Laboratory Performance of Wi-Fi WEP Point-to-Point Links: a Case Study

J. A. R. Pacheco de Carvalho, H. Veiga, N. Marques, C. F. Ribeiro Pacheco, A. D. Reis

***Abstract*—Wireless communications using microwaves are increasingly important, e.g. Wi-Fi. Performance is a very relevant issue, resulting in more reliable and efficient communications. Laboratory measurements are made about several performance aspects of Wi-Fi (IEEE 802.11a, g) WEP point-to-point links using available access points from Enterasys Networks (RBT-4102). Through OSI levels 4 and 7, detailed results are presented and discussed from TCP, UDP and FTP experiments, namely: TCP throughput, jitter, percentage datagram loss and FTP transfer rate.**

***Index Terms*—Wi-Fi, WLAN, WEP Point-to-Point Links, IEEE 802.11a, IEEE 802.11g, Wireless Network Laboratory Performance.**

I. Introduction

Wireless communications are increasingly important for their versatility, mobility, speed and favourable prices. It is the case of microwave and laser based technologies, e.g. Wi-Fi and FSO, respectively. 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 equipments with a wired based LAN through a switch/router. Therefore a WLAN, based on the AP, is formed. Wi-Fi has an increased presence in 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 specialized 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]. Due to increasing used of 2.4 GHz band, interferences increase. Then, 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 specified. 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, where 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, giving more reliable and efficient communications. New telematic applications are specially sensitive to performances, when compared to traditional applications. Application characterization and requirements have been discussed e.g. for 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 for video on demand/moving images (1-10 ms jitter and 1-10 Mbps throughputs) and for Hi Fi stereo audio (jitter less than 1 ms and 0.1-1 Mbps throughputs).

Wi-Fi 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 open 2.4 GHz Wi-Fi [8-10], as well as WiMAX and high speed FSO [11,12]. In the present work further Wi-Fi (IEEE 802.11 a,g) results arise, using WEP, 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 been growing up very considerably. Performance is evaluated in laboratory measurements of WEP 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

In the measurements we used (Fig. 1) Enterasys RoamAbout RBT-4102 level 2/3/4 access points, equipped with 16-20 dBm IEEE 802.11 a/b/g transceivers and internal dual-band diversity antennas [13], and

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100-Base-TX/10-Base-T Allied Telesis AT-8000S/16 level 2 switches [14]. The access points had transceivers based on the Atheros 5213A chipset, and firmware version 1.1.51. They were parameterized and monitored through both the console using CLI (Command Line Interface) and a HTTPS (Secure HTTP) incorporated server. The configuration was for minimum transmitted power and equivalent to point-to-point, LAN to LAN mode, using the internal antenna as the access points were very close. Interference free channels were used in the communications. 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 arrangement was planned and implemented, as shown in Fig. 2. TCP and UDP experiments at OSI level 4, were as mentioned in [12], 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 [15]. 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. Each PC had a second network adapter, to permit remote control from the oficial IP Remote Detection Unit network, via switch.

III. Results and Discussion

The RBT-4102 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 1, 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. At OSI level 1, SNR was monitored.

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 13.10 and 9.62 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 higher (2.6 ms) for 802.11g than for 802.11a (1.9 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. These results show the same trends found for TCP throughput. FTP transfer rates were also measured without WEP activation.

Generally, the results measured for WEP links at OSI levels 4 and 7 agree reasonably well, within the experimental errors, with corresponding data obtained for open links.

Fig. 1- Switch (A) [14] and access point (B) [13]

