Comparative Performance Studies of Laboratory Open IEEE 802.11b,g PTMP Links

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Abstract – **The increasing importance of wireless communications, involving electronic devices, has been widely recognized. Performance is a crucial issue, leading to more reliable and efficient communications. Laboratory measurements were performed about several performance aspects of Wi-Fi (IEEE 802.11 b, g) Open point-to-multipoint links. Our study contributes to the performance evaluation of this technology, using new available equipments (V-M200 access points from HP and WPC600N adapters from Linksys). New 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. Comparisons are made to corresponding results obtained for Open point-to-point links. Conclusions are drawn about the comparative performance of the links.**

Keywords – **Wi-Fi, WLAN, Open Point-to-Multipoint and Point-to-Point Links, IEEE 802.11bg, Wireless Network Laboratory Performance.**

I. INTRODUCTION

Contactless communication techniques have been developed using mainly electromagnetic waves in several frequency ranges, propagating in the air. Wi-Fi and FSO, whose importance and utilization have been recognized and growing, are representative examples of wireless communications technologies.

Wi-Fi is a microwave based technology providing for versatility, mobility and favorable prices. The importance and utilization of Wi-Fi has been increasing for complementing traditional wired networks. It has been used mainly in infrastructure mode. In this case an access point, AP, permits communications of Wi-Fi devices (such as a personal computer, a wireless sensor, a PDA, a smartphone, a video game console, a digital audio player) 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, where a WPAN allows personal devices to communicate. Point-to-point (PTP) and point-to-multipoint (PTMP) setups are used both indoors and outdoors, requiring specific directional and omnidirectional antennas. Point-to-point and point-to-multipoint links use microwaves in the 2.4 and 5 GHz frequency bands and IEEE 802.11a, b, g, n standards [1]. The 2.4 GHz band has been intensively used and is having increasing interferences. Therefore considerable attention has been focused on the 5 GHz band where, however, absorption increases and ranges are shorter.

Nominal transfer rates up to 11 (802.11b), 54 Mbps (802.11 a, g) and 600 Mbps (802.11n) are specified. The medium access control is CSMA/CA. There are studies on wireless communications, wave propagation [2,3], practical implementations of WLANs [4], performance analysis of the effective transfer rate for 802.11b point-to-point links [5], 802.11b performance in crowded indoor environments [6].

Performance has been a very important issue, resulting in more reliable and efficient communications. In comparison to traditional applications, new telematic applications are specially sensitive to performances. Requirements have been pointed out [7], e.g.: for video on demand/moving images, 1-10 ms jitter and 1-10 Mbps throughputs; for Hi Fi stereo audio, jitter less than 1 ms and 0.1-1 Mbps throughputs.

Wi-Fi security is very important as microwave radio signals travel through the air and can be easily captured. WEP was initially intended to provide confidentiality comparable to that of a traditional wired network. In spite of presenting weaknesses, WEP is still widely used in Wi-Fi networks for security reasons, mainly in point-to-point links. More advanced and reliable security methods have been developed to provide authentication such as, by increasing order of security, WPA and WPA2.

Several performance measurements have been made for 2.4 and 5 GHz Wi-Fi open [8,9], and WEP links [10,11], as well as very high speed FSO [12]. In the present work new Wi-Fi (IEEE 802.11 b, g) results arise, using Open links, namely through OSI levels 4 and 7. Performance is evaluated through laboratory measurements of Open PTMP links, using available equipments. Comparisons are made to corresponding results obtained for Open PTP links.

The rest of the paper is structured as follows: Section II presents the experimental details i.e. the measurement setup

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and procedure. Results and discussion are presented in Section III. Conclusions are drawn in Section IV.

II. Experimental details

The measurements used a HP V-M200 access point [13], with three external dual-band 3x3 MIMO antennas, IEEE 802.11 a/b/g/n, software version 5.4.1.0-01-9867 and a 100-Base-TX/10-Base-T Allied Telesis AT-8000S/16 level 2 switch [14]. Two PCs were used having a PCMCIA IEEE.802.11 a/b/g/n Linksys WPC600N wireless adapter with three internal antennas [15], to enable PTMP (three-node) links to the access point. In every type of experiment, interference free communication channels were used (ch 8 for 802.11 b, g). This was checked through a portable computer, equipped with a Wi-Fi 802.11 a/b/g/n adapter, running NetStumbler software [16]. No encryption was activated in the AP and the wireless adapters of the PCs. The experiments were made under far-field conditions. No power levels above 30 mW (15 dBm) were required, as the wireless equipments were close.

