Secured Communication in the IEEE 802.11a Standards

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ABSTRACT: *Wireless communication if properly employed with the use of electronic devices can ensure reliable and effective communication. In such communication the people should ensure good security. We did perform the lab analysis on the aspects of Wi-Fi IEEE 802.11a 54 Mbps open links. This study did evaluation of the technology with the proper equipment. We have presented the results with ISO level 4 from TCP experiments. TCP throughput is measured versus TCP packet length. Jitter and percentage datagram loss are measured versus UDP datagram size. Results are compared for both point-to- point and four-node point-to-multipoint links. Finally, we have made the inferences based on the link performance with extensive results.*

Keywords: Wi-Fi, WLAN, IEEE 802.11a, TCP Packet Size, UDP Datagram Size, Point-to-Point and Four-Node Point-to-Multipoint Open Links, Wireless Network Laboratory Performance

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1. Introduction

The development of contactless communication technologies has been enabled by. electromagnetic waves in several frequency ranges, propagating in the air. Examples of such technologies are wireless fidelity (Wi-Fi) and free space optics (FSO). They use microwaves and laser light, respectively. Worldly, their importance and utilization have been growing.

Wi-Fi has been increasingly important and used, as it completes traditional wired networks. The main setup is infrastructure mode. In this case a WLAN (wireless local area network) is formed where an access point, AP, permits communications of Wi-Fi devices with a wired based LAN, through a switch/router. At the personal home level a WPAN (wireless personal area network) permits personal devices to communicate. Frequency bands of 2.4 and 5 GHz are available, with IEEE 802.11a, b, g, n standards [1]. Nominal transfer rates up to 11 (802.11b), 54 Mbps (802.11 a, g) and 600 Mbps (802.11n) are specified. Carrier sense multiple access with collision avoidance (CSMA/CA) is the medium access control. Point-to-point (PTP) and point-to-multipoint (PTMP) microwave links are used. While the 2.4 GHz band has been intensively used, resulting in increasing interference, the 5 GHz band solves this problem. However, absorption increases and ranges decrease.

802.11a,g. provide a multi-carrier modulation scheme called orthogonal frequency division multiplexing (OFDM) that allows for binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK) and quadrature amplitude modulation (QAM) of the 16-QAM and 64-QAM density types. One spatial stream (one antenna) and coding rates up to 3/4 are possible and a 20 MHz channel.

There are studies are on wireless communications, wave propagation [2,3], practical setups of WLANs [4], performance analysis of the effective transfer rate f [5], performance in crowded indoor environments [6].

Communication performance is a crucial issue, giving higher reliability and efficiency. Requirements for new and traditional telematic applications are available [7].

Wi-Fi security is critically important. Microwave radio signals travel through the air and can be very easily captured. Several security methods have been developed to provide authentication such as, by increasing order of security, wired equivalent privacy (WEP), Wi-Fi protected access (WPA) and Wi-Fi protected access II (WPA2). .

Several performance measurements have been published for 2.4 and 5 GHz Wi-Fi Open [8], WEP [9], WPA[10] and WPA2 [11] links, as well as very high speed FSO [12]. Studies are published on modelling TCP throughput [13]. A formula that bounds average TCP throughput is available [14]. Studies have been given for 5 GHz 802.11n Open links [15].

The motivation of this work is to evaluate and compare performance in laboratory measurements of Open PTP and four-node point-to-multipoint (4N-PTMP) 802.11a links at 54 Mbps using new available equipments. This new contribution permits to increase the knowledge about performance of Wi- Fi (IEEE 802.11 a) links. The problem statement is that performance needs to be evaluated under several TCP and UDP parameterizations and link topologies under no security encryption. The solution proposed uses an experimental setup and method, permitting to monitor signal to noise ratios (SNR) and noise levels (N), measure TCP throughput (from TCP connections) versus TCP packet size, and UDP jitter and percentage datagram loss (from UDP communications) versus UDP datagram size.

The rest of the paper is structured as follows: Section 2 is about the experimental conditions i.e. the measurement setup and procedure. Results and discussion are given in Section 3. Conclusions are drawn in Section 4.

