

# A CONTRIBUTION TO LABORATORY PERFORMANCE COMPARISONS OF IEEE 802.11 B,G 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 b, g) point-to-point links. A contribution is given to evaluation of this technology through performance comparisons, using available access points from Enterasys Networks and Linksys. Detailed results are presented and discussed, namely at OSI levels 4 and 7, from experiments involving TCP, UDP and FTP: TCP throughput, jitter, percentage datagram loss and FTP transfer rate.

## 1 INTRODUCTION

Wireless communications are increasingly important for their versatility, mobility and favourable 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,b,c, included in IEEE Std 802.11-2007. Nominal transfer rates up to 11 (802.11b) and 54 Mbps (802.11 a, g) are permitted. CSMA/CA is the medium access control. The 802.11 architecture has been studied in detail, including performance analysis of the effective transfer rate (Schwartz, 2005). An

optimum factor of 0.42 was determined for the effective transfer rate in 11 Mbps point-to-point links, giving an effective transfer rate of 4.6 Mbps. Wi-Fi performance is available in indoor environments (Sarkar & Sowerby, 2006).

Performance has been a very important issue, resulting in more reliable and efficient communications. New telematic applications are specially sensitive to performance, depending on application requirements. Application characterization has been discussed (Monteiro & Boavida, 2000). Several measurements have been made for 2.4 GHz Wi-Fi (Pacheco de Carvalho et al., 2008a), as well as WiMAX and high speed FSO (Pacheco de Carvalho et al., 2008b), (Pacheco de Carvalho et al., 2008c). In the present work further Wi-Fi results arise, through OSI levels 4 and 7. Wi-Fi (IEEE 802.11 b,g) is evaluated and performance is compared in laboratory measurements of point-to-point links, using available access points.

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 EXPERIMENTAL DETAILS

Two types of experiments were carried out, mentioned as Expa and Expc. Expa used Enterasys RBTR2 level 2/3/4 access points (APa), with firmware version 6.08.03 (Enterasys Networks, 2005), and 100-Base-TX/10-Base-T Allied Telesis AT-8000S/16 level 2 switches (Allied Telesis, 2008). The radio cards were similar to the Agere-Systems model 0118 type. The configuration was for minimum transmitted power, micro cell, point-to-point, LAN to LAN mode, using the radio card antenna. Expc used Linksys WRT54GL wireless routers (Linksys, 2005), with a Broadcom BCM5352 chip rev0, firmware DD-WRT v24-sp1-10011 (DD-WRT, 2009) and the same type of level 2 switch. The wireless mode was set to bridged access point. In both Expa and Expc, interference free communication channels were used. WEP encryption was not activated. No power levels above the minimum were required as the access points were very close (30 cm).

Both types of experiments, Expa and Expc, were made in point-to-point mode using the laboratory setup shown in Figure 1. Measurements were made using TCP and UDP communications at OSI level 4, as mentioned in (Pacheco de Carvalho, 2008c), permitting network performance results to be recorded. For a TCP connection, TCP throughput was obtained. For a UDP test 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 can be seen as the smooth mean of differences between consecutive transit times, was continuously computed by the server, as specified by RTP in RFC 1889. 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.

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.

## 3 RESULTS AND DISCUSSION

Both APa and APc access points were configured,

for each standard IEEE 802.11 b, g, with several fixed transfer rates. For every fixed transfer rate, measurements were made, for both Expa and Expc. In this way, for each experiment type, data were obtained for comparison of the laboratory performances of IEEE 802.11 b and 802.11g links, measured namely at OSI levels 4 and 7 using the scheme of Figure 1.

At OSI level 1 in both Expa and Expc we have monitored, for every one of the cases, the signal to noise ratios SNR of the point-to-point links.

For both Expa and Expc, and for every standard and 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 results are shown in Figures 2-7. In Figures 2-3, polynomial fits were made namely for each AP implementation of IEEE 802.11 g. It is seen that the best TCP throughput performances are, by descending order, for 802.11g and 802.11b. In Expc (Figure 3), the data for 802.11 b,g are higher than the corresponding data in Expa (Figure 2). In particular for 802.11g and TCP throughput APc shows, on average, a 10 % better performance than APa. In Figures 4-7, the data points were joined by smoothed lines. In Expa (Figure 4) jitter is, on average, higher for IEEE 802.11b (2.6 ms). In Expc (Figure 5) jitter is also, on average, higher for IEEE 802.11b (2.1 ms). In both Expa (Figure 6) and Expc (Figure 7), generally, the percentage datagram loss data agree reasonably well for both standards. They are 1.3 % and 1.4 %, on average, respectively.