A laboratory setup has been planned and implemented for the measurements, as shown in Fig. 1. At OSI level 4, measurements were made for TCP connections and UDP communications using Iperf software [17]. 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 determined. Parameterizations of TCP packets, UDP datagrams and window size were as in [10]. 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, representing the smooth mean of differences between consecutive transit times, was continuously computed by the server, as specified by the real time protocol RTP, in RFC 1889 [18]. The scheme of Fig. 1 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. Another PC, with IP 192.168.0.20, was used to control the settings in the AP.

The server and client PCs were HP nx9030 and nx9010 portable computers, respectively, running Windows XP Professional. They were configured to optimize the resources allocated to the present work. Batch command files have been re-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 official IP University network, via switch.

III. Results and discussion

The PC wireless network adapter were manually configured, for IEEE 802.11 bg, with typical nominal transfer rates (1, 2, 5, 11 Mbps for 802.11b; 6, 9, 12, 18, 24, 36, 48, 54 Mbps for 802.11g). For every fixed transfer rate, data were obtained for comparison of the laboratory performance of the PTMP and PTP links at OSI layers 1 (physical layer), 4 (transport layer) and 7 (application layer) using the setup of Fig. 1. For each standard and 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.

At OSI level 1, noise levels (N, in dBm) and signal to noise ratios (SNR, in dB) were monitored and typical values are shown in Fig. 2. The main average TCP and UDP results are summarized in Table I, both for PTMP and PTP links. The statistical analysis, including calculations of confidence intervals, was carried out as in [19].

In Figs. 3-4 polynomial fits were made to the 802.11 b, g TCP throughput data for PTMP and PTP links, respectively, where R^2 is the coefficient of determination. It was found that, on average, the best TCP throughputs are for 802.11 g and PTP links (13.9+-0.4 Mbps). In Figs. 5-6, the data points representing 802.11 b, g jitter data for for PTMP and PTP links, respectively, were joined by smoothed lines. It was found that the best average jitter values are for 802.11 g and PTP links (3.1+-0.9 ms). In Fig. 7, percentage datagram loss data for 802.11 b, g are shown for PTMP links. It was found that average percentage datagram loss is not significantly sensitive to link type.

At OSI level 7 we measured FTP transfer rates versus nominal transfer rates configured in the access point and the PC wireless network adapter for IEEE 802.11 g as in [10]. The results show the same trends found for TCP throughput.

Generally it was found that, specially for TCP throughput, the data show performance degradations for PTMP links, where the AP experiences higher processing requirements so as to maintain links between PCs.

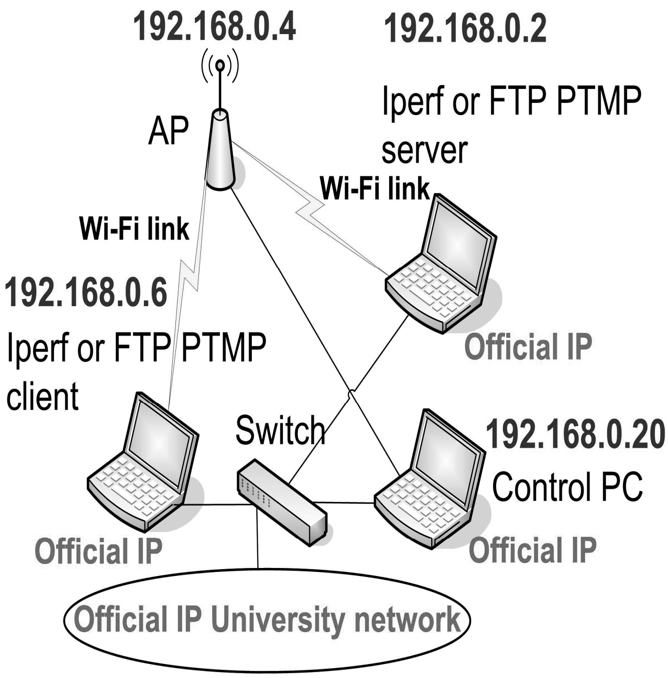

Fig. 1- Wi-Fi PTMP laboratory setup scheme.