2. Experimental Details

Here we have used a HP V-M200 access point [17], with three external dual-band 3x3 MIMO antennas, IEEE 802.11 a/b/g/n, software version 5.4.1.0-01-16481, a 1000-Base- T/100-Base-TX/10-Base-T layer 2 3Com Gigabit switch 16 and a 100-Base-TX/10-Base-T layer 2 Allied Telesis AT- 8000S/16 switch [18]. Three PCs were used having a PCMCIA IEEE.802.11 a/b/g/n Linksys WPC600N wireless adapter with three internal antennas [19], to enable 4N-PTMPlinks to the access point. In every type of experiment, an interference free communication channel was used (ch 36). This was essentially verified through a portable computer, equipped with a Wi-Fi 802.11 a/b/g/n adapter, running Acrylic WiFi software [20]. 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 used, as the wireless equipments were nearby.

A versatile laboratory setup has been planned and implemented for the measurements, as shown in Figure 1. Up to three wireless links to the AP are possible. At OSI level 4, measurements were made for TCP connections and UDP communications using Iperf software [21]. For a TCP client/server connection (TCP New Reno, RFC 6582, was used), TCP throughput was obtained for a given TCP packet size, varying from 0.25k to 64k bytes. For a UDP client/server communication with a given bandwidth parameter, UDP jitter and percentage loss of datagrams were determined for a given UDP datagram size, varying from 0.25k to 64k bytes.

One PC, with IP 192.168.0.2 was the Iperf server and the others, with IPs 192.168.0.6 and 192.168.0.50, were the Iperf clients (client1 and client2, respectively). Jitter, which is 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 [22]. A control PC, with IP 192.168.0.20, was mainly used to control the settings of the AP. Three types of experiments are possible: PTP, using the client1 and the control PC as server; PTMP, using the client1 and the 192.168.0.2 server PC; 4N-PTMP, using simultaneous connections/communications between the two clients and the 192.168.0.2 server PC.

The server and client PCs were HP nx9030 and nx9010 portable computers, respectively. The control PC was an HP nx6110 portable computer. Windows XP Professional was the operating system. The PCs were prepared to enable maximum resources to the present work. Batch command files have been re-written for the new TCP and UDP tests.

The results were obtained in batch mode and written as data files to the client PCs disks. Every PC had a second network adapter, to permit remote control from the official IP University network, via switch.

3. Results and Discussion

The wireless network adapters of the PCs were manually configured for a nominal rate of 54 Mbps. No encryption was used. Transmit and receive rates were monitored in the AP during the experiments. They were typically 54 Mbps. For every TCP packet size in the range 0.25k-64k bytes, and for every corresponding UDP datagram size in the same range, data were acquired for Open 4N-PTMP and PTP links at OSI levels 1 (physical layer) and 4 (transport layer) using the setup of Figure 1. For every TCP packet size an average TCP throughput was calculated from a series of experiments. This value was considered 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 obtained in the AP. Typical values are shown in Fig. 2. The links exhibited good, high, SNR values. The main average TCP and UDP results are summarized in Table I, for Open 4N-PTMP and PTP links. The statistical analysis, including calculations of confidence intervals, was made as in [22]. In Fig. 3 polynomial fits were made (shown as y versus x), using the Excel worksheet, to the TCP throughput data both for both links, where R2 is the coefficient of determination. It gives the goodness of fit. If it is 1.0 it means a perfect fit to data. It was found that, on average, the best TCP throughputs are for PTP links (Table 1). There is a very significant degradation to 23% in passing from PTP to 4N-PTMP. This is due to increase of processing requirements for the AP, so as to maintain links between the PCs. Fig. 3 shows that there is a fair increase in TCP throughput with packet size. For small packets there is a large overhead, as there are small amounts of data that are sent in comparison to the protocol components. The role of the frame is very heavy in Wi-Fi. For larger packets, overhead decreases; the amount of sent data overcomes the protocol components.

