# Performance Measurements of Laboratory IEEE 802.11 b, g WEP Point-to-Point Links

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***Abstract.*** *The importance of wireless communications has been growing. Performance is a most relevant issue, resulting in more reliable and efficient communications. Security is crucially important. Laboratory measurements are made about several performance aspects of Wi-Fi (IEEE 802.11 b, g) WEP point-to-point links. A contribution is given to performance evaluation of this technology under WEP encryption, using WRT54GL wireless routers from Linksys. 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 data.*

*Keywords: WLAN, Wi-Fi, WEP Point-to-Point Links, Wireless Network Laboratory Performance*

## 1. Introduction

Electromagnetic waves in several frequency ranges, propagating in the air, have been decisively important for the development of wireless communications e.g. Wi-Fi and FSO, microwave and laser based technologies, 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, permits communications of Wi-Fi devices with a wired based LAN, through a switch/router. Thus a WLAN, based on the AP, is formed. Wi-Fi has reached the personal home, forming a WPAN, where personal devices communicate. Point-to-point and point-to-multipoint setups are used both indoors and outdoors, with specific directional and omnidirectional antennas. Wi-Fi uses microwaves in the 2.4 and 5 GHz frequency bands and IEEE 802.11a, 802.11b, 802.11g and 802.11n standards [1]. Nominal transfer rates up to 11 (802.11b), 54 (802.11 a, g) and 600 Mbps (802.11n) 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, 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 fundamentally important issue, giving more reliable and efficient communications. In comparison to traditional applications, new telematic applications are specially sensitive to performances. Requirements have been pointed out, such as: 1-10 ms jitter and 1-10 Mbps throughput for video on demand/moving images; jitter less than 1 ms and 0.1-1 Mbps throughputs for Hi Fi stereo audio [7].

Wi-Fi security is very important, as microwave radio signals travel can be easily captured. WEP is a security method for providing authentication. In spite of presenting weaknesses, it is still widely used in Wi-Fi networks for security reasons. In WEP, the communicating devices use the same shared key to encrypt and decrypt radio signals.

Several measurements have been made for 2.4 and 5 GHz Wi-Fi open links [8,9], as well as very high speed FSO [10]. In the present work new Wi-Fi (IEEE 802.11 b,g) results arise, using WEP, through OSI levels 4 and 7. 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 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. Subject and Method

The measurements used Linksys WRT54GL wireless routers [11] and other equipments [8]. The wireless mode was bridged access point, point-to-point. Interference free communication channels were used for the links. 128 bits WEP encryption was activated. Data were collected under far-field conditions. No power levels above 30 mW (15 dBm) were required as the access points were close.

The laboratory setup is shown in Fig. 1. TCP and UDP experiments at OSI level 4, were as mentioned in [10], permitting network performance results to be recorded. For a TCP connection, TCP throughput was obtained. For a UDP connection with a given bandwidth parameter, UDP throughput, jitter and percentage loss of datagrams were obtained. 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 was continuously computed by the server, as specified by RTP in RFC 1889 [12]. This scheme was also used for FTP measurements, using FTP server and client applications [8]. Batch command files were written to enable the TCP, UDP and FTP tests. The results were obtained through remote control via switch and written as data files to the client PC disk.

## 3. Results and Discussion

The APs were configured, for each standard IEEE 802.11 b, 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. 1. At OSI level 1, SNR values and noise levels N were recorded, as shown in 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, which were reasonably steady versus time, are shown in Figs. 2-3. In Fig. 2, polynomial fits were made to the TCP throughput data. The best TCP throughput performance was found for 802.11g (average values of 14.3 +- 0.4 and 2.9 +- 0.1 Mbps for 802.11g and 802.11b, respectively). A fairly good agreement was found with the data obtained for open links [8]. In Figs. 2 and 3, the data points representing jitter and percentage datagram loss were joined by smoothed lines. It was found that, on average, the best jitter performances are for 802.11 g both for WEP and open links. On average, for both standards, the best jitter performances were found for open links. Concerning percentage datagram loss data (1.3 % on average) no significant sensitivities were found, within the experimental errors, either to standard or link type.

At OSI level 7 we measured FTP transfer rates versus nominal transfer rates for both standards, as in [8]. The data are shown in Fig. 3, including polynomial fits. The results show the same trends found for TCP throughput.

