Implementation & Measurement of the Performance 802.11b WLAN System Using Radio Frequency

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Abstract

This paper presents an empirical performance analysis of a wireless network of 802.11b technology. The system provides communications to fixed, portable and mobile users and offer substantial flexibility to both end-users and service providers. The basic purpose of this paper is to analyze the performance of a designed wireless network capable of sending high data rates by measurement of the power transmitted as a function of distance and calculation of the signal to noise ratio at the R_x input for different distances.

In this paper we studied the behavior of transmitted signals in free space for 400m distance between two buildings, the experimental wireless data network is designed and tested for this purpose, the measurements shows the wireless coverage and throughput patterns for static and mobile users.

We have discovered which channel parameters have the most significant impact on performance in actual local environment. The application used to perform all the experiments is typical of common applications that would use these protocols and network technologies.

1. Introduction

Wireless local area networking WLAN is an emerging technology that appears poised to become a significant force in business and consumer connectivity products. It combines the productivity gains leveraged from network data with the convenience and versatility of wireless. Beyond the simple removal of wires, the merging of these two technologies has opened the door for greater access to information in many different areas. WLANs have been used to create high-speed wireless Internet Service Protocols ISPs where formerly there was no low-cost, high bandwidth option [1].

The relatively low-cost and availability of components has also spawned the creation of mid-range neighborhood area networks that can link entire neighborhoods together. Businesses are using WLANs to expand on their wired backbones with a large savings in infrastructure costs. Wireless phone providers are looking to add 802.11 to their phones to give their users more, higher-speed connectivity options when available [2]. The standardization of a WLAN protocol has been one of the factors in their recent growth.

802.11 is the first WLAN standard, was created by information engineering electronic IEEE in 1997 and later revised in 1999. It is part of the IEEE 802 family of local and metropolitan area network standards. It provides for data rates up to 2 Mbps when using Direct Sequence Spread Spectrum DSSS (one of the physical layer options). An extension to 802.11, called 802.11b followed later that year [3].

The extension allowed for two new data rates using DSSS, 5.5 Mbps and 11 Mbps, while at the same time staying compatible with the original standard. A user can create a wireless network using 802.11 in one of two ways. The first is to use an Access Point station (AP) that servers as a central router for all data packets. End user stations called terminals talk to each other and the outside world through the AP. Wireless LANs that are configured in this way are referred to as being built around a Basic Service Set (BSS). The other configuration option is to create a network that consists only of stations, without an AP. Each station can talk directly to all other stations in its range, and no centralized control is need; all management functionality is distributed .A wireless LAN set up this way is referred to as an Independent BSS[4].

The operation of a BSS is extended by connecting AP's together to form an Extended Service Set (ESS). APs are connected over what IEEE calls a distribution system (DS). How the DS is implemented is not defined in the standard, but is left to the individual vendors. The DS can take the form of a wired connection or a separate WLAN on a different channel. APs from different vendors generally cannot connect together to form an ESS. When connected in to a wired LAN, the ESS appears to be a single MAC-layer network with stationary terminals. The mobility provided by 802.11 networks is masked to any networks outside of the ESS, allowing communication over standard networks protocols without any modification [4].

The advantages of wireless networks LANs are usually designed to operate in license-free bands making their operation and maintenance costs less than contemporary cellular and personal computer PC networks, the use of license-free spectrum, however, increases the risk of network security and in-band interference. The key advantages of wireless networks as opposed to wired networks are mobility, flexibility, ease of installation and maintenance, and reduced cost [5,6].

2. Experimental work

Our designed network is based on IEEE 802.11b WLAN standard [802.11b]. It is installed on two building at distance 400m between them, and is equipped with two wireless access points (WAPs). Each node consists of antenna and AP (access point). The two access point along the distance provides access network coverage, and each of them have two wireless interfaces, which are represented by letters ‘A’, and ‘B’ shown as Figure (1).