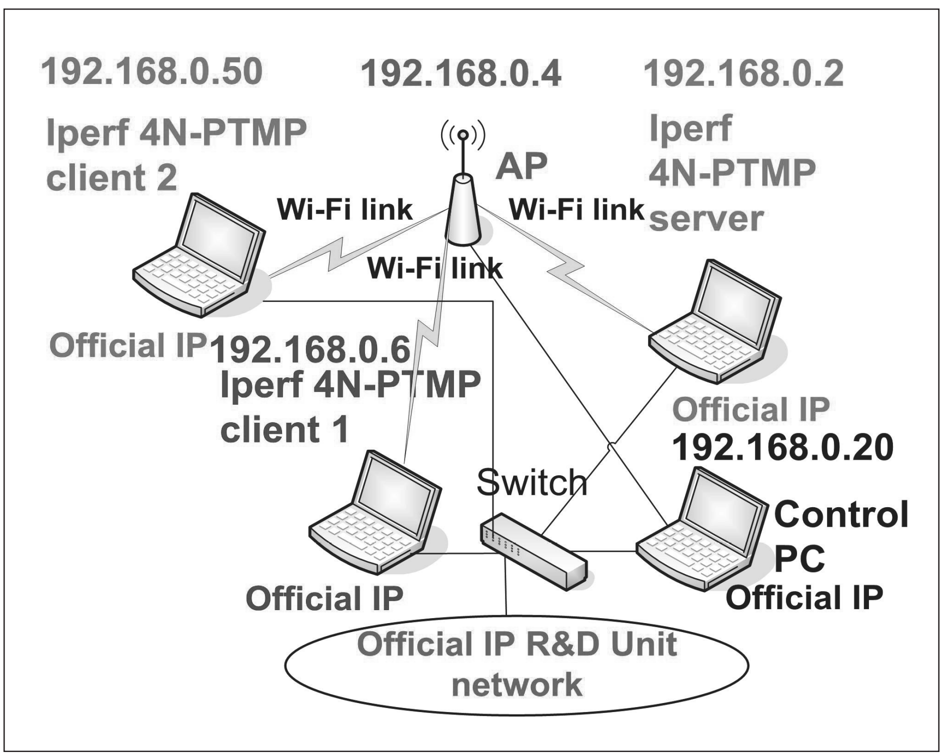

Figure 1. Wi-Fi laboratory setup scheme

In Figures. 4-5, the data points representing jitter and percentage datagram loss were joined by smoothed lines. It was found that, on average, the best jitter performance is for PTP links. Let us note a large error bar mainly in the 8k data point of the 4N-PTMP curve (Fig. 4), that needs further investigation. For PTP it can be seen that, for small sized datagrams, jitter is small. There are small delays in sending datagrams. Latency is also small. For larger datagram sizes jitter increases.

Concerning average percentage datagram loss, performances were found on average significantly better for PTP than for 4N-PTMP links (Table 1). This is due to increase of processing requirements for the AP, for maintaining links between two PCs. Let us note a large error bar mainly in the 8k data point of the 4N-PTMP curve, that needs further investigation. Figure 5 generally shows larger percentage datagram losses for small sized datagrams, when the amounts of data to send are small in comparison to the protocol components. There is considerable processing of frame headers and buffer management. For larger datagrams, percentage datagram loss is lower. However, large UDP segments originate fragmentation at the IP datagram level, leading to higher losses.

TCP throughput and percentage datagram loss were generally found to show performance degradations due to link topology, in passing from PTP to 4N-PTMP, where processing requirements for the AP are higher so as to maintain links between PCs. As CSMA/CA is the medium access control, the available bandwidth and the air time are divided by the nodes using the medium.

TCP and UDP performance aspects versus TCP packet size and UDP datagram size were found as given above.

In comparison to previous results for 5 GHz 802.11n Open links [15] the present results show that 5 GHz 802.11n givesbetter TCP, jitter and datagram loss performances than 802.11a.

