Wireless Communication Devices Performance Evaluation

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ABSTRACT: *The wireless communication devices use the electronic devises and their value is reasonably understood. Efficient communication is required for understanding the outcome of the measurements. We have given the for Wi-Fi IEEE 802.11 a WPA point-to-point links for an effective presentation. The performance evaluation of the technology with WPA encryption using the instruments is significant. In the experimentation process, we have presented the description of the OSI levels, TCP and UDP and FTP experiments. We also comparatively evaluated the results of the open point to point links. We have arrived acceptable findings which have implications for future research.*

Keywords: Wi-Fi, WLAN, IEEE 802.11a, WPA Point-to-Point Links, Wireless Network Laboratory Performance

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1. Introduction

The development of wireless communications technologies, e.g. Wi-Fi and FSO, has been possible using electromagnetic waves in several frequency intervals, propagating in the air. Their importance and utilization have been increasing.

Wi-Fi uses microwaves. It is an important and versatile technology that gives mobility and favorable prices. Wi-Fi has been increasing used for complementing wired networks. Although it can be used in ad-hoc, its main use is in infrastructure mode. Here an access point, AP, permits communications of Wi-Fi electronic devices with a wired based LAN through a switch/router, resulting in a WLAN, based on the AP. Wi-Fi has reached the personal home, where a WPAN allows personal devices to communicate. Point-topoint (PTP) and point-to-multipoint (PTMP) setups are used both indoors and outdoors, with specific directional and omnidirectional antennas. PTP and PTMP 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. The 5 GHz band overcomes this problem, however, absorption is higher and ranges diminish.

Specifications permit nominal transfer rates up to 11 (802.11b), 54 Mbps (802.11 a, g) and 600 Mbps (802.11n). The medium access control is CSMA/CA. Studies were published on wireless communications, wave propagation [2,3], practical implementations of WLANs [4], performance analysis of the effective transfer rate for 802.11b PTP links [5], 802.11b performance in crowded indoor environments [6].

Performance has been a very important criterion to evaluate communications quality, 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].

Wi-Fi security is essential. However, as microwave radio waves propagate in the air, they can be very easily captured. WEP was initially intended to provide security like that of a wired LAN. In spite of its weaknesses, WEP is still widely used in Wi-Fi networks for security reasons, mainly in pointto- point links. More advanced and reliable security methods exist to provide authentication e.g., by increasing security order, WPA and WPA2. WPA implements the majority of the IEEE 802.11i standard [1]. It includes a message integrity check, replacing the CRC used in WEP.

Several performance measurements have been made for 2.4 and 5 GHz Wi-Fi open [8,9], WEP [10,11] and WPA links [12], as well as very high speed FSO [13]. In the present work new Wi-Fi (IEEE 802.11 a) results arise, using WPA links, namely through OSI levels 4 and 7. Performance is evaluated through laboratory measurements of WPA PTP 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 2 presents the experimental details i.e. the measurement setup and procedure. Results and discussion are presented in Section 3. Conclusions are drawn in Section 4.

2. Experimental Details

The measurements used a HP V-M200 access point [14], with three external dual-band 3x3 MIMO antennas, IEEE 802.11 a/b/g/n, software version 5.4.1.0-01-16481 and a 100- Base-TX/10-Base-T Allied Telesis AT-8000S/16 level 2 switch [15]. Two out of three PCs were used having a PCMCIA IEEE.802.11 a/b/g/n Linksys WPC600N wireless adapter with three internal antennas [16], to enable PTMP (two-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 Acrylic WiFi software [17]. WPA encryption was activated in the AP and the wireless adapters of the PCs with a key composed of twenty six hexadecimal characters.. 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. It can involve up to three wireless links to the AP. At OSI level 4, measurements were made for TCP connections and UDP communications using Iperf software [18]. 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 others, with IP 192.168.0.6, and 192.168.0.50 could be the Iperf clients. 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 [19]. The scheme of Fig. 1 was also used for FTP measurements, where FTP server and client applications were installed in the PCs. Another PC, with IP 192.168.0.20, was used to control the settings in the AP. The laboratory setup permitted three types of experiments to be made: PTP, using the client1 and the control PC as server; PTMP, using the client1 and the 192.168.0.2 PC as server; 4N-PTMP, using simultaneous connections/communications between the two clients and the 192.168.0.2 PC as server.