The portable-1 are connected to the portable-2 via wireless links in a point-to-point fashion.

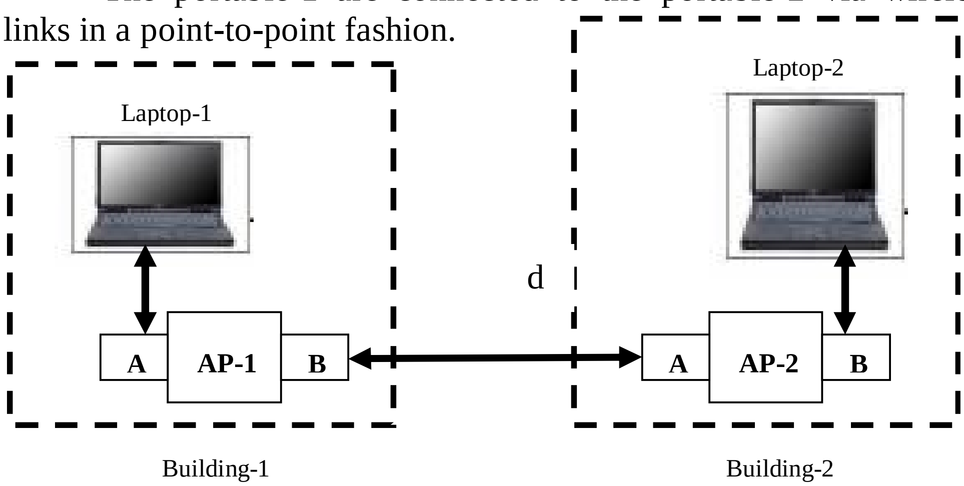


Figure (1) Network design for 802.11b WLAN

Each of the two access points is located on the surface of a building and equipped with antenna tied to a light poles. The two antennas are installed at an approximate height of (8 meters) from ground level. However, each access point (AP) shares the hardware and processing power simultaneously with its antenna .

We used two mobile computers (will be referred as Laptop's) with WLAN abilities to ensure system working and just one of them for taking network performance measurements. Our worked system was equipped with D-Link access point AP-2100, and D-Link Wireless 21 dBi omni directional antenna. Hence each AP-2100 is configured to have two distinct access points in different directions with two different channels.

The laptops is equipped with Intel Pentium (III) Mobile 866 GHz CPU, 128 MB RAM, Microsoft Windows 2000 operating system and ORiNOCO silver PC Cards as wireless client. These two laptop's are installed with ORiNOCO Client Manager software tools, which were used to measure network performance by measuring wireless link signal to noise levels and number of messages received at different data rates along the link [7] .

3. Theoretical Calculations

3.1 Calculation of Power Losses in Free Space

The total power of the received signal through the earth's atmosphere can be calculated by[6] :-

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where P_r is the received power and P_t is the transmitted power, G_t and G_r are transmitter and receiver antenna gains, d is the distance between the transmitter and the receiver, and λ is the wavelength. (wavelength = c/f where c is the speed of light = $3*10^8$ m/s and f is the carrier frequency).

In our system, the parameters used through the research is listed in table (1), shown below :-

Table (1)

Type	Properties

Output power P_t	200Mw
Antennas G_t	21Db
Antennas G_r	5 dB
signal frequency f	2.4GHz
Maximum link range d	400m

When these values are substituted in equation (1), the theoretical amount of P_r is calculated for each transmission node a locally .

These theoretical estimations were used in our system design for limitation of maximum practical possible distance between APs.

We found that for a distance of 200m from an AP:-

$$P_r = \frac{200*10^{-3}*125.89*3.162*(0.125)^2}{(4*3.14)^2*(200)^{٢}}$$

$P_r = 0.19\ \mu W$

The relation between power received with the range by theoretical estimations can be illustrated in figure(2).

