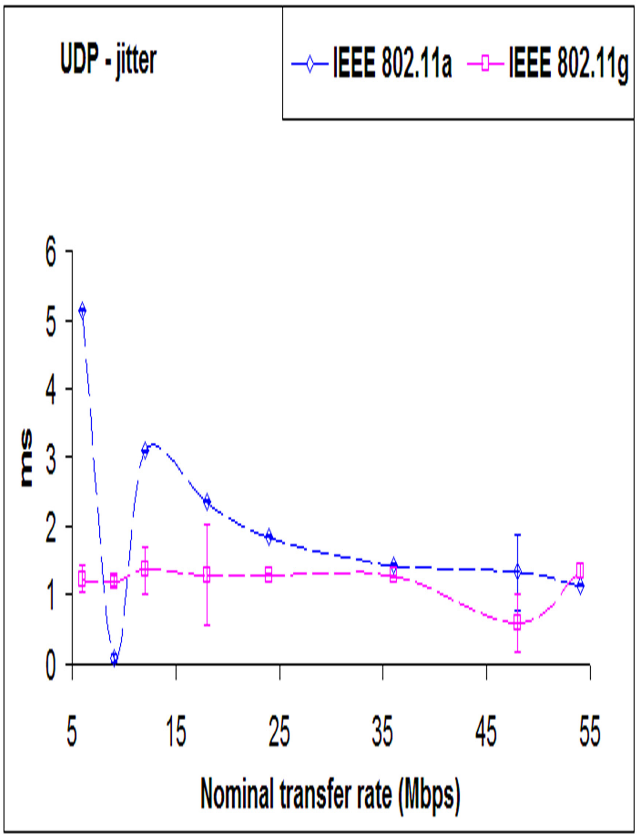

Fig.4- UDP – jitter results versus technology and nominal transfer rate.

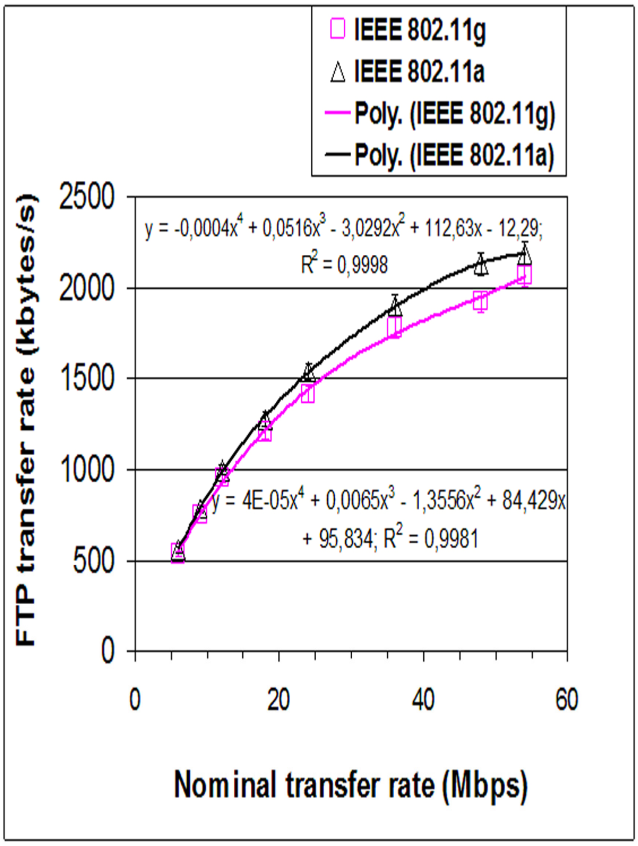

Fig.6- FTP transfer rates versus technology and nominal transfer rate.

IV. Conclusion

In the present work a simple laboratory setup was planned that permitted systematic performance measurements of available access point equipments (RBTR2 from Enterasys) for Wi-Fi (IEEE 802.11a, g) in point-to-point links. Through OSI level 4, TCP throughput, jitter and percentage datagram loss were measured and compared for each standard. The best TCP throughput was found for 802.11a. The average jitter was lower for 802.11g. For the percentage datagram loss, a reasonably good agreement was found for both standards. At OSI level 7, the best FTP performance was for 802.11a. Additional performance measurements either started or are planned using several equipments, not only in laboratory but also in outdoor environments involving, mainly, medium range links.

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