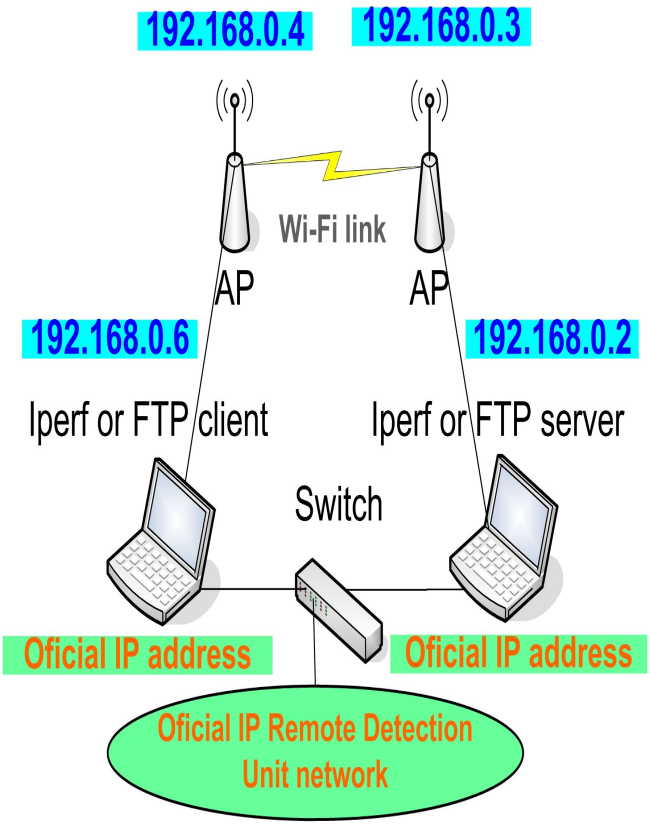

Fig. 2- Laboratory setup scheme.

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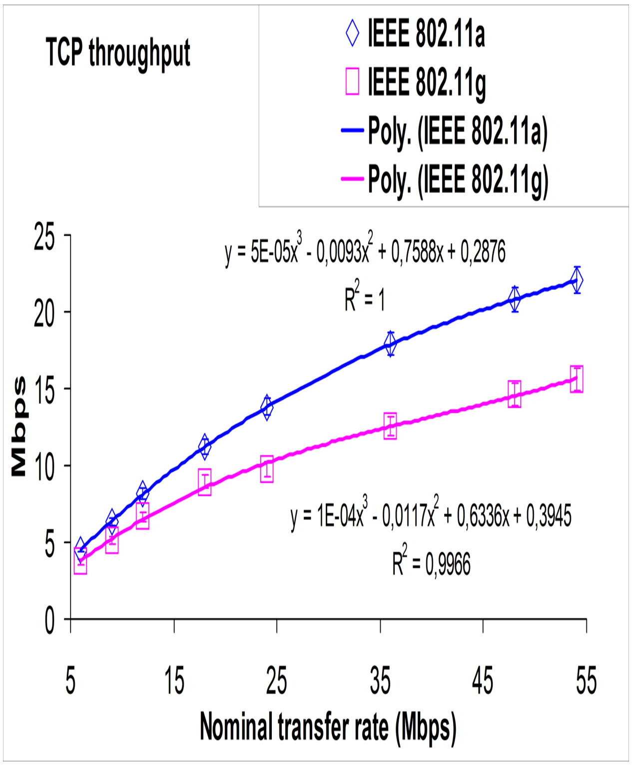

Fig. 3- TCP throughput versus technology and nominal transfer rate.

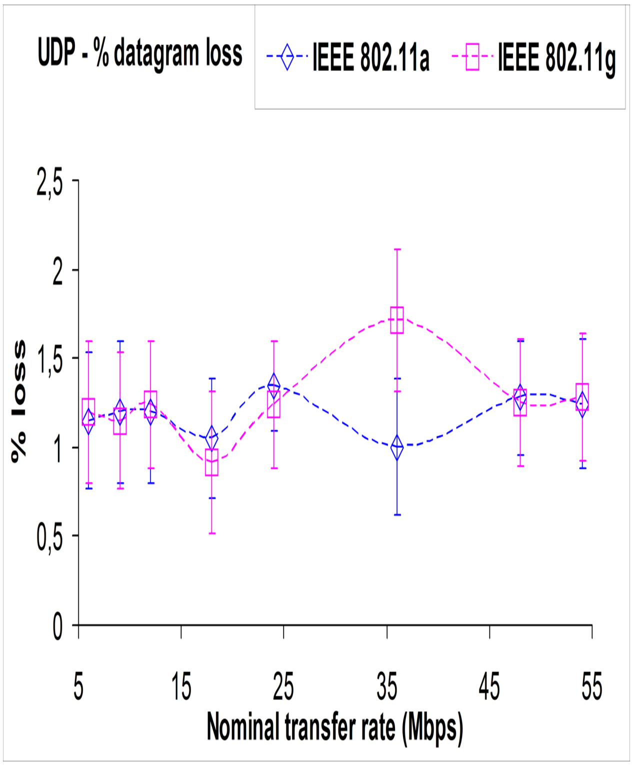

Fig. 5- UDP – percentage datagram loss results versus technology and nominal transfer rate.

