Design of a Wireless Local Area Network

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***Abstract* — This paper concerns the design of a Wireless Local Area Network (WLAN). The Wireless Local Area Network in Enugu State University of Science and Technology, Nigeria is taken as a case study. The purpose of this work is to monitor and analyze the network in order to determine the distance, free space loss, transmitted power, received power and ways of solving the problem of power losses. There is confusion in the design of a Wireless Local Area Network through the use of point-to-point and point-to-multipoint systems. The researchers have adopted a method that located the transmitting antenna at the appropriate point so that adequate signal can be received through the use of a high radio frequency signal. The results obtained from this design shows that a group of computers and peripherals were connected together through a wireless link and it is confirmed that the information received at the receiving end shows that the calculated and simulated values are the same.**

Keywords—Design; Wireless LAN; Transmitting antenna; Radio frequency signal; Computers.

I. INTRODUCTION

The growth of Wireless Local Area Network (WLAN) commenced in the mid-1980s by the U.S. Federal Communications Commission (FCC) decision to authorize the public use of the Industrial, Scientific and Medical (ISM) bands. This decision encouraged the need for companies and end users to obtain FCC license to operate their wireless products. Lack of standard expedited the appearance of many proprietary products and divided the market into several incompatible parts. These brought about the need for standardization in the area.

In 1997, IEEE approved the 802.11 standard for WLANs [1], which specifies a data transfer rate of 1 to 2 megabits per second (Mbps). In 1999, two new physical layers were finalized which is today referred to as Wi-Fi, one of which is 802.11b [2], which is emerging as the new dominant standard with data transfer to a maximum rate of 11Mbps over 2.4 gigahertz (GHz) frequency band. The other standard is 802.11a [3], which specifies data transfer at a maximum rate of 54Mbps over a 5GHz frequency band. Another standard 802.11g [4], was approved on June11, 2003 and offers data speeds up to 54Mbps and operates in the 2.4GHz and 5GHz range making it compatible with 802.11b and 802.11a.

In addition to IEEE 802.11, High Performance European Radio LAN (HIPERLAN) was developed by the European Telecommunications Standards Institute (ETSI) for high speed WLAN. The HIPERLAN1 Standard offers data rates between 2 and 25Mbps by using traditional radio modulation techniques in 5.2GHz band.

II. DESIGN, MATERIALS AND METHODS

The Wireless local area network system requires a combination of hardware and software for the design and applications. The hardware comprises of computer systems, adapters, antennas, access points, routers, and repeaters, the software components consist of UNIX, NetWare, NetWare Loadable Module, security software and remote control software.

A. Design

The following items should be considered when designing a wireless local area network.

- Site Survey
  We should perform site survey to determine the optimal locations for wireless access points to minimize channel interference while maximizing the range.

- Multi-Data Rates
  Wireless local area network clients have the ability to shift data rates while moving. This technique allows the same client operating at 11Mbps to shift to 5.5 Mbps, then 2Mbps and finally it can still communicate in the outside ring at 1Mbps.
  This rate-shifting happens without losing connection and without any interaction from the users. This provides the access point the ability to support multiple clients at multiple speeds depending upon the location of each client. This is shown in figure 1.
- Dynamic Host Control Protocol (DHCP)
  The main aspect of Wireless LAN deployment is mobility. When users roam between buildings, their IP addresses also change based on their locations. It is better to adjust the DHCP lease times to make sure IP address is not wasted.
- Antenna
  For most deployment, 2dB standard Dipole antenna is sufficient. Depending on the shape of the building, room, and materials from which the room is made up of, it is suitable to use directional antennas.
- Channel Overlap between Floors

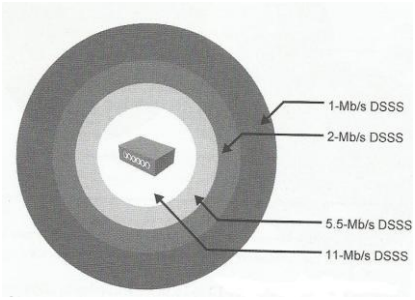
The best practice in multi-stored buildings is to ensure that channels do not overlap between floors. This is included in the site survey requirements.