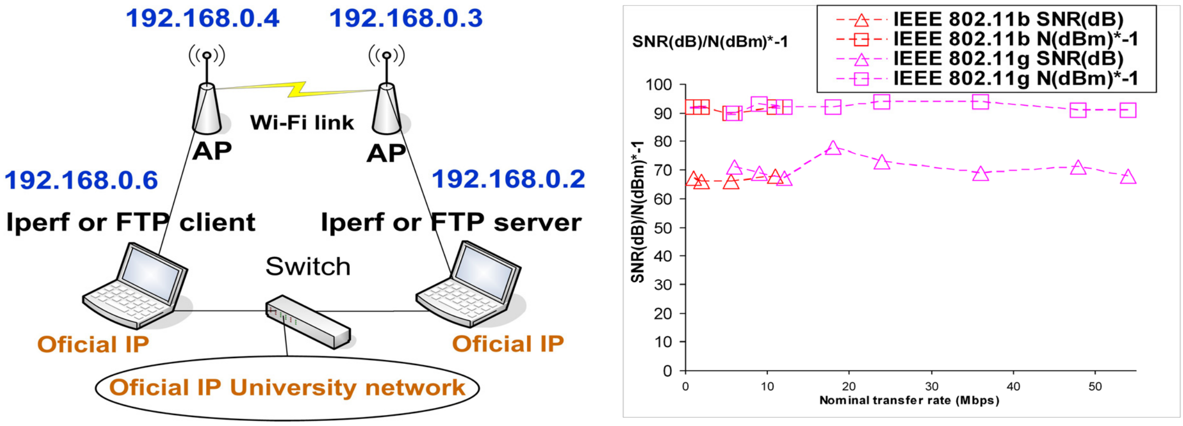


Fig. 1. Wi-Fi laboratory setup scheme and typical SNR (dB) and N (dBm).

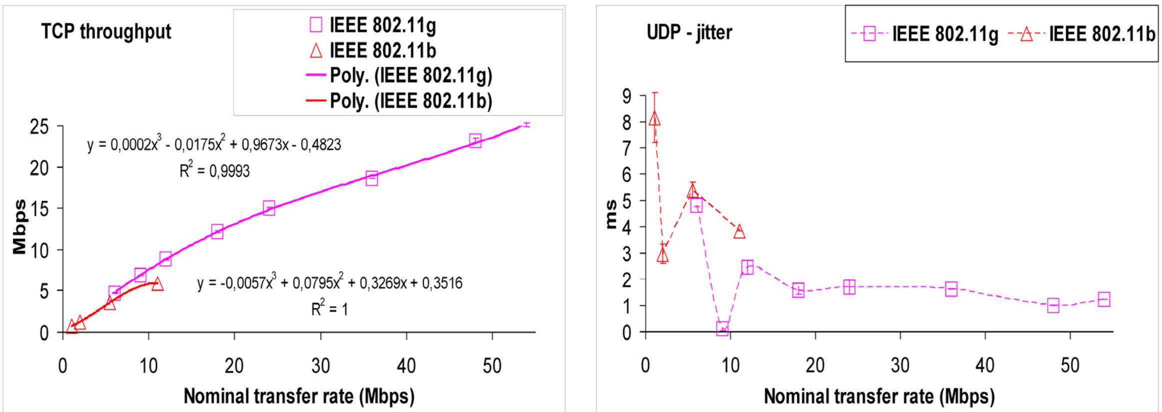


Fig. 2. TCP throughput and UDP jitter results, versus technology (IEEE 802.11 b,g).

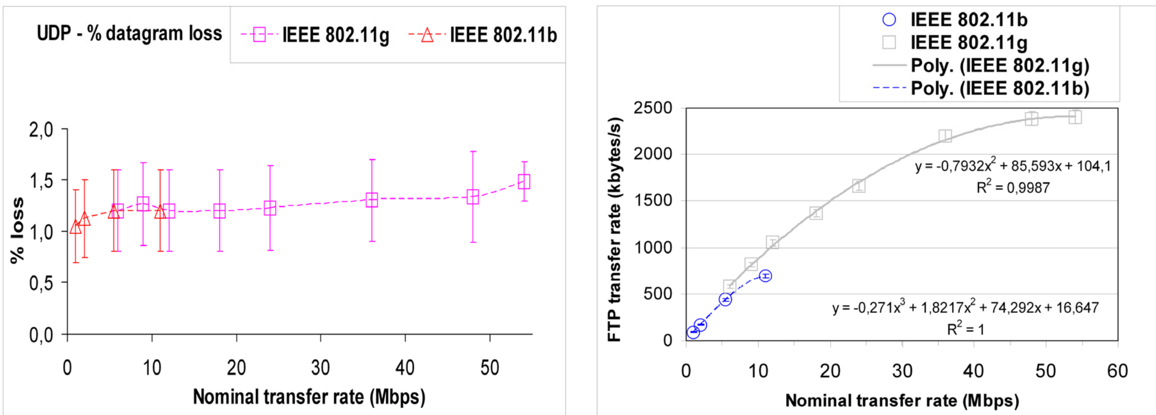


Fig. 3. Results of UDP percentage datagram loss and FTP transfer rate, versus technology (IEEE 802.11 b,g).

## 4. Conclusions

A laboratory setup was planned and implemented that permitted systematic performance measurements of available wireless equipments (WRT54GL from Linksys) for Wi-Fi (IEEE

802.11b, g) in WEP point-to-point links. TCP, UDP and FTP results were obtained and compared for each standard. The best TCP throughputs were found for 802.11g. A fairly good agreement was found for the 802.11 b, g data both for WEP and open links. For jitter, it was found that, on average, the best performance was for 802.11 g for both link types. On average, for both standards, the best jitter performances were found for open links. For percentage datagram loss, no significant sensitivities were found, within the experimental errors, either to standard or link type. FTP results show the same trends found for TCP throughput. Additional performance measurements either started or are planned using several equipments and security settings, not only in laboratory but also in outdoor environments involving, mainly, medium range links.

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