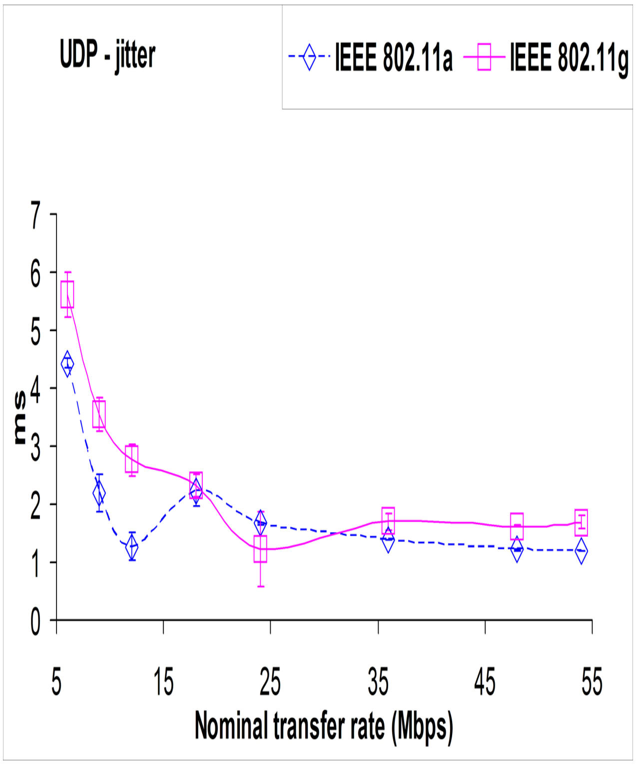

Fig. 4- UDP – jitter results versus technology and nominal transfer rate.

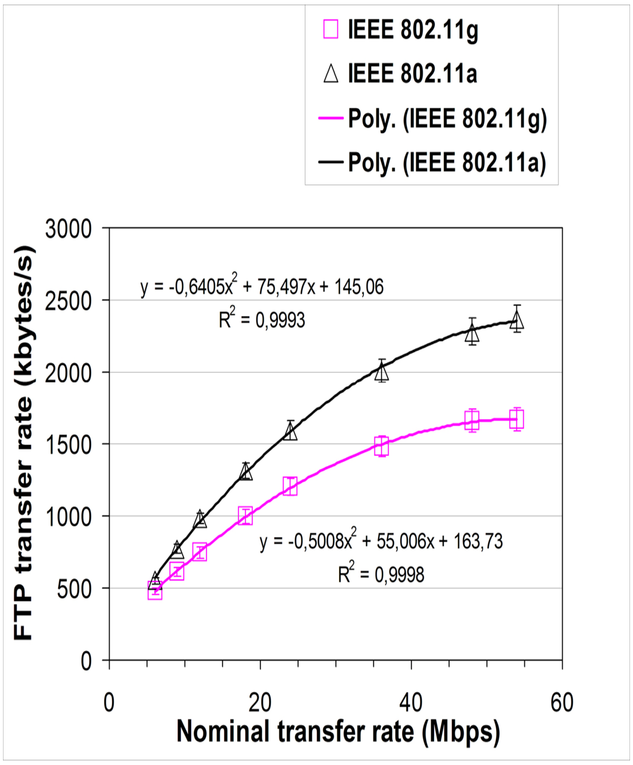

Fig. 6- FTP transfer rates versus technology and nominal transfer rate.