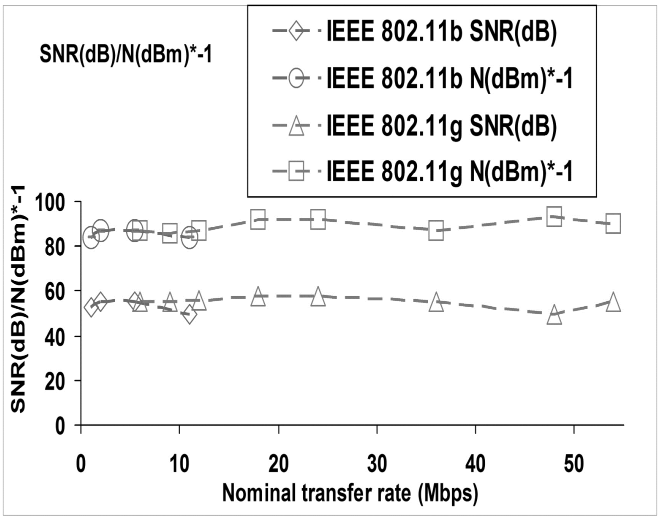

Fig. 2- Typical SNR (dB) and N (dBm); PTMP

TABLE I
AVERAGE WI-FI (IEEE 802.11B,G) RESULTS;
OPEN PTMP AND PTP LINKS.

Link type	PTMP		PTP	
Parameter/ IEEE standard	**802.11b**	**802.11g**	**802.11b**	**802.11g**
TCP throughput (Mbps)	1.5 +-0.0	6.5 +-0.2	3.3 +-0.1	13.9 +-0.4
UDP-jitter (ms)	4.2 +-0.7	3.8 +-0.7	5.6 +-0.2	3.1 +-0.9
UDP-% datagram loss	1.3 +-1.0	1.3 +-0.1	1.2 +-0.2	1.5 +-0.1

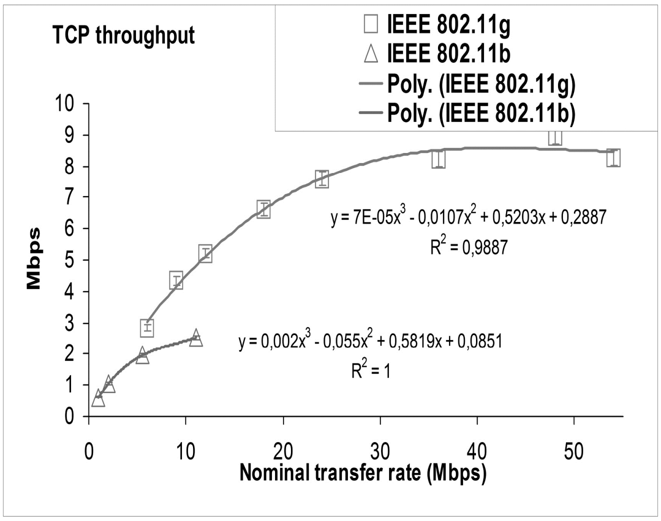

Fig. 3- TCP throughput versus technology and nominal transfer rate; PTMP.

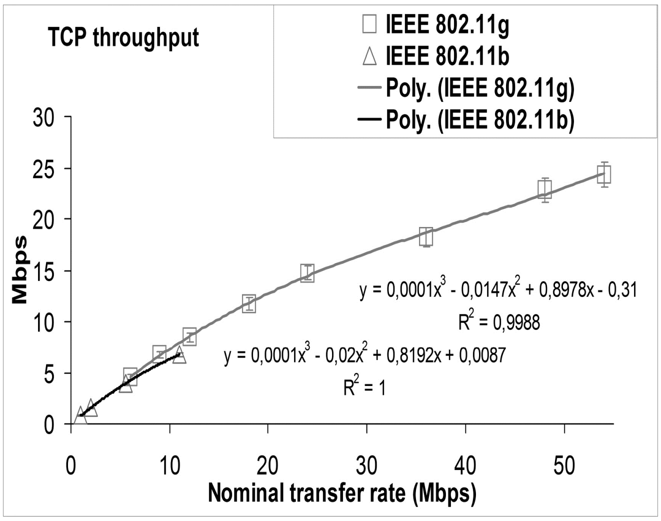

Fig. 4- TCP throughput versus technology and nominal transfer rate; PTP.

