TCP, UDP and FTP Equipment Performances in Laboratory Wi-Fi IEEE 802.11a WEP Point-to-Point Links

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Abstract **–Increasing attention has been focused on Wi-Fi IEEE 802.11a, as it works in the 5 GHz band and the growing use of 2.4 GHz band is producing higher interferences. Performance is a crucial issue, resulting in more reliable and efficient communications. Security is equally important. Laboratory measurements are made about several performance aspects of Wi-Fi IEEE 802.11a point-to-point links, under WEP encryption. A contribution is given to performance evaluation of this technology, using two types of access points from Enterasys Networks (RBTR2 and RBT-4102). Detailed results are presented and discussed, namely at OSI levels 4 and 7, from TCP, UDP and FTP experiments, resulting in determinations of TCP throughput, jitter, percentage datagram loss and FTP transfer rate. Conclusions are drawn about the comparative performance of the links.**

Keywords – **WLAN, Wi-Fi, WEP Point-to-Point Links, IEEE 802.11a, Wireless Network Laboratory Performance.**

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 penetrated the personal home, forming a WPAN, allowing personal electronic 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. Telematic applications have specific performance requirements, depending on application. New telematic applications present special sensitivities to performances, when compared to traditional applications. Application characterization and requirements have been discussed [7]. Requirements have been quoted such 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.

Wi-Fi security is most important as microwave radio signals can be easily captured by everyone. WEP was initially intended to provide confidentiality comparable to that of a traditional wired network. In spite of its weaknesses, WEP is still widely used in Wi-Fi communications for security reasons. A shared key for data encryption is involved. In WEP, the communicating devices use the same key to encrypt and decrypt radio signals.

Several performance measurements have been made for 2.4 and 5 GHz Wi-Fi [8-10], as well as high speed FSO [11]. In the present work further Wi-Fi (IEEE 802.11 a) results arise, using WEP, through OSI levels 4 and 7. Performance is evaluated in laboratory measurements of WEP point-to-point links using different types of access point 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.

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II. EXPERIMENTAL DETAILS

Two types of experiments were carried out, which are referred as Expa and Expb. The measurements of Expa used (Fig. 1-(A), (C)) Enterasys RoamAbout RBTR2 level 2/3/4 access points (mentioned as APa), equipped with 15 dBm IEEE 802.11 a/b/g cards [12], and 100-Base-TX/10-Base-T Allied Telesis AT-8000S/16 level 2 switches [13]. The access points had RBTBH-R2W radio cards similar to the Agere-Systems model 0118 type, and firmware version 6.08.03. The configuration 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. Expb used (Fig. 1-(B), (C)) Enterasys RoamAbout RBT-4102 level 2/3/4 access points (mentioned as APb), equipped with 16-20 dBm IEEE 802.11 a/b/g transceivers based on the Atheros 5213A chipset, internal dual-band diversity antennas [12], and the same type of level 2 switch [13]. The configuration was for minimum transmitted power and equivalent to point-to-point, LAN to LAN mode, using the internal antenna. In each type of experiment, interference free communication channels were used. WEP encryption was activated, using 128 bit encryption and a shared key for data encryption composed of 13 ASCII characters. No power levels above the minimum were required, as the access points were very close.

A laboratory setup was planned and implemented for the measurements (Fig. 2). TCP and UDP experiments at OSI level 4, were as mentioned in [11], permitting network performance results to be recorded. 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 [14]. 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. 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. Each PC had a second network adapter, to permit remote control from the 193.136.64.0 network, via switch.

III. RESULTS AND DISCUSSION

In each type of experiment, Expa and Expb, the corresponding access points APa and APb were configured for the IEEE 802.11a standard, with typical fixed transfer rates. For every fixed transfer rate, measurements were made for every experiment type. In this way, for each AP type, data were obtained for comparison of the laboratory performance of IEEE 802.11a (at 6, 9, 12, 24, 36, 48 and 54 Mbps) links, measured namely at OSI levels 4 and 7 using the setup of Fig. 2.

At OSI level 1, the signal to noise ratios SNR of the point-to-point links were monitored.