- Power Level on Access Points
  Most IT Standard for power level falls within the range of 1-30MW, with the standard being 5MW [5].

B. Methods

Figure 2 shows the configuration of a wireless local area network. The Radio Frequency (RF) approach involves the fitting of each workstation with a low-power transmit/receive radio antenna with frequency assignments in the 900MHz, 2GHz and 5GHz bands.

The hub antenna is located at a central point where line-of-sight can be established with the various terminal antennas. At higher frequencies, where line-of-sight is not required, the hub antenna then connects to other hub antennas, servers, peripherals, and hosts through cabled connections which also connect together multiple hub antennas for transmission between rooms, floors and buildings.



In order to serve multiple workstations, spread spectrum radio technology is employed to maximize the effective use of limited bandwidth [6]. Spread spectrum involves scattering packets of a data stream across a range of frequencies rather than using a single transmission frequency. The raw aggregate bandwidth of a wireless radio LAN is within the range of 2-4Mbps while the effective throughput falls in the range of 1-2 Mbps per hub.

Some Wireless LANs also use direct sequence transmission in which the signal is sent simultaneously over several frequencies and this allows the signal to get through to the access hub. Despite the frequency range employed, contemporary buildings are full of metals and electronics interference, which contributes to reduce the effectiveness of radio frequency based wireless LAN.

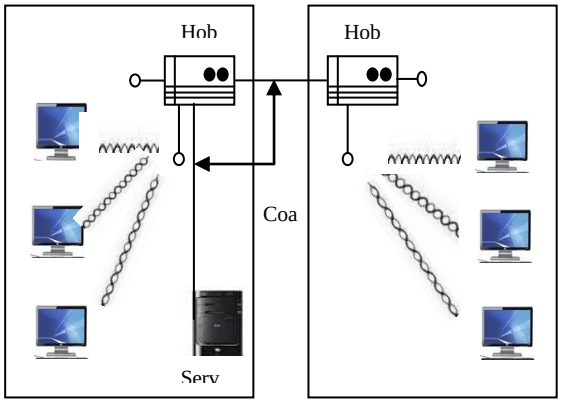


Figure 2 Configuration of a Wireless LAN

C. Transmission Techniques

There are various types of transmission techniques in wireless LAN and are stated below.

- Frequency Hopping Spread Spectrum (FHSS)
  In this technique, the signal is broadcast over a random set of frequency channels, hopping from frequency to frequency at constant time intervals [7]. The time spent on each channel is called a chip.
  The receiver executes the same hopping sequence while remaining in synchronization with the transmitter and receives the transmitted data.
  In Frequency Hopping Spread Spectrum, Wireless Local Area Networks are very robust to narrowband interference and they can operate simultaneously in the same geographical area.
- Direct Sequence Spread Spectrum (DSSS)
  In direct Sequence Spread Spectrum, each bit in the original signal is represented by a number of bits in the spread signal [8].This can be done by binary multiplication (XOR) of the data bits with a higher rate bit sequence, known as the chipping code.
  The resulting stream has a rate equal to that of the chipping code and is fed into a modulator, which converts it to analog form in order to be transmitted. The ratio between the chip and data rates is called the spreading factor and has values between 10 and 100 in commercial systems. This technique spreads the signal across a frequency band by a width proportional to the spreading factor.
  Table 1 shows a binary data stream and the resulting modulated spread signal.
  Table 2 shows the demodulation of the spread signal at the receiver. The actual rate of the direct sequence spread signal lowers with increasing spreading factor.

D. The Comparative analysis between Wi-Fi and Bluetooth technology

Table 3 shows the comparison of Wi-Fi and Bluetooth features [9].