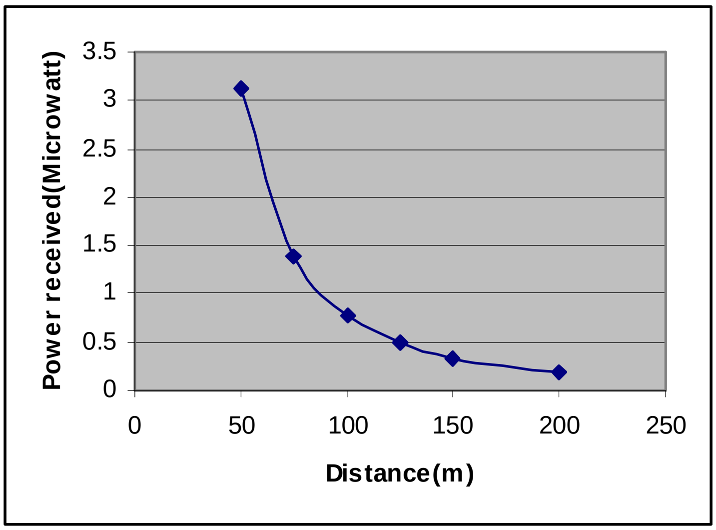


Figure (2) The relationship between the received signal power and range in theoretical calculations

3.2 Signal to Noise Ratio Calculations

Signal-to-Noise ratio (SNR) may be defined as the ratio of the power in a signal to the power contained in the noise that's present at a particular point in the transmission, typically measured at a receiver [8].

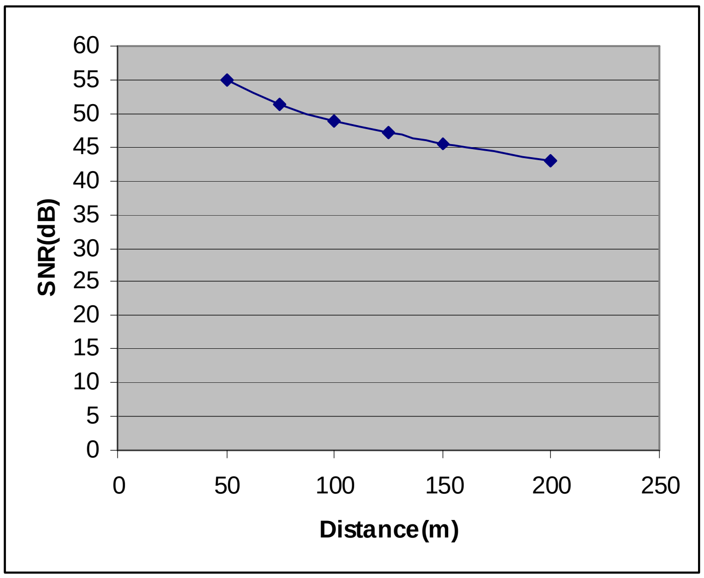
$$SNR = \frac{P_t * G_t * G_r * \lambda^2}{(4\pi)^2 * d^2 * k * T*B* F_n} \quad \ldots\ldots\ldots\ldots(2)$$

where k is the Boltzman constant=1.38*10J/K,T the temperature=300 Kelvin , B is the channel bandwidth , and F_n is the noise figure=1dB .

The total SNR of the power received at distance (2٠0m) can be calculated according to the equation (2) for transmission node with output power of 20٠mW, and a received signal power of 0.١٩ µW to be:-

SNR = = 42.9 dB

Also other SNR values in step of 50m from the selected transmission node can be represented as shown figure(3):-



Figure(3) SNR dB with distance theoretical calculation

It can be noticed that theoretical calculations for one AP are the same for each since same devices kinds are used and the two were tested in one location .

4.Experimental Results

In this section we provide a survey of our results with some discussion of general observations.