At OSI level 7, FTP transfer rates were measured versus nominal transfer rates configured in the APs for the IEEE 802.11 b,g standards. Every measurement was the average for a single FTP transfer, using a binary file size of 100 Mbytes. The results thus obtained in Expa and Expc are represented in Figures 8-9, respectively. Polynomial fits to data were made. It was found that in both cases the best performances were, by descending order, for 802.11g and 802.11b. The FTP transfer rates obtained in Expc, using both standards, were higher than in Expa. This means that APc presents a better FTP performance than APa. FTP results have shown the same trends found for TCP throughput.

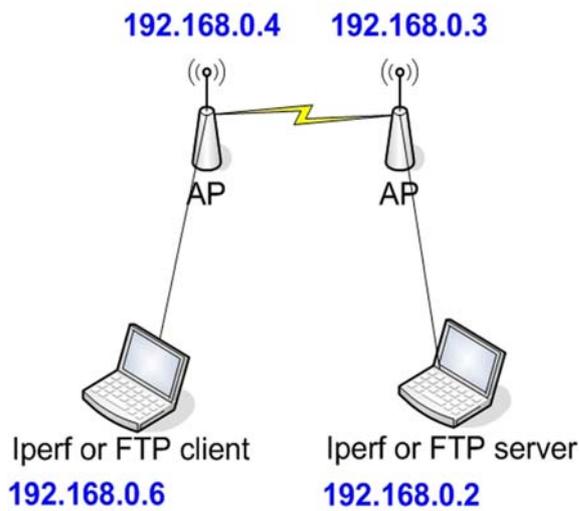


Figure 1: Laboratory setup scheme.

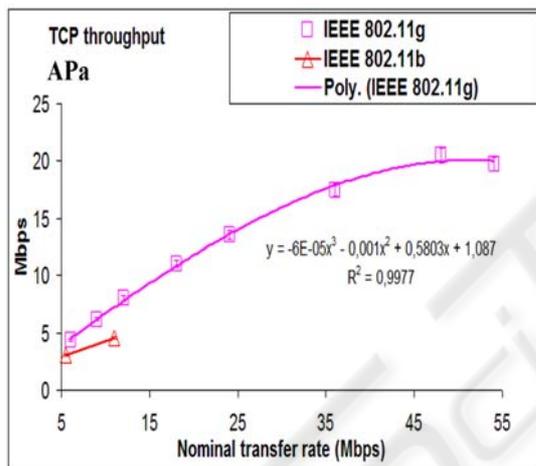


Figure 2: TCP throughput versus technology and nominal transfer rate; Expa.

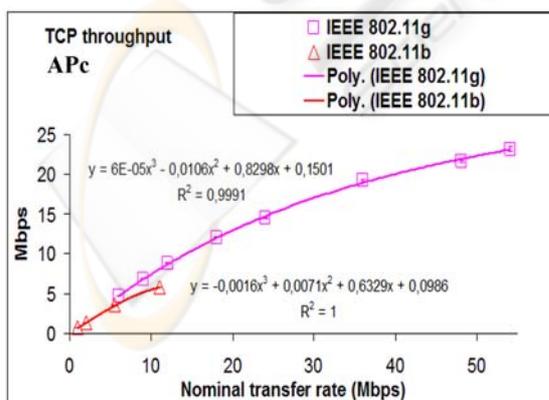


Figure 3: TCP throughput versus technology and nominal transfer rate; Expc.

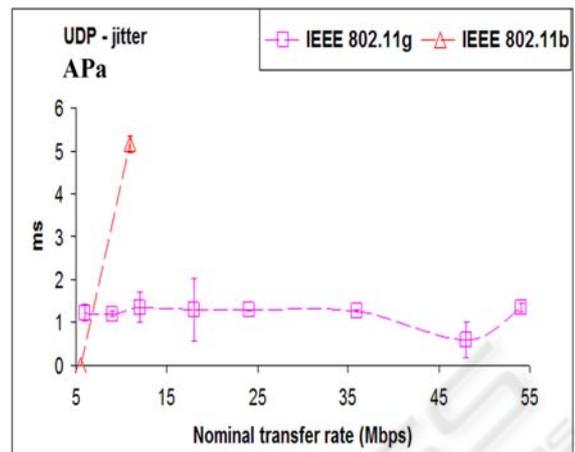


Figure 4: UDP – jitter results versus technology and nominal transfer rate; Expa.

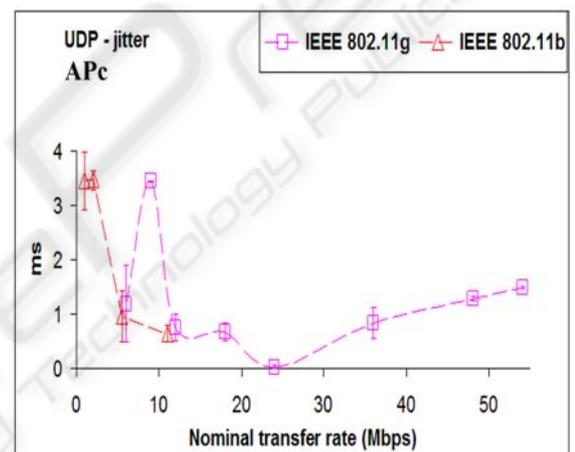


Figure 5: UDP – jitter results versus technology and nominal transfer rate; Expc.