Table 1. DSSS Modulation

Data Stream A	1			1			0			1			0		
Chip sequence B	1	0	0	1	0	1	1	0	1	0	0	1	0	1	0
Output Signal C = A⊕B	0	1	1	0	1	0	1	0	1	1	1	0	0	1	0

Table 2. DSSS Demodulation

Received signal C	0	1	1	0	1	0	1	0	1	1	1	0	0	1	0
Chip signal B	1	0	0	1	0	1	1	0	1	0	0	1	0	1	0
Data stream C = A⊕B	1			1			0			1			0		

Table 3. Comparison of Wi-Fi and Bluetooth features

Characteristics	**Wi-Fi**	**Bluetooth**
Standard	IEEE 802.11	IEEE 802.15
No of Device accessed at the same time	Multiple, Shared	Up to 8, shared
Frequency	2.4, 3.6, 5 GHz	2.4 GHz
Hardware requirement	Wireless adapters on all the devices of the network, a wireless router, wireless access points.	Bluetooth adapters on all the devices connecting with each other.
Power requirements	High	Low.
Range	With 802.111b/g the typical range is 35 meters indoors and 100 meters outdoors.	5 - 10 meters
Bit-rate	600 Mbps	2.1 Mbps
Bandwidth	High (11Mbps)	Low (800Kbps)
Transmission technique	Direct-Sequence spread spectrum (DSSS)	Frequency-Hopping Spread Spectrum (FHSS)
Security	It is more secure	It is less secure
Primary devices	Laptops, Desktops, Servers, TV, Latest Mobiles.	Mobile phones, mouse, Keyboards, office & industrial automation devices

Bluetooth operates using Frequency Hopping Spread Spectrum technique with channels 1MHz in width and a hop rate of 1600 hops per second. It transmits for 625 µs in each channel while Wi-Fi on the other hand uses Direct Sequence Spread Spectrum with a 22MHz passband and communicates with a throughput up to 11Mbps. It uses any of the eleven 22MHz sub-channels from available 83.5MHz of the 2.4GHz frequency band.

III. RESULTS AND DISCUSSION

A. Simulation

The computer system was used to compute the received power (P_R) and Free Space Lose (FSL) at the various Client stations depending on the distance between the Base station and Client Stations.
The model is as stated below.

$P_R = P_T + G_T + G_R - FSL$
P_R = Received Power
P_T = Transmitted Power
G_T = Transmitted Antenna Gain (dB)
G_R = Received Antenna Gain (dB)
FSL = Free Space Loss

B. Presentation of results and analysis

The results of the distance, free space Loss and received Power for different locations are shown in table 4 below.

Table 4. Distance, Free Space Loss and Received Power at various base stations

Location	Distance (km)	Free Space Loss (dB)	Received Power (dB)
Faculty of Education	0.2	50.50	71.49
Faculty of Engineering	0.3	54.02	67.97
Faculty of Agriculture	0.4	56.52	65.47
Faculty of Law	0.5	58.46	63.53
Faculty of Environmental Science	4.5	77.55	44.44
Faculty of Management science	5.0	78.46	42.70
Administration Block	5.2	78.80	43.19
Faculty of Social Science	5.5	79.29	42.70
Library	6.5	80.74	41.25

C. Analysis of Results

There were nine locations used for the design of a Wireless Local Area Network. The distance between the Base and Client stations, the free space loss and the received power were calculated for each location. In the faculty of Engineering, the free space loss was calculated as follows:

FSL = 32.44 + 20 Log (D) + 20 Log (F)
D = Distance (km).
F= Frequency (Hz)
When D = 0.3 and F = 40.
FSL = 32.44 + 20 log (0.3) + 20 log (40)
FSL = 32.44 – 10.46 + 32.04
FSL = 54.02dB
Also, the received Power was calculated as:
$P_R = P_T + G_T + G_R - FSL$
When P_T = 76.99, G_T = 25, G_R = 20 and FSL = 54.02
P_R = 76.99 + 25 + 20 – 54.02
P_R = 121.99 – 54.02
P_R = 67.97dB

It is observed that, when the distance of a particular location is small, the received power increased to a large value than the free space loss value. Also, when the corresponding distance increases to a large value the free space loss is greater than the received power value, and vice versa.
It is evident that, the results obtained from the software program are accurate, since it has indicated the incident of poor signal quality due to power loss in transmission [10].

IV. CONCLUSIONS

The Wireless design is a worthy venture for institutions to join the trend in information technology with the motive of reducing the manual task for the staff of an organization.
The system has encouraged on-line researches on the web where users can access servers, network printers and other network resources regardless of their location. Wirelesses LAN has the ability to enhance security and also ensure the confidentiality and integrity of Wireless Communications [11].

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