The scheme of Figure 1 was also used for FTP measurements, where FTP server and client applications were installed in the PCs.

The server and client PCs were HP nx9030 and nx9010 portable computers, respectively, running Windows XP Professional. They were set to optimize the resources allocated to the present work. Batch command files have been re-written to enable the new 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 R&D Unit network, via switch.

3. Results and Discussion

The PC wireless network adapter were manually configured, for IEEE 802.11 a, with typical nominal transfer rates (6, 9, 12, 18, 24, 36, 48, 54 Mbps). For every fixed transfer rate, data were obtained for comparison of the laboratory performance of WPA and Open 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, signal to noise ratios (SNR, in dB) and noise levels (N, in dBm) were monitored and typical values are shown in Fig. 2. The main average TCP and UDP result are summarized in Table I, both for WPA and Open PTP links. The statistical analysis, including calculations of confidence intervals, was carried out as in [20]. In Figs. 3-4 polynomial fits were made to the 802.11 a TCP throughput data for WPA and Open PTP links, respectively, where R2 is the coefficient of determination. It was found that, on average, TCP throughput is slightly better for Open than WPA PTP links (Table I). This is due to increase in data length due to WPA encryption. In Figs. 5-6, the data points representing 802.11 a jitter data for WPA and Open PTP links, respectively, were joined by smoothed lines. It was found that, on average, the best jitter performances are for Open PTP links (Table I). Figs. 5-6 show decreases in jitter with increasing nominal transfer rate. In Figure 7, percentage datagram loss data for 802.11 a are shown for WPA PTP links. The best performances were found for Open PTP links (Table I).

At OSI level 7 FTP transfer rates were measured versus nominal transfer rates configured in the access point and the wireless network adapters of the PCs for IEEE 802.11 a, as in [10]. The results show the same trends found for TCP throughput.

In comparison to Open links, for WPA links, TCP throughput, jitter and percentage datagram loss were found to show performance degradations, as data length is increased due to encryption.