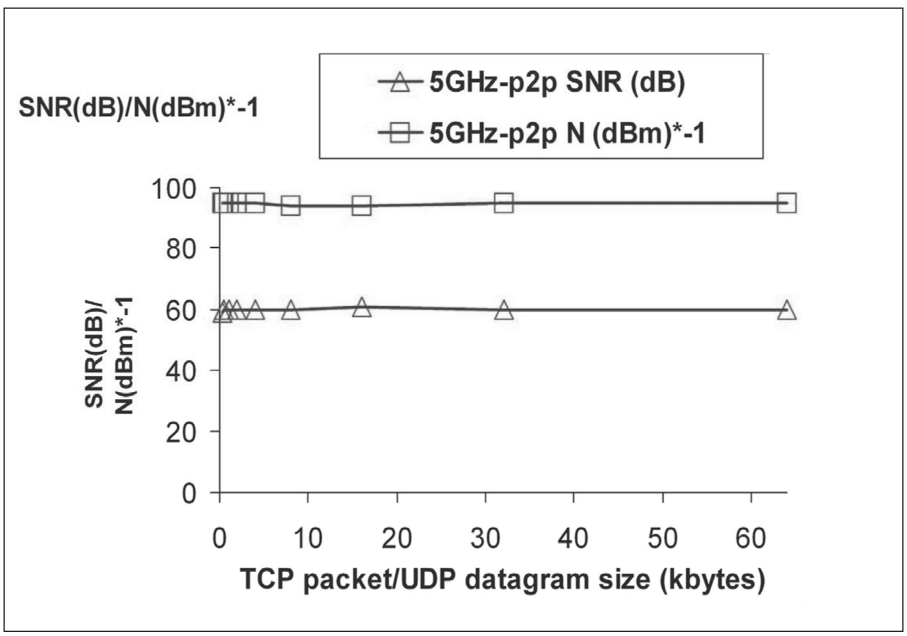

Figure 2. Typical SNR (dB) and N (dBm)

4. Conclusion

In the present work a versatile laboratory setup arrangement was devised and implemented, that permitted systematic performance measurements using new available wireless equipments (V-M200 access points from HP and WPC600N adapters from Linksys) for Wi-Fi (IEEE 802.11 a) in 54 Mbps Open PTP and 4N-PTMP links.

Through OSI layer 4, TCP and UDP performances were measured versus TCP packet size and UDP datagram size, respectively. TCP throughput, jitter and percentage datagram loss were measured and compared for Open PTP and 4NPTMP links. TCP throughput was found to increase with packet size. For PTP jitter, for small sized datagrams, is found small. It increases for

Parameter/Link type	PTP	4N-PTMP
TCP throughput (Mbps)	22.9 +- 0.7	5.2 +- 0.2
UDP-jitter (ms)	4.1 +- 0.6	10.2 +- 0.7
UDP-% datagram loss	1.2 +- 0.1	12.7 +- 8.1

Table 1. Average WI-FI (Ieee 802.11.a) Results; OPEN PTP and 4N-PTMP Links

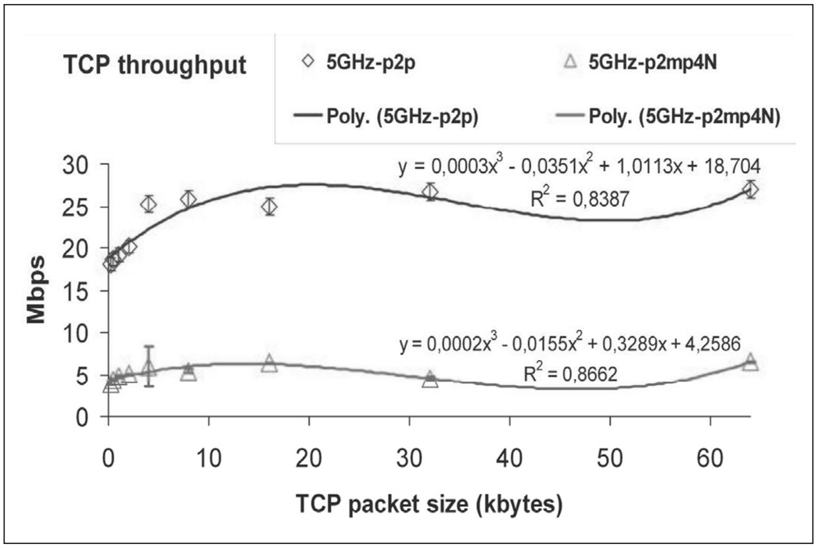

Figure 3. TCP throughput (y) versus TCP packet size (x)