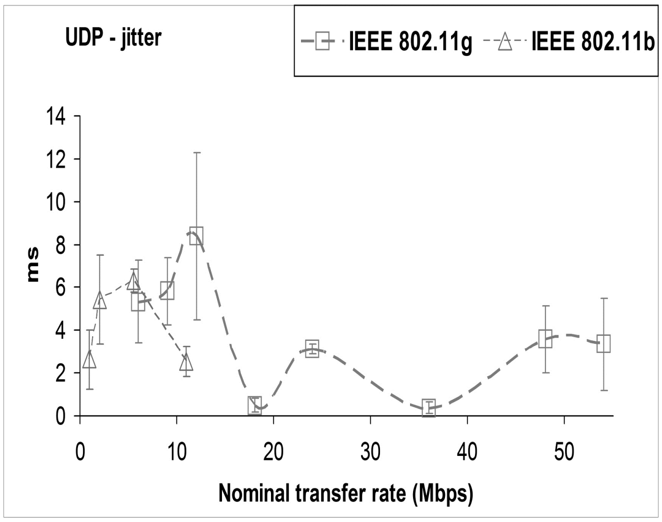

Fig. 5- UDP - jitter results versus technology and nominal transfer rate; PTMP.

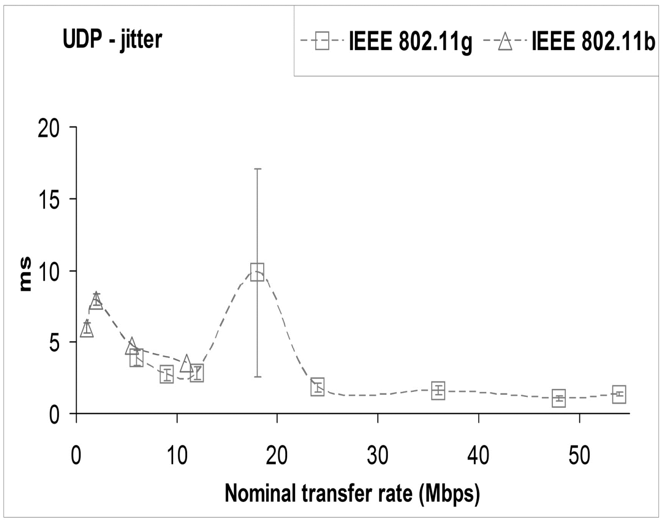

Fig. 6- UDP - jitter results versus technology and nominal transfer rate; PTP.

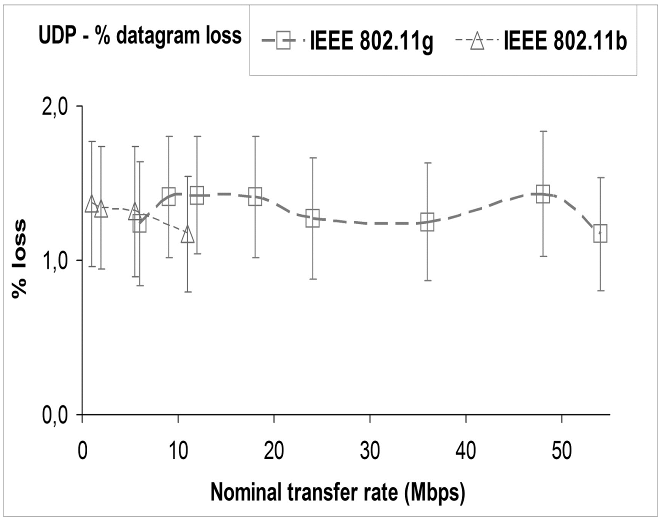

Fig. 7- UDP – percentage datagram loss versus technology and nominal transfer rate; PTMP.

IV. Conclusion

A versatile laboratory setup arrangement has been planned and implemented, that permitted systematic performance measurements of available wireless equipments (V-M200 access points from HP and WPC600N adapters from Linksys) for Wi-Fi (IEEE 802.11 b, g) in Open PTMP links.

Through OSI layer 4, TCP throughput, jitter and percentage datagram loss were measured and compared for each standard to corresponding results obtained for Open PTP links. It was found that, on average, the best TCP throughputs are for 802.11 g and PTP links. It was also found that the best average jitter values are for 802.11 g and PTP links. .Concerning average percentage datagram loss data, it was found as not significantly sensitive to link type.

Generally it was found that, specially for TCP throughput, the data show performance degradations for PTMP links, where the AP experiences higher processing requirements so as to maintain links between PCs.

At OSI layer 7, FTP performance results have shown the same trends found for TCP throughput.

Further performance studies are planned using several equipments, topologies, security settings and noise conditions, not only in laboratory but also in outdoor environments involving, mainly, medium range links.

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