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IV. CONCLUSION

In the present work a laboratory setup arrangement was planned and implemented, that permitted systematic performance measurements of available access point equipments (RBT-4102 from Enterasys) for Wi-Fi (IEEE 802.11a, g) in WEP 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 jitter data are on average higher for 802.11g than for 802.11a. Generally, the percentage datagram loss data agree reasonably well for both standards.

At OSI level 7, the best FTP performance was for 802.11a. This result shows the same trends found for TCP throughput.

Generally, the results measured for WEP links agree reasonably well, within the experimental errors, with corresponding data obtained for open links.

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.

REFERENCES

[1] Web site http://standards.ieee.org; IEEE 802.11a, 802.11b, 802.11g, and 802.16d standards.

[2] J. W. Mark, W. Zhuang, *Wireless Communications and Networking*, Prentice-Hall, Inc., Upper Saddle River, NJ, 2003.

[3] T. S. Rappaport, *Wireless Communications Principles and Practice*, 2nd ed., Prentice-Hall, Inc., Upper Saddle River, NJ, 2002.

[4] W. R. Bruce III, R. Gilster, *Wireless LANs End to End*, Hungry Minds, Inc., NY, 2002.

[5] M. Schwartz, *Mobile Wireless Communications*, Cambridge University Press, 2005.

[6] N. Sarkar, K. Sowerby, "High Performance Measurements in the Crowded Office Environment: a Case Study", In *Proc. ICCT'06-International Conference on Communication Technology*, pp. 1-4, Guilin, China, 27-30 November 2006.

[7] E. Monteiro, F. Boavida, *Engineering of Informatics Networks*, 4th ed., FCA-Editor of Informatics Ld., Lisbon, 2000.

[8] J. A. R. Pacheco de Carvalho, P. A. J. Gomes, H. Veiga, A. D. Reis, "Development of a University Networking Project", in *Encyclopedia of Networked and Virtual Organizations*, Goran D. Putnik, Maria Manuela Cunha, Eds. Hershey, PA (Pennsylvania): IGI Global, pp. 409-422, 2008.

[9] J. A. R. Pacheco de Carvalho , H. Veiga, P. A. J. Gomes, Cláudia F. F. P. Ribeiro Pacheco, Nuno Marques, A. D. Reis, "Laboratory Performance of Wi-Fi Point-to-Point Links: a Case Study", In *Proc. WTS 2009-8th Wireless Telecommunications Symposium*, pp. 143-147, Prague, Czech Republic, April 22-24, 2009.

[10] J. A. R. Pacheco de Carvalho, P. A. Gomes, H. Veiga, C. F. Ribeiro Pacheco, N. Marques, A. D. Reis, "A Contribution to Laboratory Performance Evaluation of IEEE 802.11 a, b, g Point-to-Point Links: a Case Study", Proc. WCE 2009 - World Congress on Engineering 2009, pp. 884-888, 2009 Imperial College London, London, England, 1-3 July 2009.

[11] J. A. R. Pacheco de Carvalho, H. Veiga, R. Costa, P. A. J. Gomes, A. D. Reis, "A Contribution to Experimental Performance Evaluation of Point-to-Point WiMAX Links", In *Proc. ISSPIT 2008-8th IEEE International Symposium on Signal Processing and Information Technology*, pp. 150-153, Sarajevo, Bosnia and Herzegovina, December 16-19, 2008.

[12] J. A. R. Pacheco de Carvalho, H. Veiga, P. A. J. Gomes, C. F. F. P. Ribeiro Pacheco, A. D. Reis, "Experimental Performance Study of a Very High Speed Free Space Optics Link at the University of Beira Interior Campus: a Case Study", In *Proc. ISSPIT 2008-8th IEEE International Symposium on Signal Processing and Information Technology*, pp. 154-157, Sarajevo, Bosnia and Herzegovina, December 16-19, 2008.

[13] Web site http://www.enterasys.com; RoamAbout RBTR2 and RBT-4102 Access Points technical data.

[14] Web site http://www.alliedtelesis.com; AT-8000S/16 level 2 switch technical data.

[15] Network Working Group, "RFC 1889-RTP: A Transport Protocol for Real Time Applications", http://www.rfc-archive.org

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