For Expa and Expb, and for every nominal fixed transfer rate, an average TCP throughput was determined from several experiments. 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. 3-8. In Figs. 3-4, polynomial fits were made to the TCP throughput data, where R^2 is the coefficient of determination. It is seen that both APa and APb have similar TCP throughput performances, within the statistical error. The same trends were observed for open links. In Figs. 5-8, the data points representing jitter and percentage datagram loss were joined by smoothed lines. From Figs. 5-6 it follows that the lowest jitter values are for APa. The average jitter values are 1.8+-0.1 ms for APa and 1.9+- 0.1 ms for APb. This means that, on average, APa has a slightly better jitter performance than APb. This is the reverse situation when compared to open links. Figs. 7-8, where there are significant statistical errors, show that on average the percentage datagram loss is slightly lower for APb (1.2+-0.1%) than for APa (1.3+-0.1%).

At OSI level 7 FTP transfer rates were measured versus nominal transfer rates configured in the access points for the IEEE 802.11a standard. 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 Figs. 9-10. Polynomial fits were made to data of each experiment. It was found that APa and APb have similar FTP performances, within the statistical error. These results show the same trends found for TCP throughput and for open links.

Generally, the WEP throughput and FTP transfer rate results are consistent and agree, within the experimental errors, with open link results. Jitter and percentage datagram loss WEP results are, as for open links, sensitive to AP type; but APs behave in a reverse way, as described above. This is, probably, due to the WEP implementation of 802.11a for each AP type.

Fig. 1- Access Points (A), (B) [12] and switch (C) [13].

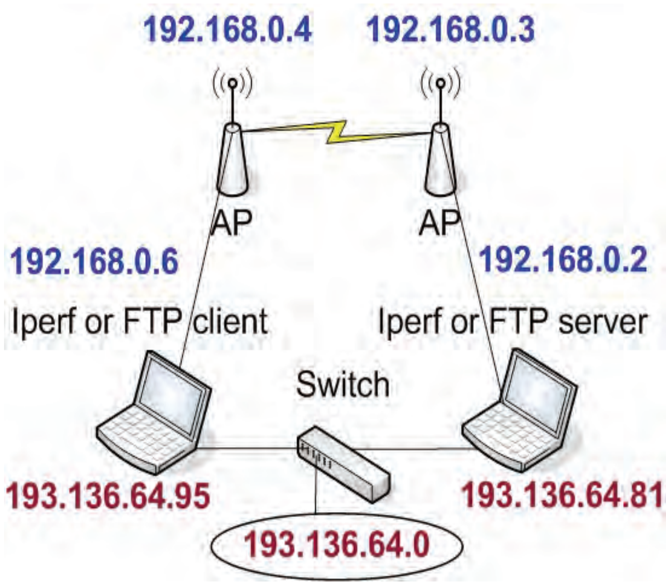

Fig. 2- Laboratory setup scheme.

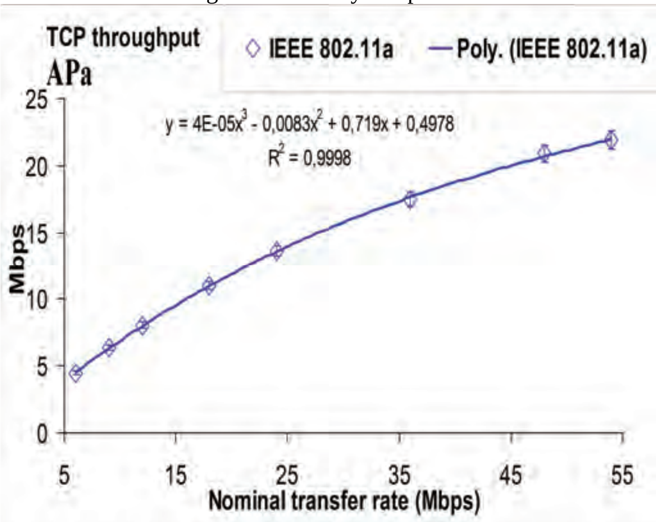

Fig. 3- TCP throughput versus technology and nominal transfer rate; Expa.