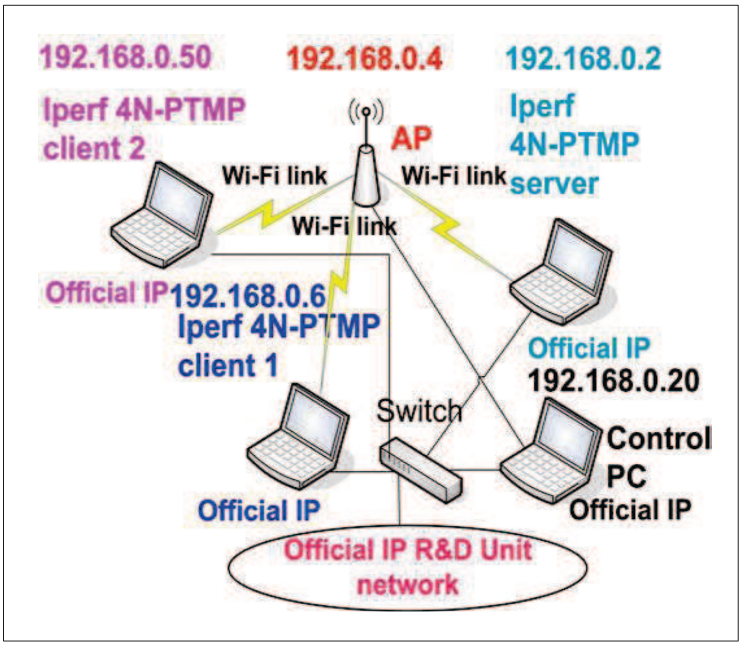

Figure 1. Wi-Fi laboratory setup scheme

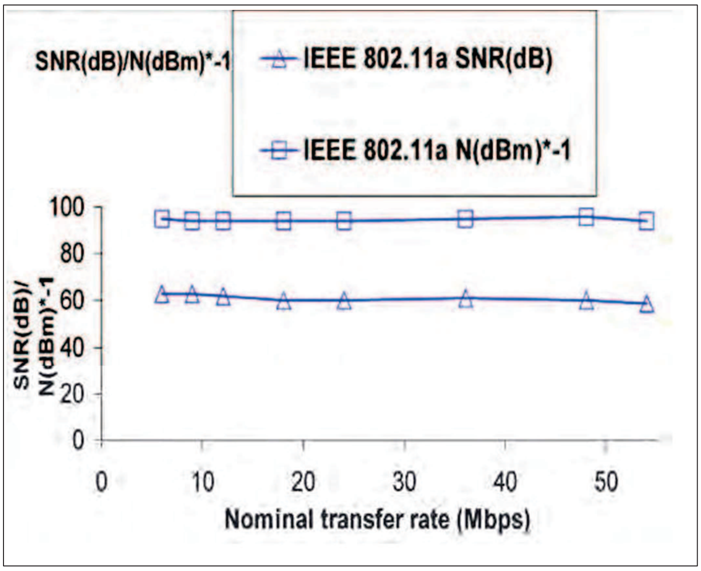

Figure 2. Typical SNR (dB) and N (dBm); WPA

Link type	WPA	Open
TCP throughput (Mbps)	14.6 +- 0.4	15.0 +- 0.5
UDP-jitter (ms)	2.3 +- 0.2	2.2 +- 0.1
UDP-% datagram loss	1.9 +- 0.3	1.4 +- 0.1