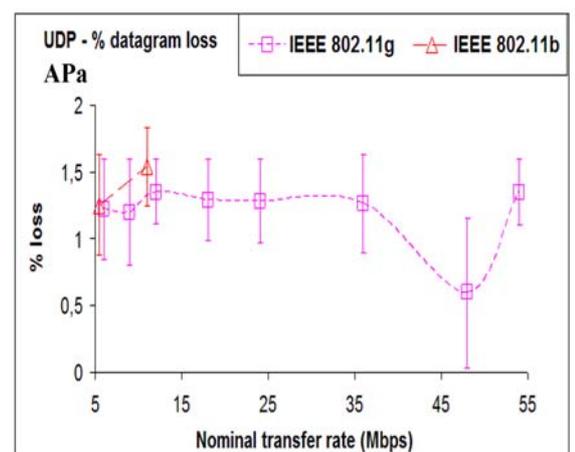


Figure 6: UDP - percentage datagram loss results versus technology and nominal transfer rate; Expa.

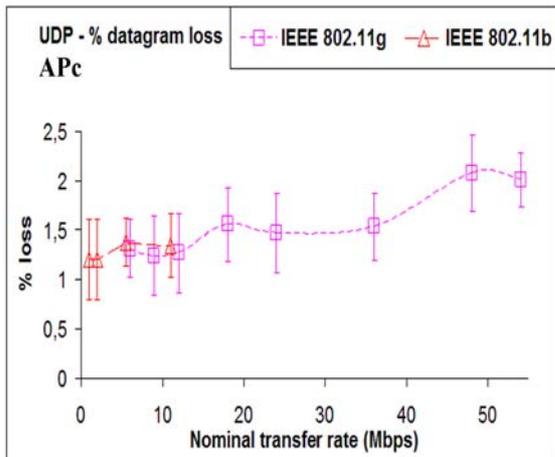


Figure 7: UDP - percentage datagram loss results versus technology and nominal transfer rate; Expc.

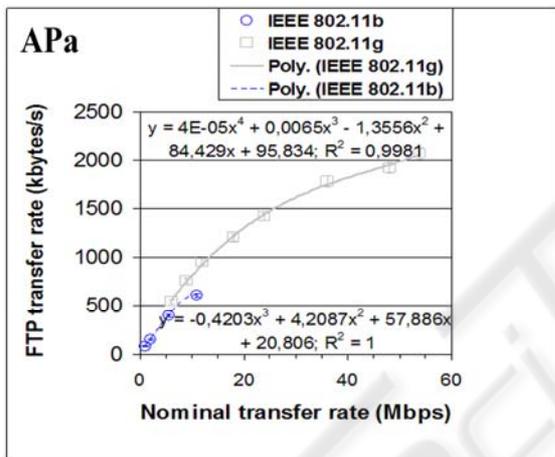


Figure 8: FTP transfer rate versus technology and nominal transfer rate; Expa.

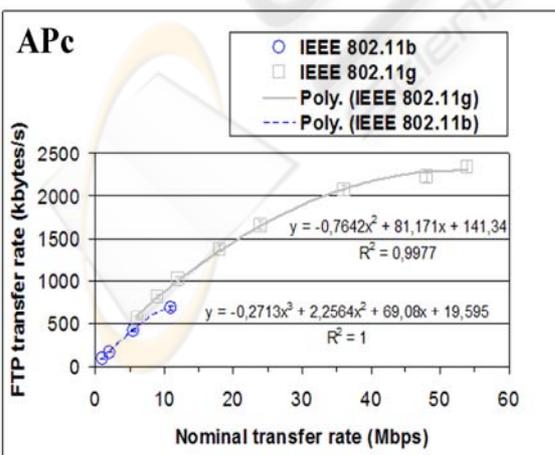


Figure 9: FTP transfer rate versus technology and nominal transfer rate; Expc.

## 4 CONCLUSIONS

In the present work a simple laboratory arrangement was implemented that permitted systematic performance measurements of available equipments in IEEE 802.11 b, g point-to-point links. Through OSI level 4 the best TCP throughputs were found, by descending order, for 802.11g and 802.11b. TCP throughputs were also found sensitive to AP type. The lower values of jitter were, on average, found for IEEE 802.11g. For the percentage datagram loss, a reasonably good agreement was found for both standards. At OSI level 7, the measurements of FTP transfer rates have shown that the best performances were, by descending order, for 802.11g and 802.11b. FTP performances were also found sensitive to AP type. FTP results have shown the same trends found for TCP throughput. Additional 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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