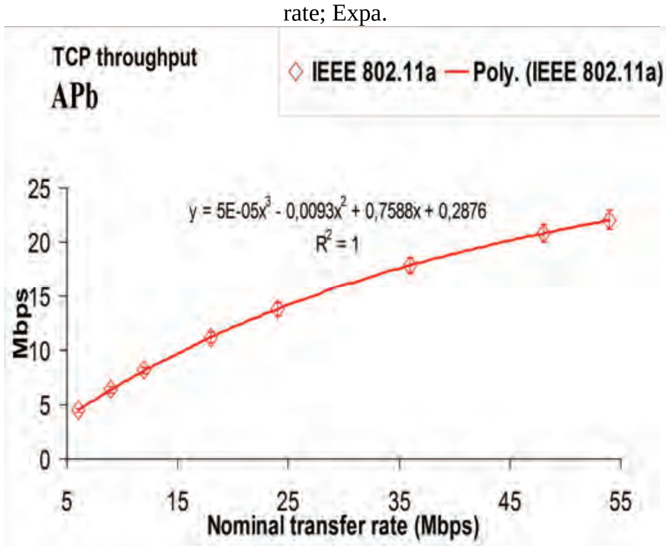

Fig. 4- TCP throughput versus technology and nominal transfer rate; Expb.

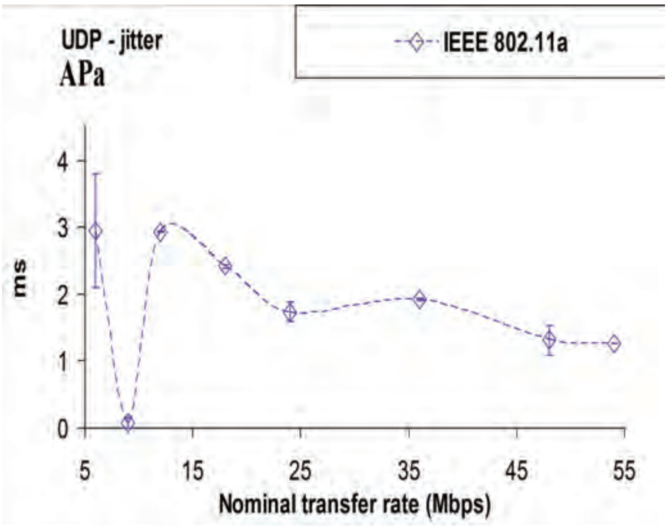

Fig. 5- UDP – jitter results versus technology and nominal transfer rate; Expa.

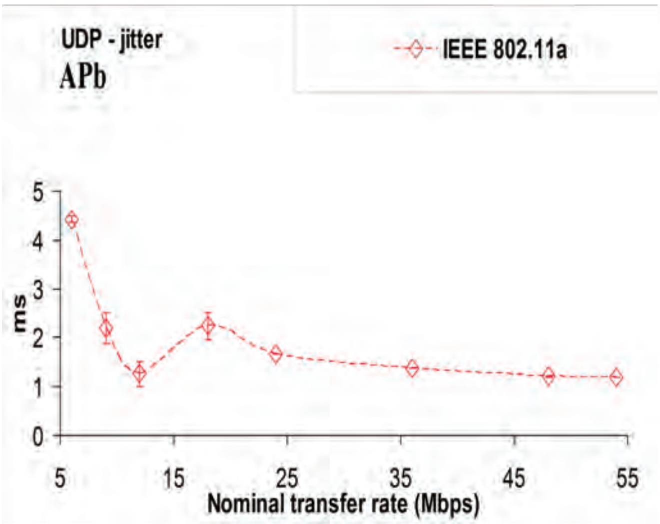

Fig. 6- UDP – jitter results versus technology and nominal transfer rate; Expb.

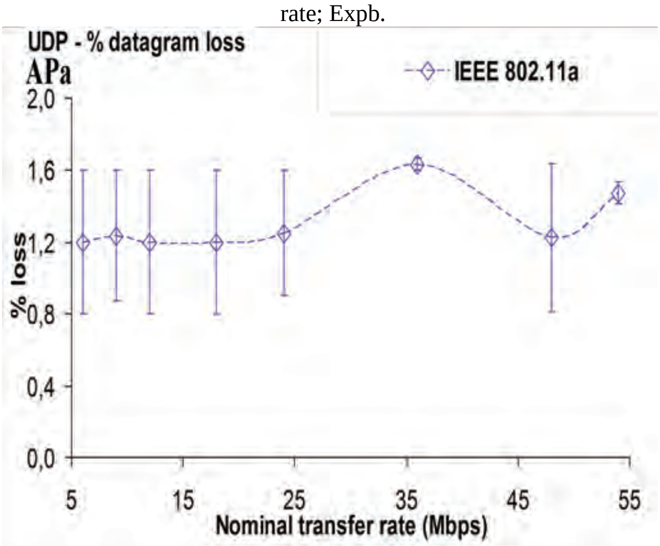

Fig. 7- UDP – percentage datagram loss results versus technology and nominal transfer rate; Expa.