Table 1. Average Wi-fi (Ieee 802.11a) Results; WPA and OPEN PTP Links

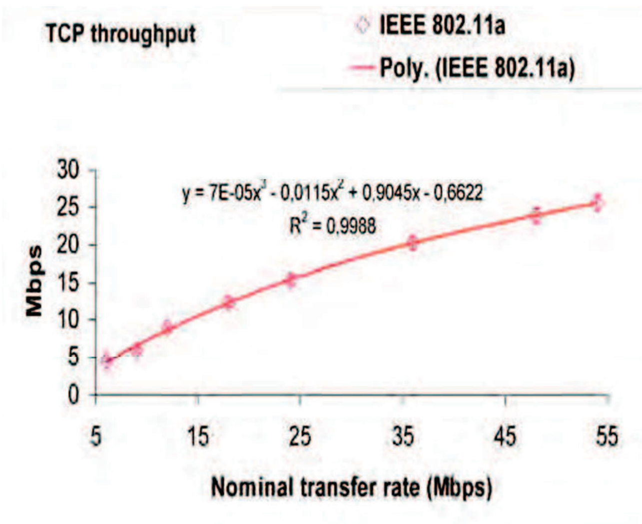

Figure 3. TCP throughput versus technology and nominal transfer rate; WPA, PTP

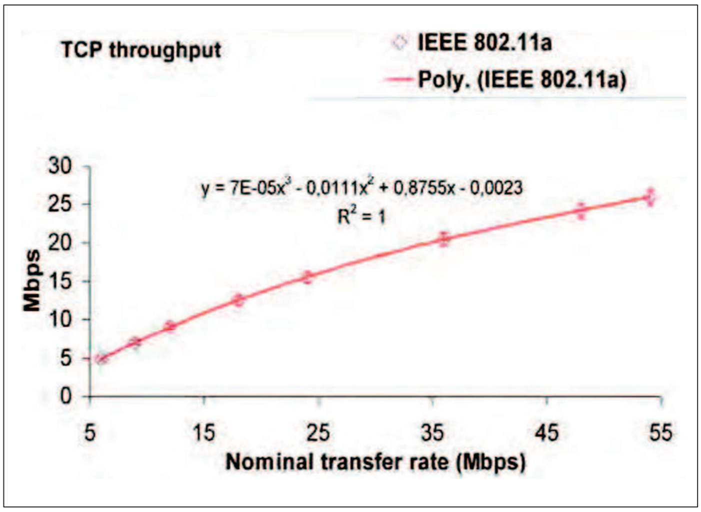

Figure 4. TCP throughput versus technology and nominal transfer rate; Open, PTP

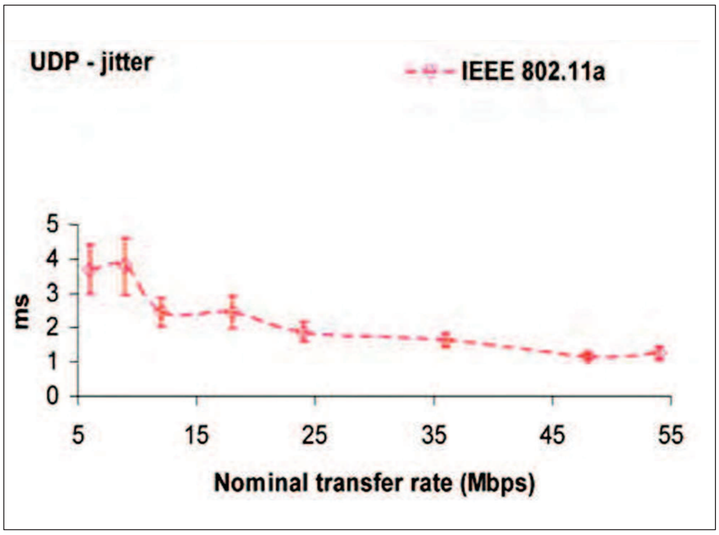

Figure 5. UDP - jitter results versus technology and nominal transfer rate; WPA, PTP

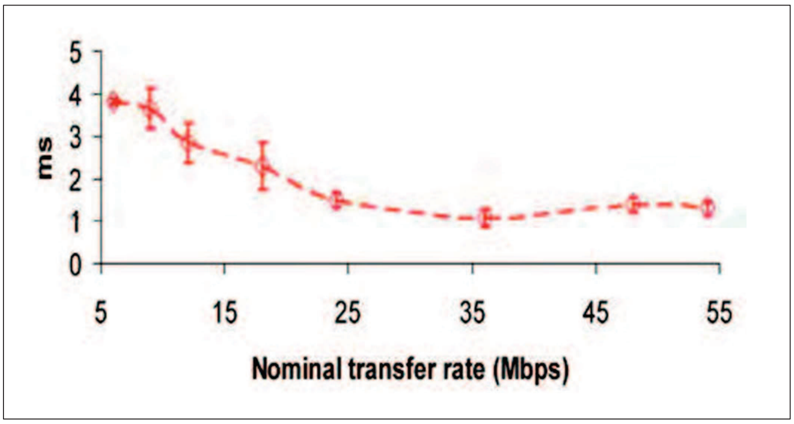

Figure 6. UDP - jitter results versus technology and nominal transfer rate; Open, PTP

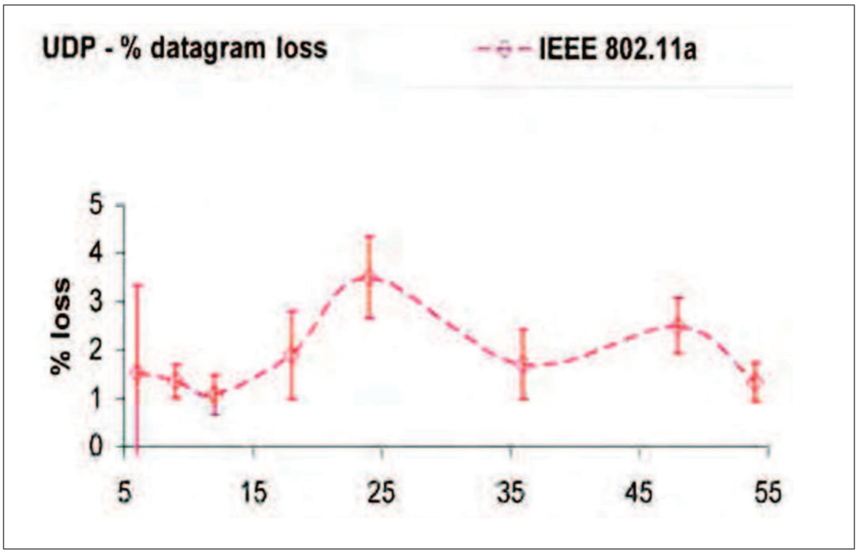

Figure 7. UDP – percentage datagram loss versus technology and nominal transfer rate; WPA, PTP

4. 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 a) in WPA PTP 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. In comparison to Open links, TCP throughput, jitter and percentage datagram loss were found to show performance degradations for WPA links, where data length is increased due to encryption. However performance decreases in TCP throughput were found to be within the experimental error.

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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