4.1 SNR Measurement

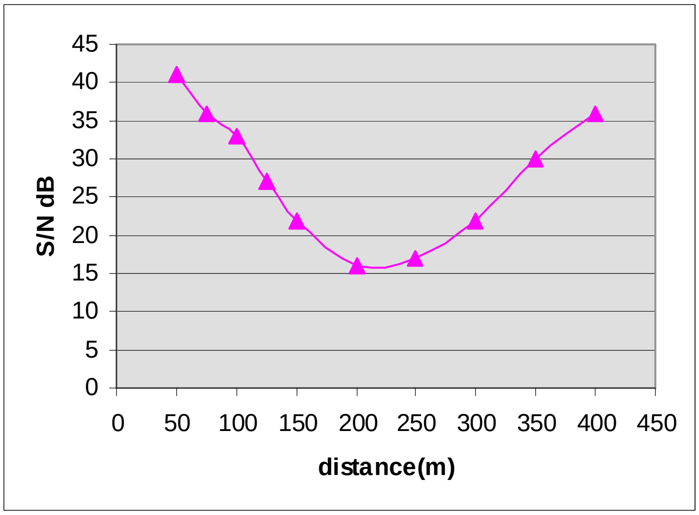
The measurements have been taken by software program ORiNOCO Manager tool installed in the Laptop, they are taken in the road along the distance between building-1 and building-2, inside the coverage area of AP-1 and AP-2.

The experimental measured SNR values were represented in curve plot shown in figure (4) along 400m distance starting from location of building-1 to building-2 in steps of 50m .

The SNR values give us an insight into network performance. It can be noted here that the wireless link has comparatively low SNR .

We obtained 16 dB SNR at 200m distance from each of APs, this difference in values between the theoretical calculation and practical measurement is due to atmospheric attenuation and noise.

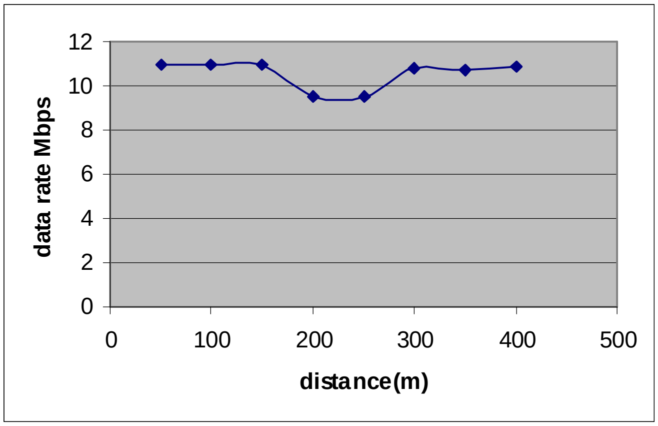
It can be seen that SNR decreases with the increase of the range between the transmitter and receiver.



Figure(4) The laptop's SNR dB with distance

4.2 Average Data Rate

It is calculated by averaging the number of test messages received at different rates recorded by Client Manager. It is to be noted here that at a particular static location, test messages may not be received at a constant rate due to random nature of SNR and subsequent power and data rate adoption of access point. At least 16-dB SNR may guarantee data rates of (9-11) Mbps between the Laptop and access points. Figure (5) shows a graph of Laptop's average data rate as measured by Client Manager.



Figure(5) The average data rate of point to point wireless link

5.Conclusions

From this study, we can conclude the following:-

Wireless coverage and supported data rate for end-user wireless link depends also on site details. Thus, the implementation rather than the standard that is the deciding factor in the success or failure of WLAN systems in challenging new environments. There are a myriad of technical challenges standing in the way of providing 802.11b services to mobile users ,one of them is that radiated power remains relatively low and as a result, the coverage radius of a WLAN stations remains in order of hundreds of meters.

From the calculations and results obtained, we observe the performance effects of placing a WLAN link in actual environment. However, in this system where a ORINOCO card acts as the receiver ,the path measuring points exhibit a certain periodicity ,where system coverage parameters decreased with increasing distance at the middle of wireless link.