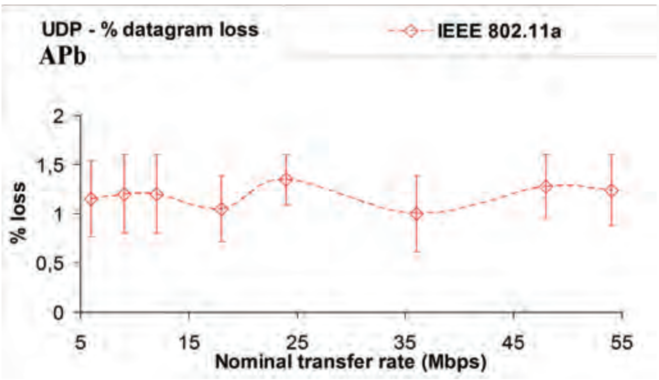

Fig. 8- UDP – percentage datagram loss results versus technology and nominal transfer rate; Expb.

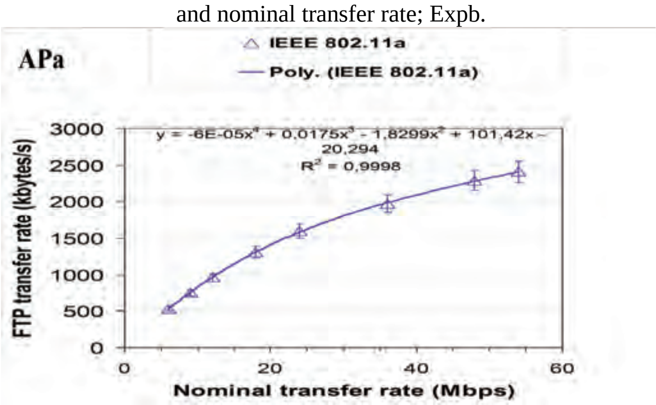

Fig. 9- FTP transfer rates versus technology and nominal transfer rate; Expa.

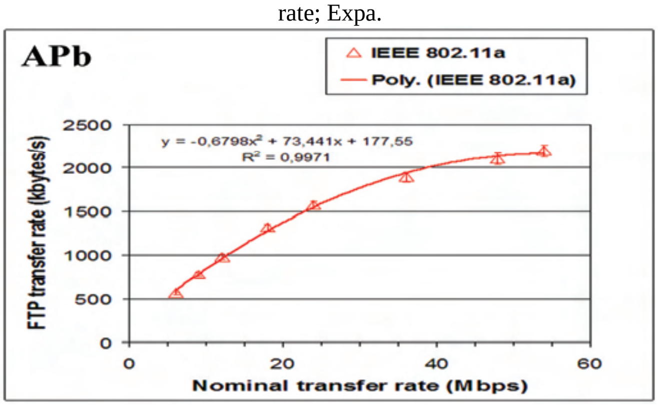

Fig. 10- FTP transfer rates versus technology and nominal transfer rate; Expb.

IV. Conclusion

In the present work a laboratory setup was planned and implemented that permitted systematic performance measurements of available access points equipments (RBTR2 and RBT-4102) from Enterasys in WEP Wi-Fi IEEE 802.11a point-to-point links. Through OSI level 4, TCP throughput, jitter and percentage datagram loss were measured and compared. It was found that both APs have similar TCP throughput performances. Concerning jitter and percentage datagram loss, results were found, as for open links, sensitive to AP type; but APs behave in a reverse way. At OSI level 7 it was found that both APs have similar FTP performances. This result shows the same trends found for TCP throughput and for open links.

Additional measurements either have been planned or are under way using several equipments, not only in laboratory but also in outdoor medium range links.

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