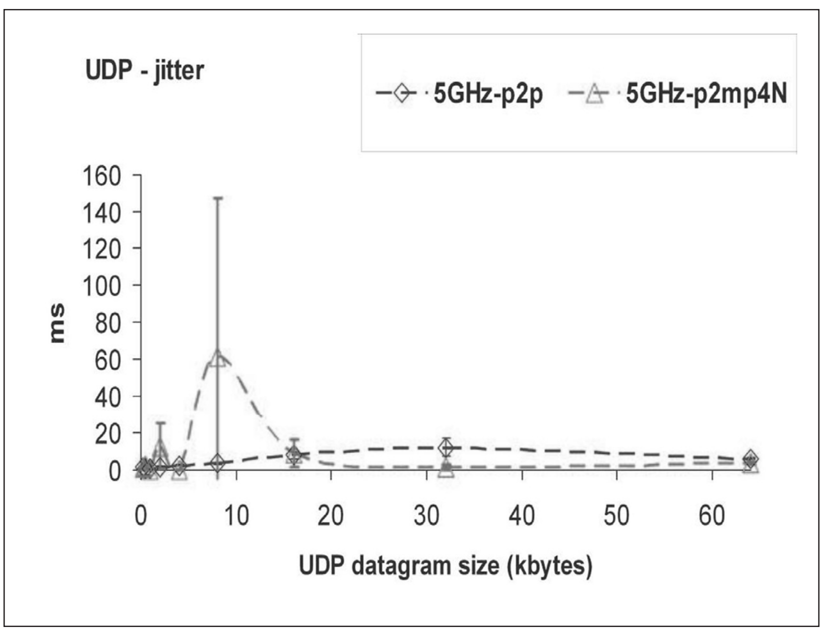

Figure 4. UDP - jitter versus UDP datagram size

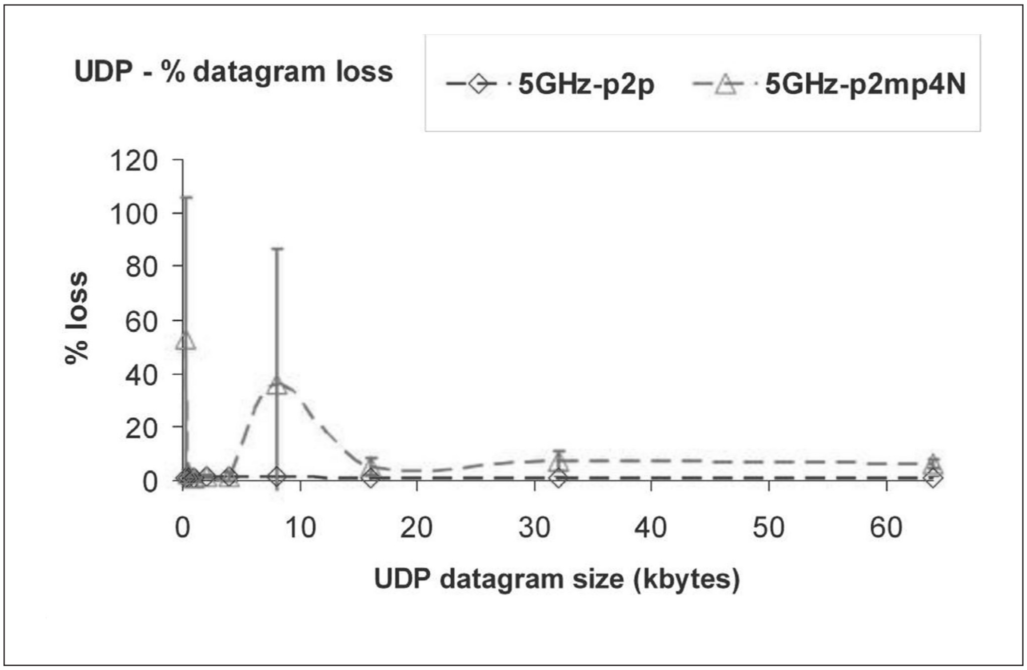

Figure 5. UDP – percentage datagram loss versus UDP datagram size

larger datagrams. Concerning percentage datagram loss, it was found high for small sized datagrams. For larger datagrams it diminishes. However, large UDP segments originate fragmentation at the IP datagram level, leading to higher losses. In comparison to PTP links, TCP throughput and percentage datagram loss were found to show significant performance degradations for 4N-PTMP links, where the AP experiments higher processing requirements for maintaining links between PCs. The present results show that 5 GHz 802.11n gives better TCP, jitter and datagram loss performances than 802.11a.

Further performance studies are planned using several standards, 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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